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GROWING POPULARITY OF SORGHUM IN RICE FALLOWS – AN IIMR CASE STUDY

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PREFACE

Sorghum is very important crop to the resource poor farmers for nutritional and livelihood security point of view. However, the area under sorghum is decreasing drastically. The changing pattern of the sorghum utilization calls for renewed thinking in planning, research, marketing and policy for its sustainable development. It is being grown in rice-fallows are challenged by vagaries of environment such as biotic and abiotic stresses. Selection of location-specific sorghum cultivars resilient to these challenges and diverse end-uses is the key to improving sorghum productivity in farmers' fields and to make sorghum cultivation profitable. A thorough knowledge on the nature and intensity of these challenges and changing demands, and keeping abreast of the latest developments in these fields are essential for overall improvement of sorghum.

I hope that the cultivation of the sorghum in rice-fallows will have immense scope and challenges too. The challenges will definitely be accepted by scientists of ICAR-Indian Institute of Millets Research (IIMR). There is a need to adopt multifarious strategy for analysis of the situations, technology evaluation and refinement, and integrated farming system approach making the efficient use of natural resources. Accordingly, an attempt has been made in this direction by the IIMR.

With this backdrop, the authors have made an attempt to highlight salient research findings and various factors responsible for improvement of sorghum cultivation in rice-fallows. It also involves the analysis of socio-personal and economic status of the farmers, resources available, and their efficiency in the farming situation, and its future scope. I am sure; this bulletin will be useful for researchers, policy makers and stakeholders for the sorghum improvement.

IIMR, Hyderabad
22nd April, 2017

(Vilas A. Tonapi)

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Authors

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1. Introduction

Sorghum (*Sorghum bicolor* L. Moench) popularly known as *jowar* in India, is an important staple food for millions of people in the semi-arid tropics of Asia and Africa. India contributed 13 per cent of the total world area (44.20 m ha) under sorghum with 8.00 per cent of total world production (67.87 m t) during 2014-15. It is cultivated for food, feed, fodder and more recently for bio-fuel.

In India, Maharashtra State is the largest sorghum grower and producer followed by Karnataka, Madhya Pradesh and Telangana State. Sorghum was known as “great millet” till early eighties with an area of more than 18 million ha. The area has declined drastically from 10.25 m ha in 1999-2000 to 5.82 m ha in 2014-15. The total production also declined from 8.68 m t to 5.39 m t. But, the productivity has increased from 847 kg /ha to 907 kg /ha during the same period mainly due to adoption of improved production technologies by the farmers. The declining area has therefore, necessitated the search for new niches for sorghum cultivation.

The poorest people in the arid and semi-arid tropics are at a high risk from deficiencies of calories and micronutrients especially the deficiency of iron, zinc and vitamins, as they cannot afford a variety of food items in their diet. Besides stress tolerance for cultivation, sorghum provides nutritious food as compared to others cereals with high fibre content, minerals and slow digestibility. This crop can constantly help to meet out the needs of their animal feed and fodder, and will continue to be grown by dryland farmers in the foreseeable future. Nutritional relevance of sorghum and other major cereals is given in Table 1.

Table 1 Nutritional composition of staple cereals (per 100 g)

Staple cereal	Protein (g)	Carbohy-drades (g)	Fat (g)	Crude fibre (g)	Mineral matter (g)	Calcium (mg)	Phosp-horus (mg)
Sorghum (*Jowar*)	10.4	72.6	1.9	1.6	1.6	25	222
Pearl millet (Bajra)	11.6	67.5	5.0	1.2	2.3	42	296
Finger millet (Ragi)	7.3	72.0	1.3	3.6	2.7	344	283
Foxtail millet	12.3	60.9	4.3	8.0	3.3	31	290

Staple cereal	Protein (g)	Carbohy-drades (g)	Fat (g)	Crude fibre (g)	Mineral matter (g)	Calcium (mg)	Phosp-horus (mg)
Barley	11.5	696	1.3	3.9	1.2	26	215
Maize	11.5	66.2	3.6	2.7	1.5	20	348
Wheat	11.8	71.2	1.5	1.2	1.5	41	306
Rice	6.8	78.2	0.5	0.2	0.6	10	160

Source: National Institute of Nutrition (NIN), Hyderabad.

Unlike in other parts of the world, sorghum in India is grown both in rainy and post-rainy seasons. While the rainy season sorghum grain is used for both human consumption and livestock feed, post-rainy season produce is used primarily for human consumption. Thus, sorghum is the key for the sustenance of human and livestock population in an era of climate change.

Rice fallows cultivation in India

Rice fallows basically imply to those lowland *kharif* sown rice areas which remain uncropped during *rabi* (winter) due to various reasons such as lack of irrigation, cultivation of long-duration varieties of rice, early withdrawal of monsoon rains leading to soil moisture stress at planting time of winter crops, water logging and excess moisture in November / December, lack of appropriate varieties of winter crops for late planting, and socio-economic problems like stray cattle, blue bulls etc. (*Ali* and *Kumar*, 2009).

India accounts for 79% (11.65 million ha) of the total rice fallows of South Asia (15.0 million ha). Rice fallows are mainly spread in the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, West Bengal and Uttar Pradesh (*Subbarao et al.*, 2001). The coastal region of Andhra Pradesh, Karnataka and Tamilnadu form an important rice fallow ecology in peninsular area.

In order to meet domestic demands of food, feed and fodder, there is huge scope to promote sorghum in such unconventional areas. The rice fallows offer good scope for area expansion of this crop and crop intensification. Their productive utilization can overcome many social and economic problems like, unemployment, labour migration and low income. Development and popularization of improved hybrids of sorghum

suiting to rice fallows of different agro-ecological regions coupled with improved agro-technologies can boost production, and thus improve income and livelihood security of farming community. Moreover, introduction of legumes can provide a sustainable production base to the continued rice mono-cropped system and obviate decline in total factor productivity and also provide much needed nutritional security and soil fertility improvements.

Potential crops for rice fallows

After the harvest of *kharif* rice, climatic conditions of rice fallow lands in many areas are suitable for growing cool and warm season pulses profitably. The residual moisture left in the soil at the time of rice harvest is often sufficient to raise short-season crops. Further, by use of short-duration and high-yielding varieties of rice allowing to vacate fields in September-October, the traditional rice fallows can be converted into productive lands. Introduction of cool and warm season pulses such as lentil, mungbean, urdbean, lathyrus, peas etc., in rice fallows can increase the productivity as well as sustainability of rice. The small-seeded varieties of these pulses may find prominence under *Utera* cultivation (relay cropping) in the states of Chhattisgarh, Jharkhand, Bihar, West Bengal and Assam. This practice can be made more effective by using short-duration and high-yielding varieties of rice, as rice will vacate the field in September-October. In low land areas with excessive soil moisture, lentil is more suitable and assured than chickpea. Consequently, the rice-lentil system can be made more popular in the lowlands of eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal. Introduction of groundnut in rice fallows can be a profitable proposition in *Char* area of Bihar and eastern Uttar Pradesh, Mahananda of Odisha, Brahmaputra valley of Tripura, Assam, Meghalaya, Manipur, and coastal Andhra Pradesh. Under zero-till, mustard in eastern Uttar Pradesh has good scope besides traditional urdbean and mungbean. Of late, *rabi* sorghum has also been successfully introduced in the rice fallows of coastal Andhra Pradesh (Patil *et al*., 2012).

Rice fallows ecology

In India, rice is cultivated on wide range of soils from loamy sands in Punjab to clayey soils in several states. Heavy-textured soils with high water-holding capacity produce higher rice yields and are suitable for subsequent short-season crops under rainfed

conditions. Since rice fallows are distributed in eastern plains, central region, coastal peninsula and north-east hills, the edaphic and climatic conditions vary greatly.

The agro-climate of the coastal Andhra Pradesh is characterized by dry sub-humid with hot summers and very mild winters. The mean annual temperature varies from 26-29°C rising to a maximum of 39-40°C in May and June and dropping to a minimum of 20-22°C in January. The mean annual rainfall ranges from 1000-1200 mm meeting 60-70% of the PET demand (600-1800 mm). The moisture availability period begins with the onset of rainfall in September, and continues up to November / December and ends with the utilization of stored soil moisture in January. In Krishna delta, rainfall is high (up to 1500 mm) and growing period extends up to 210 days. The soils are deep and clayey.

2. Sorghum production scenario in Andhra Pradesh

The contribution of undivided Andhra Pradesh to total sorghum production of the country (7.64 million tonnes during 2008-09) is only 6%. Sorghum is grown in the state in the area of 0.12 m ha in kharif and 0.16 in *rabi* with an average productivity of 1563 kg / ha. The major sorghum growing districts are Adilabad, Anantapur, Chottore, Cuddapah, East Godavari, Guntur, Karimnagar, Khammam, Krishna, Kurnool, Mahaboobnagar, Medak, Nalgonda, Nellore, Nizamabad, Prakasam and Ranga Reddy. Local cultivars like "*pachha jonna*" (yellow sorghum) is the most popular among the farmers. However, the improved hybrids like, CSH 16 and Palem 1 are also grown during rainy season. Coastal Andhra Pradesh (AP) especially Guntur district is considered to be the non-traditional area for sorghum cultivation. Traditionally in rice-fallows of the coastal AP, blackgram was the major crop. However due to the diseases (yellow vein moisac) problems and weeds infestation, the productivity of blackgram declined considerably and farmers have now switched over to maize and sorghum in rice-fallows. The productivity of sorghum in rice-fallows is the highest (6.9 t /ha during 2014-15) in the country (Fig. 1 & 2) and farmers are getting good profits in this system and hence, the area under sorghum is also increasing.

Sorghum in rice-fallows (Guntur district in coastal Andhra Pradesh) had the highest productivity (6.9 t /ha in 2014-15) in the country. Sorghum in rice fallows in coastal Andhra

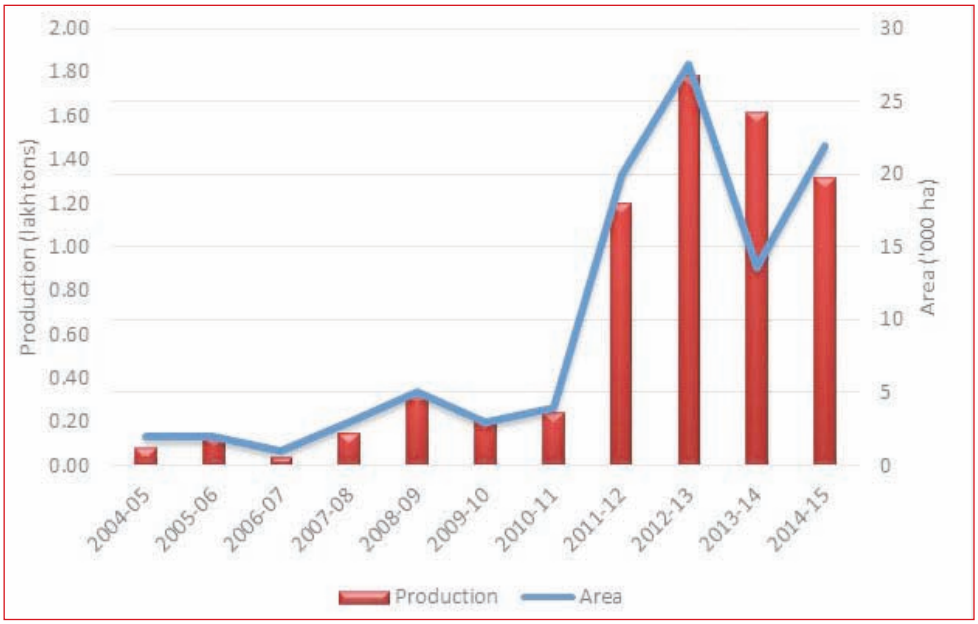

Figure 1. Area and production of sorghum in Guntur district of Andhra Pradesh

(Source: State Department of Agriculture, ADA, Guntur district, Andhra Pradesh, India)

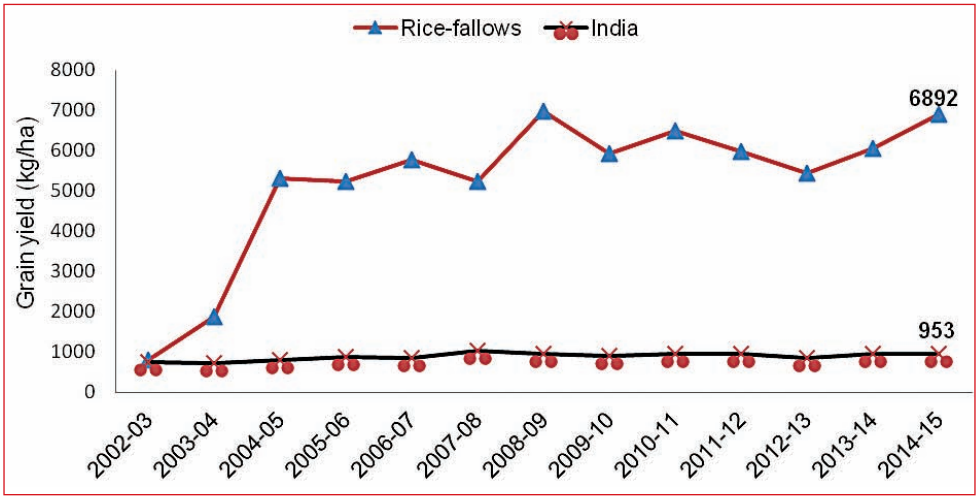

Fig. 2. Productivity of sorghum in rice-fallows in Guntur district and national average

Pradesh, especially in Guntur and adjoining districts is gaining popularity among the farmers and the crop is exclusively cultivated in rice fallows under zero tillage condition (Mishra *et al*. 2011). It is now grown in more than 14,000 ha area in rice-fallows with an average productivity of 6.9 t/ha. Sorghum has been recognized as more drought tolerant than other cereals. Sorghum after rice gave the highest output energy of 59.1 x 10^3 MJ/ha as compared to rice-pigeonpea and rice-safflower (Mahendra Kumar, 1997). Sorghum cultivation under zero tillage has many economic and environmental benefits over conventional tillage, such as lower labour and fuel needs, reduced soil erosion, reduced runoff, increased soil organic Carbon contents, and increased soil biological activity (West and Post 2002). Schlegel *et al*. (2007) recorded 25% higher grain yield in no-tillage than reduced tillage and 98% greater than conventional tillage.

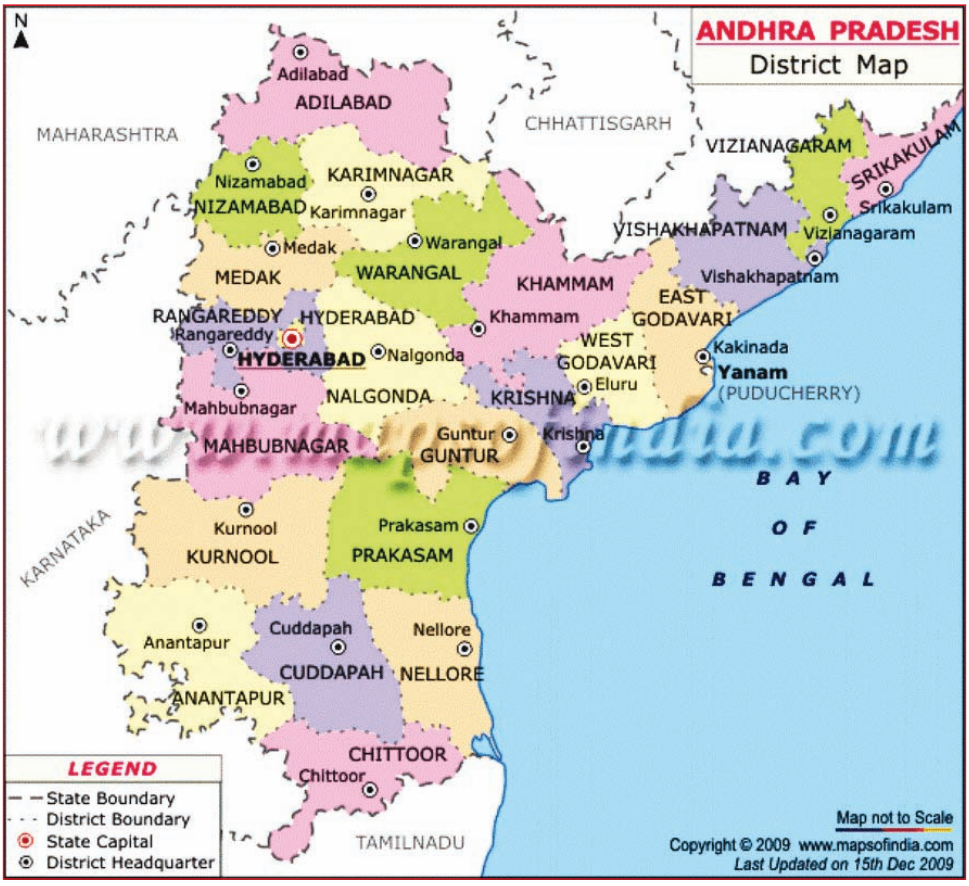

Fig.2. Districts of Andhra Pradesh

Of late, the area under pulses has declined due to late planting of rice and severe attack of viral diseases and parasitic weed *Cuscuta* (Mishra *et al*., 2009). Maize is a major competitor to sorghum due to its higher productivity. However, sorghum is preferred in areas where irrigation is a limiting factor. Indiscriminate use of agro-chemical for sorghum production in rice-fallows is major concern (Chapke *et al*. 2011). Practically, the sorghum growers in this area are mostly inclined towards obtaining maximum monetary benefits from grain yields. Although, they are getting higher yields but the profit margin could be increased by introducing potential cost-effective technologies.

3. Major cropping systems of Telangana and Andhra Pradesh

The Andhra Pradesh and Telangana are states of large diversity of soil and climatic conditions that leads to diversified cropping systems (Fig. 2 & Table 2). The major cropping system of the state is rice-based rotations followed by sorghum, groundnut, cotton, sugarcane and maize systems (Table 3). Maize systems are dominant in Telangana region during monsoon season whereas during winter season, maize and sorghum systems are mainly practiced in Krishna and Godavari zones in rice-fallows in Andhra Pradesh. Details about the soil types, crop and irrigation intensity of different agro-climatic zones of Telangana and Andhra Pradesh is depicted in Table 3.

Table 2. Major cropping systems in different agro-climatic zones of AP

S. No.	Name of zone	Districts
1	North Coastal zone	Rice-rice, Rice-groundnut, Rice-sesame, Sugarcane, Mesta-rice, Ragi-rice
2	Godavari zone	Rice-rice, Rice-maize, Sugarcane, Tobbaco
3	Krishna zone	Rice-rice, Rice-maize, Rice-sorghum, Rice-blackgram, Rice-sesame, Cotton, Sugarcane, Chillies
4	Southern zone	Rice-rice, Rice-ragi, Rice-groundnut, Groundnut+redgram, Groundnut-groundnut, Groundnut-pulses
5	Northern Telangana zone	Rice-rice, Rice-groundnut, Groundnut-groundnut, Groundnut-pulses, Cotton-maize
6	Central Telangana zone	Rice-rice, Rice-maize, Sorghum-red gram, Sorghum+bajra, Castor-red gram, Groundnut, Cotton
7	Southern Telangana zone	Rice-rice, Sorghum-red gram, Sorghum+castor, Rice-maize
8	Scarce rainfall zone	Groundnut-red gram, Sorghum+red gram, Sorghum-groundnut
9	High altitude tribal zone	Mostly *podu* cultivation

Table 3. Major soil types, cropping intensity and irrigation intensity in different agro-climatic zones of Andhra Pradesh and Telangana

S. No.	Name of Zone	Districts	Major soil types	Cropping Intensity (%)	Irrigation Intensity (%)
1	North Coastal zone	Srikakulam, Vizianagaram, Vishakhapatanam	Alluvial, red sandy loams, red loams with clay based coastal sands, lateritic soil	132	116
2	Godawari zone	East and West Godavari	Black cotton soil, coastal sands, red loams	173	172
3	Krishna zone	Krishna, Guntur, Prakasam	Red heavy black, light black, red chalka, coastal sand, problem soils	131	122
4	Southern zone	Cuddapah, Nellore, Chitoor	Red soils, black soils, alluvial, sandy soils, coastal sand, lateritic soils, problem soils	116	124
5	Northern Telangana zone	Adilabad, Karimnagar, Nizamabad	Red sandy, red earths with loamy sub soil, lateritic soils black cotton, forest soils	135	160
6	Central Telangana zone	Warangal, Khammam, Medak	Red sandy, red earths with loamy sub soil black cotton, forest soils, problem soils	121	107
7	Southern Telangana zone	Mahbobnagar, Nalgonda, Ranga Reddy	Red sandy soils, red earth, black cotton soils, problem soils	115	137
8	Scarce rainfall zone	Ananthpur	Deep black light, black road earth with clayey sub soil, red loamy soils, red earth with loamy sub soils, red sandy soils problem soils	108	123
9	High altitude tribal zone	High altitude tribal area of Srikakulam, Vizianagaram, East Godavari, Adilabad and Khammam	Alluvial, red sandy loam, red loam with clay base, coastal sand and forest	120	110

4. Major crops in rice fallows in Guntur district

Previously, rice fallows blackgram was the major cropping system of the coastal areas of A.P. where blackgram seeds were broadcast in standing crop of rice (before rice harvest) to utilize the residual soil moisture. However, due to infestation of yellow mosaic virus and parasitic weed, namely field dodder (*Cuscuta campestris)*, the productivity of blackgram declined considerably. Blackgram cultivation has now been reduced drastically. According to the farmers, the reason for its reduction was late receipt of monsoon and late release of water from *Krishna* river, resulting in late sowing of paddy crop and delayed harvesting (in December). This lead to poor germination of blackgram, due to low temperature, and infestation of diseases like, yellow mosaic virus.

Blackgram infested with yellow vein mosaic disease and weeds in rice-fallows

In the changed scenario, the farmers were shifted to maize (in assured irrigation) and sorghum (in limited irrigations) in place of blackgram. Although, maize was a major competitor, nevertheless, sorghum was preferred in areas where irrigation is limited and requirements of inputs for maize are more which is not comparatively profitable. These were the second and third major factor behind sorghum cultivation. Taking advantage of residual moisture, saving in cost of land preparation, judicial use of seeds, limited irrigation water and weed management have shown positive change in attitude of farmers. The preliminary studies indicated that the farmers were interested in grain sorghum only because they found only marginal difference between price of sorghum (Rs. 1200/- to 1500/- per 100 kg) and maize (Rs. 1300/- to 1800/- per 100 kg). Fourth important motive was, a short duration crop like sorghum (110-120 days) is suitable to fit in the crop rotation and fifth motive was, less insect-pest problems in sorghum compared to other crops. Hence, since last 8-10 years, farmers are cultivating sorghum after harvest of rice on the residual soil moisture under zero tillage.

5. Sorghum package of practices adopted by farmers

With vast experience of farming, availability of seeds in market and improved practices followed in maize cultivation,the following practices in sorghum cultivation are followed by the farmers.

Cultivars

Hybrids with high yield potential and medium height (2.0 to 2.5 m) to avoid losses from lodging are being sown. Majority of the farmers of the area were growing locally available sorghum hybrids like, Mahico 51, Bhagylaxmi, Haritha and Mahalaxmi 296.

Method of sowing, spacing and seed rate

Sorghum is being sown after the harvest of *kharif* transplanted rice, from second fortnight of December to first week of January. The sowing operation was being done manually in rows (40 cm x 20 cm) at 4 - 6 cm depth by making a hole with wooden stick and putting 3-4 seeds in each hole with seed rate of 8-10 kg /ha. Some farmers have improvised manually operated small implement with wheel, which can make the holes in two rows at a time and is easy to operate in between the rice stubbles (Fig. 4). The advantage of high inputs and fertility of the soils, is being exploited by the farmers by sowing 3-4 seeds at each hill and thus the plant density is higher (> 200000 per ha) than the normal cultivation as advocated for irrigated post-rainy (*rabi*) sorghum (180000 per ha). Mechanization attempts by few active farmers in fabricating a suitable tractor-driven implement to drill holes for sowing is helping to reduce cost of sowing (in photo below).

Fig 4. Sowing of sorghum in rice-fallows

Nutrient management

In rice-fallows, the farmers were applying higher dose of fertilizers in the range of 150-200 kg N, 75-80 kg P_2O_5 and 75 kg K_2O per ha. Typically, no basal fertilizer was applied at the time of sowing but around 30 days after sowing (just before Ist irrigation), a mixture of 75-100 kg /ha N and 75-80 kg/ha P_2O_5 was side dressed to individual plant in rows manually (Fig. 6). At 60 days after sowing (just before 2nd irrigation) 75-100 kg N and 75 kg K_2O /ha were applied.

Fig. 6. Fertilizers application to sorghum in rice-fallows

Weed management

Weeds including grassy and broadleaf were a major problem in rice-fallows under zero-tillage. They emerged even before sorghum sowing and had an advantage over the main crop for available resources. Grassy weeds especially *Echinochloa* spp. were the major weeds infesting the crop. Therefore, both; pre-emergence and post-emergence weedicides were useful under this zero tilled condition. The farmers wisely sprayed both, paraquat (post emergence) + atrazine (1.0+0.5 kg/ha) (pre-emergence) one day after sowing for effective weed control. Paraquat controls already existed (emerged weeds) and atrazine acts as pre-emergence i. e. to control emerging weeds along with sorghum (Fig. 7).

Severe infestation of weeds

Fig 7. Weed controlled plot with tank mixed atrazine+paraquat (0.50+1.00 kg a.i./ha) as pre-emergence weedicide

Insect-pests management

Due to high humidity in coastal regions, heavy infestation of insect-pests and diseases was observed. Among major pests, shootfly, aphids and stem borer were dominant. For effective control of shootfly, the farmers were spraying cypermethrin @ 2 ml/l of water at 1 week after germination and again giving need-based spray at two weeks interval. On the basis of improved practices of other crops, they were applying furadon 3G granules (@10-12 kg per ha) in leaf whorls of individual plant manually after 30-35 days of sowing

Spraying of insecticides

Application of Furadon 3G granules in leaf whorls

Irrigation management

Two irrigations are sufficient to harvest good sorghum yield whereas, maize required four irrigations and hence, its preference were number of irrigations were limited. The

farmers were judiciously using available water by giving first irrigation at 30 days after sowing (DAS) and 2nd at 60 DAS.

Harvesting and threshing

In the coastal areas, strong winds in March and April due to low pressure was resulting in severe damage of crop. Therefore, the farmers harvested the crop at early maturity stage (105-110 days) to avoid losses from cyclonic rains. After harvest, the panicles were sundried for a week and later processed. On an average, sorghum grain yield ranged from 6.5 t/ha, 7.5 t/ha in these rice fallows. The sorghum productivity potential of improved cultivars was attained due to intensive crop management by the farmers (Fig. 9). The farmers were able to earn gross returns of Rs. 92,400/- per ha (with an average market price @Rs.1200/- per quintal) excluding fodder price. All the farmers sold the produced grains in the local markets after harvest. The highest fodder yield was also recorded (10-12 t/ha).

Fig. 9 Harvesting of sorghum crop

IIMR recommended package for sorghum in rice fallows

Five major cultivation practices suitable for rice fallows under zero-tillage were evaluated and validated in farmers' fields, and documented for ready reference to the farmers.

1. Cultivar with high potential : CSH 16

Year of release	**:**	1997
Duration	**:**	110 days
Grain yield	**:**	8.0-8.5 t/ha (in rice-fallows)
Fodder yield	**:**	11.5-13.7 t/ha (in rice-fallows)
Salient features	**:**	Medium tall, long loose panicle, medium bold seed, tolerant to grain mould and resistant to leaf spot disease and lodging, easily digestible fodder for cattle

2. Seed rate

- Put 3-4 seeds in each hole at 4 cm - 6 cm depth @ 7-8 kg seeds per ha (3 kg/acre)

3. Seed treatment

- Before sowing, treat sorghum seed with 14 ml Imidacloprid (*Goucho*) + 2 g Carbendazim (*Bavistin*) for one kg of the seed, or
- Thiomethaxam (*Cruser*) 3 g/kg of seed

4. Spacing

- Row to row 45 cm and plant to plant distance 10 to15 cm
- Maintain plant population as 1,80,000 plants per ha (72,000 plants per acre)

5. Fertilizers application

- *First dose of fertilizers:* Half dose of Nitrogen i.e., 40 kg per ha, full dose of P_2O_5 i.e, 40 kg per ha and full dose of K_2O i.e, 40 kg per ha at sowing. Apply basal fertilizers in each hole at 6-8 cm at the time of sowing and cover it with pinch of soils before sowing the seeds
- *Second dose of fertilizers:* Apply half Nitrogen dose i.e., 40 kg N before first irrigation at around 30-35 days after sowing

Drying / Bagging

After threshing the grains are sundried for 1-2 days to reduce the moisture content up to 10%. Bagging of the grains is done in plastic or gunny bags for immediate marketing.

Economics

On an average, farmers' expenditure incurred on sorghum cultivation was Rs. 29000 – 30000 per ha which could produce an average 7.70 tonne per ha grain with CSH 16, was resulted into net profit of around Rs.63000 /ha. Component-wise cost and benefits are highlighted in Table 4. However, the cost of stover was not included in the net benefit as it is either burnt or incorporated in the soil.

Table 4 Economics of sorghum cultivation in rice-fallows as per the farmer's experience

Sl. No.	Particular	Cost (Rs. /ha)
1	Seed	1125
2	Fertilizers	6926
3	Herbicide	1250
4	Pesticides	3750
5	Irrigation	5000
6	Labour	11250
	Total cost of production	29,301
	Gross returns*	92,400
	Net returns	63,099
	Benefit : Cost ratio	3.15:1

**Excluding fodder's price, selling price of sorghum grain @Rs. 12000/- per tonne.*

6. Performance of public and private sorghum hybrids under zero-tillage in rice fallows

A field experiment was conducted in farmers' fields at eight villages namely, Ananthavaram, Kondur, Kuchalapadu, Nallapadu, Sripuram, Nandivellugu, Sagupalem and Athrota in Guntur district (16^0 18' N, 80^0 29' E, 31.5 m above mean sea level) in Andhra Pradesh, India, during three winter seasons of 2008-09, 2009-10 and 2010-11. The soil was clay loam (vertisol), low in organic carbon (0.35%), medium in available phosphorus (28.4 kg/ha) and high in available potassium (392 kg/ha) with pH 7.6.

In total, seventeen rainy (*kharif*) and post-rainy (*rabi*) sorghum cultivars including public and private along with a popular hybrid 'Mahalaxmi 296' were evaluated (Table 5, 6 & 7) in randomized block design. After the harvest of late-*kharif* transplanted rice, the sorghum cultivars were sown in December under zero-tillage to utilize the residual soil moisture. The sowing was done manually in rows 40 x 20 cm apart at 4-6 cm depth by making a hole with wooden stick and putting 2-3 seeds in each hole (dibbling). For effective weed control, pre-emergence application of paraquat plus atrazine (1.0+0.50 kg/ha) was done one day after sowing. Crop was irrigated twice at 30 and 60 days after sowing (DAS).

Total thirteen sorghum cultivars *viz.*, 'CSH 16', 'C 43', 'Laxmi', 'M35-1', 'CSV 216R', 'MGSH 55', 'MRS 4094', 'SPH 1148', 'SPH 1149', 'CSV 22R', 'MJ 4334', 'Sudama 333', 'CSH 15R' were evaluated during 2008-09 in rice-fallows under zero-tillage in farmer's fields at Ananthavaram village in Guntur district in Andhra Pradesh (A.P.).

Results (Table 5) revealed that sorghum hybrids yielded significantly superior than varieties. Among different hybrids, Sudama 333 (8.44 t/ha) being on par with CSH 16 (7.80 t/ha), MJ 4334 (7.37 t/ha) and MRS 4094 (7.14 t/ha) registered the highest grain yield. These hybrids recorded 43, 32, 25 and 21 % higher yields over check 'Laxmi' (5.89 t/ha). The increase in grain yield was due to increased panicle length and number of grains/panicle. The lowest grain yield (3.27 t/ha) was recorded with SPH 1148 followed by M 35-1 (3.56 t/ha) and SPH 1149 (4.5 t/ha). It was realized that the *kharif* hybrids with medium height up to 2 m and high grain yield potential were suitable for this area.

Table 5. Plant height, yield attributes and yields of sorghum cultivars under zero-tillage in rice fallows 2008-09

Cultivars	Plant height (cm)	Panicles /m2	Panicle length (cm)	Grains /panicle	100-grain wt (g)	Grain yield (t/ha)	Stover yield (t/ha)
CSH 16	142	16.4	41.4	3087	2.67	7.80	13.17
C 43	122	17.2	26.5	2141	2.93	5.78	13.64
M 35-1	301	16.8	19.7	1605	2.43	3.56	10.24
CSV 216 R	320	14.6	24.4	1993	2.49	3.63	10.86
MGSH 55	163	16.0	37.7	3203	2.15	5.84	14.29
MRS 4094	154	19.8	32.3	2787	2.63	7.14	16.66
SPH 1148	169	13.6	31.8	1414	2.94	3.27	9.49
SPH 1149	286	14.4	22.9	2214	3.01	4.50	13.09
CSV 22R	288	16.0	23.0	2597	2.08	4.60	14.51
MJ4334	157	17.4	38.4	2857	3.04	7.37	16.85
Sudama 333	141	18.6	38.2	3510	2.49	8.44	19.46
CSH 15R	191	15.4	29.4	2372	3.51	6.03	16.35
Laxmi (Check)	143	16.8	38.0	3340	1.89	5.89	13.73
SEm±	4.14	0.55	0.36	246	0.08	0.47	1.18
CD (P=0.05)	12.10	1.56	1.04	699	0.22	1.33	3.35

Sorghum hybrids *viz*., 'CSH 16', 'CSH 23', 'CSH 15R', 'NSH 27', 'Kaveri 6363', 'SBSH 151' including 'Mahalaxmi 296' as check commonly grown by the farmers, were evaluated during 2009-10 in rice fallows in farmer's field at Kondur, Athrota, Sripuram and Nellapadu villages in Guntur district in Andhra Pradesh. After the harvest of *kharif* transplanted rice, the sorghum cultivars were sown during 25 December 2009 to 5 Jan., 2010 under zero-tillage to utilize the residual soil moisture. Results revealed (Table 6) that 'NSH 27' (7.75 t/ha), 'CSH 16' (7.43 t /ha) and 'Kaveri 6363' (7.40 t /ha) registered the highest grain yield than the check Mahalaxmi (7.11 t /ha).

Table 6. Plant height, yield attributes and yields of sorghum hybrids under zero tillage in rice-fallows 2009-10

Sorghum hybrid	Plant height (cm)	Panicles /m2	Panicle length(cm)	Grains /panicle	Grain weight /panicle (g)	100-grain wt (g)	Grain yield (t/ha)
NSH 27	162.60	15.07	29.58	2951	54.70	2.58	7.57
CSH 16	174.29	18.40	30.71	2471	50.05	2.66	7.43
Kaveri 6363	162.50	17.43	28.37	2780	52.83	2.46	7.40
Mahalaxmi 296	145.97	17.15	28.96	2352	46.90	2.55	7.11
SBSH 151	171.12	15.77	28.46	2446	49.48	2.88	6.97
CSH 15R	251.25	16.18	26.71	1948	41.35	2.86	5.95
CSH 23	154.55	17.91	25.42	2498	36.78	2.41	5.39
CD (P=0.05)	18.73	3.62	1.85	611.63	8.25	0.36	0.92

Similarly, six public and private sorghum hybrids *viz*., 'CSH 16', 'CSH 23', 'NSH 27', 'Kaveri 6363', 'Sudama 333' including 'Mahalaxmi 296' as a check were evaluated in rice fallows in farmers' fields at Nallapadu, Sripuram and Athrota villages in Guntur district in Andhra Pradesh during 2010-11. After the harvest of *kharif* transplanted rice, the sorghum varieties were sown during 25-28 December 2010 under zero-tillage condition to utilize the residual soil moisture. Results revealed (Table 7) that all the demonstrated hybrids 'CSH 16' (8.61 t /ha), 'Kaveri 6363' (7.61 t /ha), 'Sudama 333' (7.11 t /ha), 'NSH 27' (7.04 t /ha) and 'CSH 23' (6.86 t /ha) yielded better than the check 'Mahalaxmi 296' (6.63 t /ha). Moreover, the significant increase (30%) was observed with 'CSH 16' (8.61 t /ha). The increase in grain yield was due number of grains/panicle and grain weight per panicle and plant populations.

Table 7. Plant height, yield attributes and yields of sorghum hybrids in rice-fallows

Hybrid	Plant population/m row	Plant height at harvest (cm)	Panicles /m^2	Panicle length (cm)	Grains /panicle	Grain weight /panicle (g)	100-grain weight (g)	Grain yield (t/ha)	Fodder yield (t/ha)
CSH 16	12.6	174.2	12.6	31.6	4503	75.0	1.90	8.61	11.78
Kaveri 6363	10.4	183.2	10.4	35.6	3043	76.8	2.52	7.61	10.70
Sudama 333	11.4	171.8	11.4	30	2309	64.6	2.85	7.11	9.75

Hybrid	Plant population/m row	Plant height at harvest (cm)	Panicles /m²	Panicle length (cm)	Grains /panicle	Grain weight /panicle (g)	100-grain weight (g)	Grain yield (t/ha)	Fodder yield (t/ha)
NSH 27	11.4	183.0	11.4	35.4	2544	68.8	2.71	7.04	8.39
CSH 23	11.4	187.2	11.4	36.8	3159	70.4	2.23	6.86	9.40
Mahalaxmi 296	12.80	170.8	12.8	32.40	2378	55.2	2.31	6.63	10.35
LSD (P=0.05)	2.05	8.50	2.05	4.27	1201	11.85	0.45	1.71	2.37

Results of the experiment trials conducted during three years (2008-11) shows (Fig. 3) that, 'CSH 16' gave higher grain yield (7.95 t /ha) compare to all 17 public and privates sorghum hybrids evaluated and also higher than local check 'Mahalaxmi 296' (6.54 t / ha). The farmers of this area liked this hybrid much due to it's high grain potential and medium height and demanding its seeds. However, the privates hybrids are ruling in this area. Plant height showed negative relation with grain yield indicating the need for medium-tall hybrids for rice fallow situations.

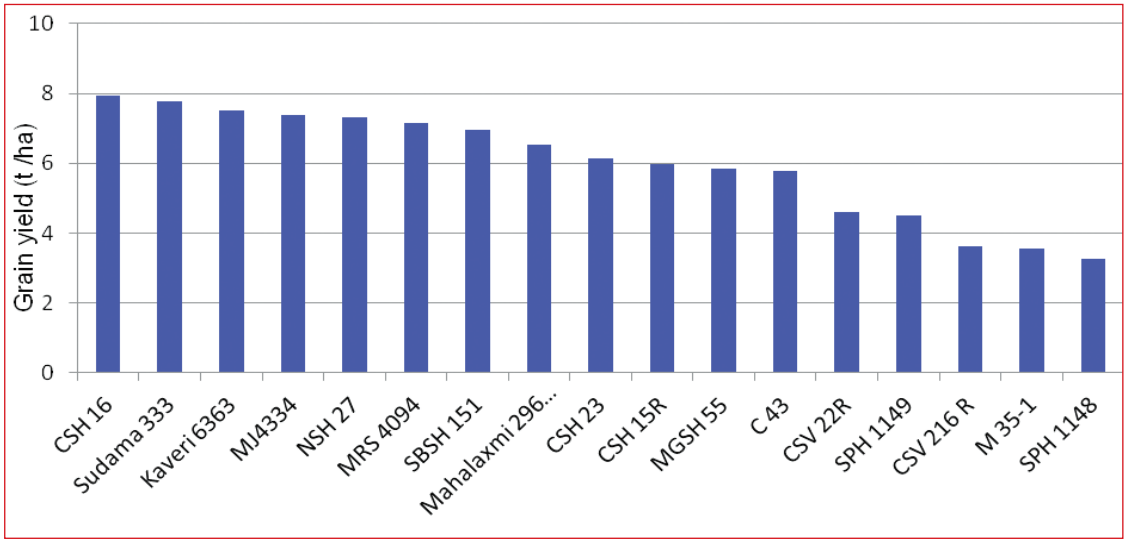

Fig. 3. Grain yield performance of sorghum cultivars in rice fallows under zero-tillage

Mahalaxmi 296

A view of sorghum trials in rice fallows

7. Popularization of proven sorghum production technologies in rice fallows

Keeping in view of increasing popularity of sorghum cultivation in rice fallows in Guntur district in Andhra Pradesh, field demonstrations of promising sorghum hybrid CSH 16 were organized on large scale to popularize the cultivar.

Results of 126 frontline demonstrations (FLDs) organized during 2011-12 revealed that CSH 16 (8.62 t ha^{-1}) yielded significantly better than the locally popular hybrid Mahalaxmi 296 (6.06 t ha^{-1}). Moreover, the significant increase of 42% was observed with CSH 16 over check Mahalaxmi 296. The increase in grain yield was due more grain weight per panicle and number of panicles per unit area. Though, the fodder was not much important to the farmers of this area, the same trend of fodder yield was also recorded from CSH 16 (12.50 t ha^{-1}) and Mahalaxmi 296 (7.90 t ha^{-1}). On an average, the demonstrated hybrid, CSH 16 under FLDs in rice-fallows gave 68% higher net returns (Rs.57,500/- per ha) than the check Mahalaxmi 296 (Rs.31,900/- per ha) at the cost of Rs.28,700/- per ha.

During 2014-15, total 50 field demonstrations on sorghum were organized on 20 ha in rice fallows under zero-tillage in Guntur district in Andhra Pradesh. The demonstrations were undertaken in four major sorghum growing villages *viz.*, Nandivellugu,Yerapalem, Athotta and Krapa of this district. Results revealed that CSH 16 (7.73 t ha^{-1}) yielded significantly better under the field trials than the locally popular hybrid Mahalaxmi 296 (6.64 t ha^{-1}). Moreover, the increase of 16% was observed with CSH 16 over the check Mahalaxmi 296.

Scientist examining the crop in farmer's field

Farmer's awareness programmes on improved sorghum cultivation in rice fallows

Several Farmers' Day were organized by the ICAR-Indian Institute of Millets Research (IIMR) at seven different villages, near Tenali mandal in Guntur district since 2009.

Total 21 field day programmes including farmers' rally on sorghum cultivation in rice fallows were organized in collaboration with College of Agriculture, Bapatla, Acharya NG Ranga Agriculture University, Department of Agriculture and DeV Gen Seed Company, Hyderabad in Tenali and Repalle blocks of the Guntur district. The aim of the programme was to make farmers aware of the modern crop protection, production technologies, value-addition and utilization of sorghum products. More than 4500 farmers were benefited and got acquainted with the techniques of improved sorghum cultivation through Scientists-Farmers' interactions. Different sorghum food products from sorghum were displayed in exhibition stall and explained importance of sorghum as a health food and fodder for animals. Farmers' response was commendable to the exhibited sorghum technologies and food products as well.

Pre-season (left) and in-season (right) field days organized

8. Response of sorghum hybrids to nitrogen under zero tillage in rice fallows

Farmers of the area were using the fertilizers and pesticides indiscriminately but harvesting on an average 6.0-6.5 t /ha grain yield. Therefore, the present investigation was undertaken to optimize the dose of nitrogen in sorghum in rice-fallows. A field experiment was conducted during *rabi* 2009-10 at farmer's field at Tenali in Guntur district of Coastal Andhra Pradesh. Treatments consisting of 5 nitrogen levels (25, 75, 125, 175 and 225 kg/ha in main plot) and 7 sorghum hybrids (Mahalaxmi 296, NSH 27, SBSH 151, Kaveri 6363, CSH 23, CSH 16 and CSH 15R in sub plots) were replicated thrice in split-plot design. After the harvest of *kharif* transplanted rice, the sorghum cultivars were sown on 16 December 2009 under zero-tillage to utilize the residual soil moisture. The sowing was done manually in rows (45x15cm) at 4-6 cm depth by making a hole with wooden stick and putting 2-3 seeds in each hole. For effective weed control, tank mixed application of atrazine+paraquat (1.0+0.50 kg/ha) was done one day after sowing. No fertilizer was applied at sowing. However, at 30 days after sowing (after first irrigation), 50% of N (as per treatment) and 125 kg P_2O_5/ha and 75 kg/ha K_2O/ha were side dressed to individual plants. Remaining 50% of N was side dressed at 60 DAS (after 2nd irrigation). Cypermethrin @ 2.00 ml/lit of water was sprayed at 20 and 30 days after sowing to reduce the incidence of shoot fly. Furodon 3G at 12 kg/ha was applied in leaf whorl of individual plants at 40 days after sowing. Crop was harvested manually at 115 days after sowing.

Results revealed that maximum grain yield of sorghum (8.17 t/ha) was obtained with application of 225 kg N/ha, but the response was significant only up to 175 kg N/ha. Grain

yield obtained with 175 kg N/ha (7.67 t/ha) was at par with that of 125 kg/ha (7.24 t/ha) but significantly superior to 75 kg N/ha (6.22 kg/ha). Among different sorghum hybrids, 'SBSH 151', 'CSH 16', 'Kaveri 6363' and 'Mahalaxmi 296' were at par (Grain yield 7.09 - 7.27 t/ha), but significantly superior to CSH 23 (5.88 t/ha) and CSH 15 R (5.67 t/ha) (Table 8). Increasing levels of nitrogen significantly increased the NPK content in grain, but the effect was more pronounced on N content. Among different sorghum hybrids, CSH 15R had the highest N content (1.61%) and CSH 16 had maximum K content (0.40%). It may be concluded that sorghum hybrids viz., CSH 16, SBSH 151, Kaveri 6363 and NSH 27 with application of 175 kg N/ha are most suitable for rice fallows in costal Andhra Pradesh.

Table 8. Effect of nitrogen levels and genotypes on growth, yield attributes and yields of sorghum cultivars in rice fallows

Treatment	Plant height at harvest (cm)	Panicles /m^2	Grains /panicle	100-grain weight (g)	Grain yield (t/ha)	Nutrient content in grain (%)		
						N	P	K
Nitrogen levels (kg/ha)								
25	159	13.1	1401	2.63	4.81	1.49	0.46	0.33
75	170	13.3	1851	2.69	6.22	1.54	0.48	0.34
125	177	12.9	2225	2.74	7.24	1.55	0.49	0.34
175	187	12.4	2391	2.78	7.67	1.57	0.49	0.34
225	188	13.2	2249	2.96	8.17	1.58	0.49	0.35
LSD (P=0.05)	12	NS	93	0.09	0.89	0.03	0.01	0.01
Genotypes								
Mahalaxmi 296	139	12.6	2229	2.66	7.09	1.57	0.50	0.33
NSH 27	160	12.7	2267	2.63	7.23	1.50	0.49	0.35
SBSH 151	171	11.6	2307	2.85	7.27	1.55	0.46	0.34
Kaveri 6363	168	12.7	2370	2.69	7.24	1.51	0.48	0.33
CSH 23	149	13.2	1571	2.86	5.88	1.42	0.48	0.32
CSH 16	180	13.3	2107	2.70	7.24	1.60	0.49	0.40
CSH 15R	266	14.7	1317	2.94	5.67	1.61	0.49	0.33
LSD (P=0.05)	10	1.1	100	0.05	0.57	0.03	0.01	0.02

9. Socio-personal traits and feedback of sorghum farmers of rice fallows

The productivity of sorghum in Guntur district is the highest (6.8 t/ha) in the country and the crop is exclusively grown for grain purpose in rice fallows. This was the main reason to select this district for the study. The study was conducted at seven villages, namely Athrota, Kamathavaripalam, Dhanthuluru, Siripuram and Kunchavaram (Block-Kollipara), and Nandivelugu and Ananthavaram (Block-Tenali). Total sample of 100 progressive and cooperative farmers from different categories were randomly selected for the study.

To study the different socio-economic, personal, situational and farming characteristics, which may have influence on sorghum cultivation in rice-fallows, a data collection schedule was developed. The data were collected with the help of the semi-structured interview schedule by conducting personal interviews, group discussions, field and empirical observations. The data were analyzed using SPSS and descriptive statistics.

Group discussions among scientists and farmers

It was assumed that socio-personal, economic and family background have an influence on sorghum cultivation in rice fallows. The following variables related with socio-personal traits of the sorghum growers were studied.

Age

Age was counted in view to study effective involvement of an individual in sorghum cultivation. Most of the farmers (61%), who were engaged in sorghum cultivation were of middle age group (30-50 years) followed by old age group (above 50 years). However, a few were of young age group (below 30 years).

Occupation

Majority of the sorghum growers (81%) were engaged in multi-business, like government or private service and dairy including farming for their livelihood. Only 19 per cent farmers in the study area were solely engaged in farming. It indicated that only faming could not satisfy the needs of the famers. They were inclined to go for more business or works along with crops cultivation.

Education

Education was referred to formal schooling of an individual farmer from school to university degrees. It was found that most of the farmers (60%), who had no formal

education, were engaged in sorghum cultivation. They may be called as formally illiterates. A few of them were educated up to middle school (14%), higher secondary (12%) and graduate (10%) level. It showed that educated people were not willing to enter in sorghum farming.

Land holding

About 60 per cent of the farmers were having small land holding (up to 2 ha) followed by 30 per cent with medium land holding (2 - 4 ha) and only 10 per cent having above 4 ha. The land holding was positively corelated with sorghum productivity and gross income.

Annual income

Annual income refers as total income of the farmer including all family members from all the sources. The 42 per cent farmers come under annual income below Rs. 20,000/- from all the sources and 41 per cent farmers had annual income between Rs.20,001 and Rs.40,000/-. Only 17 per cent were above Rs.40,000/- annual income. Annual income has the association of timely use of inputs and scientific orientation towards crop cultivation.

Family size

It was assumed that family size has an important role in crop cultivation. Majority of the famers (68%) had 3 to 4 members in their family. About one fourth of them (24%) had only 2 members. A few of them (8%) had more than 4 members.

Working members

About 58 per cent of the farmers were having less working members (only 2 working members) with 18 years age. It was followed by those having 3 to 4 working members in their family (40%). Only two per cent were having more than 4 members.

Correlation between farmers' traits and gross returns

With the assumption that gross returns obtained from the sorghum cultivation in rice fallows is influenced by various socio-personal traits of the respondents and agro-economical factors, the relationship of nineteen variables with gross income was computed with the help of correlation coefficient.

It was observed that (Table 9) correlation coefficient of six variables, namely land holding, area under sorghum crop, fertilizers cost, total cost of inputs and labour cost were significant at 1% level probability with gross returns obtained from the sorghum cultivation in rice-fallows. Among agro-economical variables, only cost of irrigation and pesticides were found correlated significantly at 5% level probability with gross returns.

It is revealed from the above findings that there were significant correlations between majority of farm related variables including cost of cultivation and gross returns obtained from the sorghum cultivation in rice fallows. This strong association suggested that resourceful farmers having spending capacity, were able to increase gross returns from the sorghum cultivation in rice fallows. This indicated that the farmers are highly profit oriented to gain gross returns from the sorghum cultivation in rice fallows by putting higher inputs across the different socio-economic status.

Table 9. Correlations between farmers' socio-personal traits, components of sorghum cultivation and gross income obtained from sorghum cultivation

Code	Variable	Coefficient of correlation (r)
X_1	Age	-0.103
X_2	Experience in sorghum cultivation	0.164
X_3	Occupation	0.115
X_4	Education	0.005
X_5	Land holding	0.275**
X_6	Annual income	0.050
X_7	Animals	-0.007
X_8	Family size	-0.092
X_9	Working members	-0.043
X_{10}	Crops per year	-0.004
X_{11}	Area under sorghum crop	0.467**
X_{12}	Seed cost	-0.030
X_{13}	Fertilizers cost	0.664**
X_{14}	Irrigation cost	0.210*
X_{15}	Herbicide cost	0.062
X_{16}	Pesticide cost	0.245*
X_{17}	Cost of inputs	0.429**
X_{18}	Labour cost	0.403**
X_{19}	Grain yield	0.955**

**Significant at 5% level, **Significant at 1% level*

10. Introduction of summer sorghum in rice fallows in Tamilnadu

Since, sorghum cultivation during summer in rice fallows is new endeavor in the Tamilnadu; the main objective of the programme was to evaluate and demonstrated high yielding sorghum cultivars, and build-up confidence to adopt them for increasing profitability and socio-economic upliftment of the sorghum growers including tribal farmers. Numbers of field trials on summer sorghum with CSH 16, CSH 14 and TKSV 0809 were organized at around Tenkasi-taluk in Tirunelveli district in Tamilnadu.

A field day on summer sorghum was organized with the help of All India Coordinated Research Project (AICRP) on Sorghum Tamilnadu Agriculture University (TNAU), Kovilpatti on 17th July, 2014 at the premises of Grampanchayat, Nainaragaram village, Kadayanallur-block, Tenkasi-taluk, Dist-Tirunelveli in Tamilnadu by Indian Institute of Millets Research (IIMR), Hyderabad. More than 200 farmers from Tenkasi-taluk and four surrounding blocks in Tirunelveli district including IIMR scientists and officials from the state agriculture department attended the programme. All the participants gathered at Nainaragaram Grampanchayat office and proceeded to farmer's fields for visit where

Field visit of farmers and experts at demonstration field at Nainagaram village

trials on CSH 16, CSH 14 and TKSV 0809 were organized with the help of AICRP, Kovilpatti. The farmers including non-trial farmers and the state department officials observed performance of the demonstrated cultivars in comparison with their existing cultivars. They got impressed with performance of CSH 14 because of its earliness and grain yield potential.

There was interaction session where they could get clarified their doubts which was held at the Grampanchayat office, in presence of IIMR Scientists, the Joint Director Agriculture, Deputy Director Agriculture, Assistant Director Agriculture, the oi/c, Agriculture Research Station and AICRP stations TNAU, Kovilpatti regarding advantages of the demonstrated cultivars over the existing private hybrids and local varieties. The programme was started with highlights of potential of sorghum production technologies and scope of value-addition. The experts explained importance, need and economic sustainability of sorghum cultivation in their area to the farmers. They were made aware on sorghum cultivation with latest improved production technologies, plant protection measures and diversified value-added food products. The farmers shown keen interest in sorghum cultivation with latest technologies and expressed curiosity to know more about preparation of sorghum food products. They express satisfaction, wish to grow CSH 14 and were demanding seeds of latest cultivars. Moreover, a few sorghum panicles were displayed through small exhibition and relevant literatures on sorghum in local language were also distributed for their further use. The farmers visited exhibition stall and enquired about preparation of different sorghum food products and its marketing.

Farmers-scientists interaction at Field Day at Nainagaram Grampanchayat office

11. Trends in sorghum marketing

Marketing information is essential for producers in planning farming and market led production. It is equally important for other market participants for trading. Recently, Govt. of India has launched Agricultural Marketing Information Network Scheme through Directorate of Marketing & Inspection (DMI) to bring out improvement in the present market information scenario by linking all agricultural produce wholesale markets in the States and Union Territories. The data received from markets is being displayed on the website **www.agmarknet.nic.in**.

The following are the important marketing channels existing in the marketing of sorghum

1) Producer—Wholesaler—Retailer--Consumer
2) Producer—Commission Agent—Wholesaler—Retailer—Consumer
3) Producer—Commission Agent—Wholesaler—Broker—Processor—Consumer
4) Producer—Retailer--Consumer
5) Producer—Consumer

There are many marketing channels involved in marketing of sorghum. The following are the criteria for the selection of efficient marketing channels:

- The channel, which ensures reasonable return to producer, is considered to be good or efficient
- Transportation cost in that channel
- Commission charges and market margins received by the intermediaries, such as trader, commission agent, wholesaler and retailer
- Financial resources
- The shorter channel with minimum market cost should be selected

Market extension is a vital factor enlightening the farmers about proper marketing, removal of marketing constraints and improves their awareness in various modern post harvest measures for efficient and cost effective marketability. Important benefits are:

- Provides the up-to-date information on the arrivals and prices of agricultural commodities in different markets
- Guides the producers to take right decision, when, where and how to market their produce

- Educate the producers/traders about the post harvest management i. e.
  - ★ Harvesting care
  - ★ Techniques to minimize losses during post harvest period.
  - ★ Value addition to the produce by proper cleaning, processing, packaging, storage and transportation
- Orient the producers/traders about prevailing price trends, demand and supply situation, etc.
- Orient the producer regarding the importance of grading, cooperative/group marketing, direct marketing, contract farming, future trading, etc.
- Provides the information about the sources of credit availability, various Govt. schemes, policies, rules and regulations, etc.

The following are the sources of marketing information available in the country.

Source / Institution	Activities for marketing information and extension
Directorate of Marketing and Inspection (DMI), NH-IV, CG Faridabad website www.agmarknet.nic.in	Provides information through nationwide Marketing Information Network (“AGMARKNET” portal). Marketing extension through training to educate producers, graders, consumers, etc. graders, consumers etc. Marketing research survey. Publication of reports, pamphlets, leaflets, Agricultural Marketing journal, Agmark standards, etc.
Central Warehousing Corporation (CWC), 4/1 Siri Opp. Siri fort, New Delhi-110016 Website www.fieo.com/cwc/	Farmers Extension Service Scheme (FESS) was launched by CWC in the year 1978-79 with the following objectives To educate farmers about the benefit of scientific storage and use of public warehouses. To impart training to the farmers on the techniques of scientific storage and preservation of foodgrains To assist farmers in getting loans from the banks against pledge of warehouse receipt. Demonstration of spraying and fumigation methods to control insects.

Source / Institution	Activities for marketing information and extension
Director General of Commercial Intelligence & Statistics (DGCIS), 1, Council House Street Kolkata -1	Collection, compilation and dissemination of marketing related data i.e. export import data, inter-state movement of foodgrains, etc.
Directorate of Economics and Statistics, Shastri Bhavan, New Delhi Website **www.agricoop.nic.in**	Compilation of agricultural data for development and planning. Dissemination of market intelligence through publication and internets
Agriculture Produce Marketing Committee (APMC)	Provides market information on arrivals, prevailing prices, despatches etc Provides market information of adjoining / other market committees. Arranges training, tours, exhibitions etc.
Federation of Indian Export Organizations (FIEO), PHQ House(3rd Floor) Opp. Asian Games, New Delhi-110016	Provides information to its members about latest developments in export and import. Organizes seminars, workshops, presentation, tours, buyer-seller meets, sponsoring participation in international trade fair, exhibitions and providing advisory services with specialized divisions. Provides useful information on India's export and import with diverse database.
State Agricultural Marketing Boards, At different State capital	Provides marketing related information to co-ordinate all the market committees in the state. Arrange training, seminars, workshops and exhibitions on subjects related to agricultural marketing.
Kisan Call Centers (New Delhi, Mumbai, Chennai, Kolkata, Hyderabad, Banglore, Chandigarh and Lucknow)	Provides expert advise to the farmers. These centers will operate through toll free telecam lines throughout the country. A country wide common four digit 1551 has been allocated to these centres

Source / Institution	Activities for marketing information and extension
Mass Media Support to Agriculture Extension	Mass media support to agriculture extension has been augmented with three new initiatives. The first component establishes a cable satellite channel for national broadcast using the existing facilities available with Indira Gandhi National Open University (IGNOU). The second component is use of low and high power transmitters of Doordarshan for providing areas specific telecast. Initially, 12 locations chosen to launch broadcasting are Jalpaiguri (West Bengal), Indore (Madhya Pradesh), Sambhalpur (Orissa), Shillong (Meghalaya), Hissar (Haryana), Muzzafarpur (Bihar), Dibrugarh (Assam), Varanasi (Uttar Pradesh), Vijaywada (Andhra Pradesh), Gulbarga (Gujarat), Daltonganj (Jharkhand). The third component of the mass media is use of FM transmitter network of All India Radio (AIR) to provide area specific broadcasting through 96 FM stations.
Agriculture-Clinics and Agri-Business by Agriculture Graduates	A central sector scheme “Establishment of Agriculture-Clinics and Agri-business Managed by Agriculture graduates” is being implemented since 2001-02. The aim is to provide opportunity to all eligible agriculture graduates, to support agriculture development through economically viable ventures. The scheme is being jointly implemented by NABARD, National Institute of Agricultural Extension Management (MANAGE) and Small Farmers’ Agri-business Consortium (SFAC) in association with about 66 reputed training institutes in the country.
Different websites on Agricultural Marketing Information	www.agmaknet.nic.in
	www.agricoop.nic.in
	www.fciweb.nic.in
	www.fieo.com/cwc/
	www.ncdc.nic.in
	www.apeda.com
	www.nic.in/eximpol
	www.fmc.gov.in

Source / Institution	Activities for marketing information and extension
	www.millets.res.in
	www.icar.org.in
	www.fao.org
	www.agrisurf.com
	www.agriculturalinformation.com
	www.agriwatch.com
	www.kisan.net
	www.agnic.org
	www.indiaagronet.com
	www.commodityindia.com

12. Major production constraints of rice fallows

A study to identify different factors responsible for sorghum cultivation in rice fallows was conducted by this institute in Guntur district in coastal Andhra Pradesh. It elicited response of farmers identifying the major constraints such as use of indiscriminate agro-chemicals including chemical fertilizers, poor crop management practices, biotic and abiotic stresses, lack of suitable methods of cultivation including quality seed of high yielding hybrids and integrated pest management, unawareness of value-addition and nutritional importance of sorghum fodder, poor linkage, with market, and government support price policies. Addressing these major constraints through appropriate interventions will pave way in remunerative sorghum production in long term and improving the well-being of sorghum farmers in the state.

Lack of improved hybrids and quality seeds: Sorghum hybrids specially suited for rice fallows for this region exclusively have not been developed, and therefore, among the available hybrids in the local market which have comparative advantage, are being grown. There is a shortage of quality seeds of public potential hybrids, compelling farmers to grow poor-yielding private hybrids.

Dense plant stand: Due to adequate availability of residual moisture, fertilizers after harvest of rice and highly fertile soil status, all 4-5 seeds dibbled in a one hole are grown healthy. However, plant stand needs to be standardized to maximize yield and optimum space for intercrop like, pulses.

Weed menace: Weeds are a serious problem under *utera* cropping as there is no land preparation. Hand weeding is a difficult proposition due to fast drying of soil surface. In many areas, cuscuta infestation is also associated with urdbean and mungbean (*Satyanarayana et al*., 1997). Use of pre-emergence plus post-emergence herbicides can be a feasible option under these conditions.

Indiscriminate use of fertilizers: In rice fallows, generally no manure or fertilizer is applied due to no-tillage practice under relay planting, and consequently the crops suffer due to nutrient stress. However, sorghum farmers in Guntur district of coastal Andhra Pradesh were applying higher dose of fertilizers in the range of 150-200 kg N, 75-80 kg P_2O_5 and 75 kg K_2O per ha. Typically no basal fertilizer was applied at the time of sowing but around 30 days after sowing (just before Ist irrigation), a mixture of 75-100 kg /ha N and 75-80 kg/ha P_2O_5 was side dressed to individual plant in rows manually. At 60 days after sowing (just before 2nd irrigation) 75-100 kg N and 75 kg K_2O /ha were applied.

Frequent cyclone: Being coastal area, frequent small cyclones and high wind velocity affects the crop heavily. The crop like sorghum can easily be lodged and infected by powdery diseases at the maturity. Therefore, the farmers were preferred medium height (2-2.5m height) and short duration hybrids to avoid the losses.

Prevalence of diseases: Powdery mildew is a serious disease of *rabi* planted urdbean mungbean and sorghum in coastal peninsula. In sorghum, grain mold and stem rot cause severe losses.

Delayed planting: In rice fallows, planting is dependent upon duration of rice varieties, release of water from Krishna river canal, withdrawal of monsoonal rains and soil moisture status which are highly variable. Delayed planting is often reduces crop yield.

Poor crop management: Late *rabi* crops in rice fallows is considered as bonus crop. In view of the risk involved in successful cultivation of second crop due to limiting soil moisture and likely shortage of irrigation water besides socio-economic problems, farmers do not pay much attention to crop management such as choice of appropriate potential public hybrids, seed rate, pest management, bio-fertilizers, foliar nutrition, mechanization etc.

Socio-economic constraints: Rice fallows are generally invaded by stray cattle, birds and wild animals like blue bulls, boars etc. Moreover, unawareness of value-addition, nutritional importance of sorghum fodder and poor linkage with market are also major problems which required community-based approach and policy support to overcome on them.

13. Future interventions in rice fallows

1. There is huge potential of sorghum cultivation in rice fallows. Evaluation of new sorghum hybrids of medium height to avoid loss from lodging need to be done in newer locations to identify and spread the most suitable and yield potential hybrid.
2. Seeds of the potential sorghum hybrids need to be put in seed channels for easy access to the farmers.
3. Concerns of rice followed by sorghum or maize cultivation in these areas in terms of soil health, need to be addressed by introducting intercropping with pulses.
4. Strategy for optimizing nutrient management need to be contemplated as fertilizer management is one of the important factors that continue to be a problem in high residue (zero-till) farming systems.
5. Awareness regarding nutrienal importance of sorghum fodder for animals over paddy straw is need to be created among the farmers . Strategies for alternate uses of fodder such as, raw material for paper as pulp or biogas generation, etc. have to be developed.
6. Concerted efforts should be initiated for dissemination of the promising sorghum production technologies, use of recommended fertilizers doses, etc. and its wider adoption..
7. Market extension has to play vital role for developing market intelligence, enlightening the farmers about proper marketing and their awareness in various modern post-harvest measures for efficient and cost effective marketability.
8. Awareness about preparation of the value-added sorghum products and its marketing need to be created among the farmers for sustainable cultivation of sorghum in rice-fallows.
9. Mechanization like, use of zero-till seed-drill, combine harvester, etc., need to be introduced to make sorghum production more cost-effective and overcome the labour problems.
10. Identification of suitable legume crop to fit in the crop system is very essential to maintain fertility of the soils in long term..

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