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Best Practices for Sorghum Cultivation and importance of value-addition

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Abstract

This reference book of the model training is a compilation of lectures delivered by the experts on latest aspects of sorghum development including millets on improved production technologies, crop management, preparation and value-added products, sweet sorghum, nutritional benefits, technology transfer and future implications. These apart, practical aspects of new process/methods, production and marketing were also covered. All the articles represented views of the respective contributors and they assume responsibility for any odd/advanced statements and opinions.

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13.Sorghum cultivation in rice-fallows: A new opportunity

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Sorghum is emerging as a potential alternative feed, fodder and bio-energy besides, food crop under changing climate scenario. However, the area under kharif sorghum cultivation is decreasing rapidly due to various reasons. The situation demands a search for potential niches for its cultivation in non-traditional areas. Sorghum cultivation in rice-fallows with an average productivity of 6.5 t /ha, which is the highest in the country, is a valuable opportunity. The farmers were commercially motivated and selected to grow sorghum instead of maize on residual moisture of rice-harvested field without tillage condition after comparing economic benefits. They preferred to grow hybrids which had high grain yield potential and medium height (2.0 to 2.5 m) to avoid losses from lodging. With advancement in use of modern agricultural practices, the farmers were applying high inputs like, fertilizers, weedicides, pesticides, irrigations labourers, and its skillful management in order to the crop response to their soils. The practices of farmers' innovative knowledge were identified, validated and documented in this manuscript.

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is emerging as a potential alternative feed, fodder and bio-energy crop apart from food grain. Moreover, its resilience to high temperature and moisture stress conditions makes it a climate-ready crop. There is a huge diversity in bio-physical and socio-economic environment in the sorghum cultivation of the country, and strong competition with cash crops in the present days. Therefore, the area under sorghum is decreasing rapidly from 18.6 m ha in 1970 to 7.06 m ha in 2010-11. However, sorghum cultivation in rice-fallows under zero-tillage condition is increasing in the Guntur district of Andhra Pradesh continuously since 2004 which is non-traditional area (Fig. 1). It is now grown in more than 24,000 ha area with an average productivity of 6.5 t/ha in 2010-11, which is the highest in the country (Fig. 2)[1]. Due to the latest adoption of the crop in this area, standard production practices for zero-till cultivation in rice-fallows are lacking. The farmers are adopting cultivation practices by using fertilizers and pesticides indiscriminately as per the crop response to their soils and their own wisdom[2]. Consequently, they are getting higher yield than any other sorghum situations in India. Practically, the sorghum growers in this area are inclined towards obtaining maximum monetary benefits from grain yields than other benefits.

Farmers' knowledge is the result of their own experience and response of the skillfully management of the available resources[3]. Though, the area is endow with rich natural resources in terms of fertile soils, moisture availability due to being coastal area, suitable temperature, sufficient sunlight, ecological conditions, possession of agricultural assets with the farmers and infrastructure facilities, most important is the farmers aggressiveness to adopt new ideas and tacit knowledge for efficient management. Obviously, their action is dependent on many factors like social, economical, physical, situational, cultural and market conditions, which regulates their decision making process to select new crop and its management on their own innovative ideas without scientific interventions[4]. Farmers-based innovative/indigenous knowledge has scientific rationale and great deal of relevance for agricultural productivity and sustainability. Such type of farmers' innovativeness and tacit knowledge to use high inputs to sorghum would be a path finder for the sorghum farmers to raise their profit margins in the different parts of the country. In contrast, knowledge, skill and strategy of farmers operating with their own ideas and tacit knowledge suitable to local situations have often been undermined in modern agriculture[5]. Therefore, the present investigation was carried out to identify and document farmers' innovative knowledge (FIK) used in sorghum farming in rice-fallows under zero-tillage conditions in achieving the highest productivity in the county. The study was conducted in seven villages namely, Athota, Kamathavaripalam, Dhanthuluru, Siripuram and Kunchavaram (Block-Kollipara), and Nandivelugu, and Ananthavaram (Block-Tenali) in the Guntur district of Andhra Pradesh which is coastal area (latitude $15^0$18'0" -16°50'0" N and 15°18'0" -16°50'0" E). The location was purposefully selected as the productivity of sorghum in the district was the highest (6.5 t/ha in 2011-12) in the country.

Motive behind selection of sorghum for cultivation in rice-fallows

Previously, rice-fallows-blackgram was the major cropping system in the coastal areas of A.P. where blackgram seeds were broadcasted in standing crop of rice (before rice harvest) to utilize the residual soil moisture. However, due to infestation of yellow mosaic virus (YMV) and parasitic weed, namely field dodder (*Cuscuta campestris)*, the productivity of blackgram declined considerably (Fig.3)[6] and the area has now been reduced drastically, which was the foremost reason to shift towards growing maize and sorghum in their area. Besides, due to the late receipt of monsoon and late release of water from the *Krishna* river now-a-days, transplanting of paddy crop is delayed and the crop is harvested in mid December. Sowing of blackgram in standing rice crop during late December leads to poor germination due to low temperature. 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 on land preparation, judicial use of seeds, limited irrigation water and weed management have shown positive change in attitude of farmers and farm functionaries[7]. 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/- per 100 kg) and maize (Rs. 1300/- 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 were occurred on sorghum than other crops. From the last 6-8 years, the farmers are taking sorghum after harvest of rice on the residual soil moisture without tilling the field. It is observed that there is good scope for increasing yield and profits by using standard cultivation technologies. They were cautious to gain maximum economic benefits by cultivating sorghum hybrids mainly for grain purpose.[8&9] Area under sorghum in this area is expected to increase in future due to the scarcity of irrigation water.

Innovative practices followed by the farmers

Being new area of sorghum in rice-fallows, there was no specific standardized practices of sorghum cultivation. The farmers were following the practices based-on their wisdom and crop response to the given inputs. Some of the practices being followed by the farmers are mentioned hereunder.

Cultivars used

The farmers were commercially motivated and not at all using sorghum for their consumption. They wisely prefer to grow hybrids with high yield potential and medium height (2.0 to 2.5 m) to avoid losses from lodging. They were not aware about high yielding sorghum hybrids of public sector and were growing locally available private hybrids namely, Haritha, NH 27, Kaveri 6363 and Mahalaxmi 296. The Mahalaxmi 296 was ruling hybrid in the rice-fallows area[8]. If they find a hybrid which gives higher yield than the existing one, they are ready to adopt it in their fields.

Method of sowing, spacing and seed rate

Sowing of crops 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 C contents, and increased soil biological activity[10]. The researchers recorded 25% higher grain yield in no tillage than reduced tillage and 98% greater than conventional tillage[11]. In this area, after the harvest of *kharif* transplanted rice, sorghum was sown in second fortnight of December under zero-tillage on the residual soil moisture. Sowing was 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. Making holes manually in line with the help of labourers without tilling the rice-harvested fields that is under zero-till conditions for sowing is however, time consuming and costly. Some farmers have designed manually operated small implement with wheel, which makes the holes in two rows at a time and is easy to operate in the field (Fig. 4). With taking advantage of high inputs and fertility of the soils, the farmers allow to grow 3-4 plant at each hill and plant density became higher (> 200000 per ha) than the normal cultivation as advocated for irrigated post-rainy (*rabi*) sorghum (180000 per ha). In view to high wages and shortage of labourers, mechanization like, use of zero-till seed-drill, combine harvester, etc., is essential to make sorghum production more cost-effective. A few active farmers are making efforts to fabricate a suitable tractor-driven holes making implement to overcome problem of labourers, out of their own interest (Fig. 5).

Nutrient management

As per recommended dose of fertilizers for traditional sorghum under irrigated condition requires 80-100 kg nitrogen, 40-50 kg phosphorus, and 40-50 potash /ha. Half quantity of the nitrogen and full amount of phosphorus and potash should be given at sowing and remaining nitrogen at 30-45 days after sowing. However, in rice-fallows, the farmers were applying higher dose of fertilizers (150-200 kg N, 75-80 kg P_2O_5 and 75 kg K_2O per ha). Being a zero-till manually sown crop, no nutrient was applied at the time of sowing. At 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 with the help of labourers (Fig.6). At 60 days after sowing (just before 2nd irrigation) 75-100 kg N and 75 kg K_2O /ha were applied. Though, the farmers were obtaining high yields with higher dose of nutrients, the nutrient-use efficiency was overlooked as phosphorus and potassium fertilizers were applied as top-dressing. This point attracts attention of the researchers to understand the nutrient dynamics in rice-fallow sorghum cropping system as a whole, so that profit margin of the farmers could be enhanced.

Weed management

Weeds including grassy and broadleaf were the major problem in rice-fallows in zero-tillage. They emerged even before the crop sowing and compete with the crop for resources. Grassy weeds especially *Echinochloa* spp. were the major weeds infesting the crop. Some of the weeds already existed in rice-harvested field while sowing of sorghum and some were emerging after sowing. Therefore, two types of weedicides; pre-emergence and post-emergence were much useful under the situation. The farmers wisely used both, tank mixed application of paraquat + atrazine (1.0+0.5 kg/ha) 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). This practice is very important to maintain the crop healthy and overcoming the labour problem which was followed by the farmers timely and carefully.

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 furodon 3G granules (@10-12 kg per ha) in leaf whorls of individual plant with the help of labourers after 30-35 days of sowing (Fig. 8).

Irrigation management

Scarcity of irrigation water due to very limited or no release of water from the *Krishna* river and late receipt of monsoon, were among the major reasons to increase in sorghum area in this region. Sorghum in rice-fallows was grown on residual moisture, which supports the crop growth for germination and early establishment. Lower initial soil moisture sometimes results in poor plant population. Two irrigations are sufficient to harvest good yield whereas, maize is required four irrigations and more inputs. The farmers were judiciously using available water by giving first irrigation at 30 days after sowing (DAS) and 2^{nd} at 60 DAS. These two irrigations are sufficient to obtain good yield in that area. Irrigation frequency was also depends on the seasonal rains. They were receiving frequent rains with high wind velocity, which also supports to meet water requirements of the crop.

Harvesting and threshing

In the coastal areas, there is frequent occurrence of heavy rains and strong winds in March and April due to low pressure in sea resulting in severe damage of crop. Therefore, the farmers harvested the crop with the help of labourers at early maturity stage (105-110 days) to avoid losses from cyclonic rains and diseases. After harvest, the panicles were sundried for a week and thereafter the grains are separated by manual or mechanical threshing. On an average, the farmers obtaining grain yield of 6.5 t/ha, however, some farmers were getting up to 7.5 t/ha in this area. The higher grain yield than the normal sorghum productivity was may be due to more number of plants per unit area, timely use of high inputs and intelligent crop management done by the farmers (Fig. 9). Thus, they were able to earn gross returns of Rs. 78,000/- per ha (with an average market price @Rs.1200/- per 100 kg) excluding fodder price. All the farmers sold the produced grains in the local markets after harvest. The highest fodder yield was also recorded (12-15 t/ha). The high bio-mass was produced due to more plant populations and plant height. However, the farmers were burning fodder in their field itself due to lack of knowledge about its nutritional importance, and sufficient availability of grasses and paddy straw in this area [12]. Awareness regarding nutritional importance of sorghum fodder for animals over paddy straw marketing fodder in its deficit areas by building market linkage, would be additional source of their income. It indicated huge potential for increasing sorghum productivity in rice-fallows. The Directorate of Sorghum Research (DSR) has recently taken initiatives to standardize the crop production technologies for this area.

Summary

In rice-fallows of coastal Andhra Pradesh, sorghum cultivation was found to be high yield potential with labour and inputs intensive crop system. It is found that use of high inputs *viz.*, pesticides, weedicides, fertilizers, labourers, and skillful management of all the innovative practices including irrigations, were resulted into the high yield. It is implied that the farmers were highly profit oriented and obtained high returns from the sorghum cultivation. Continuously, rice followed by sorghum or maize cultivation in this area would deteriorate the soil health in long term. Another issues, proper utilization of stover as fodder and marketing of this bio-mass by making bio-fortified fodder blocks through value addition in deficit areas to prevent the present practice of fodder burning or incorporating in the soil, are needs to address through scientific interventions. Their profit margin could be further increased by mechanization and introducing standard package of practices. Keeping the yield benefits in view, the farmers innovative knowledge should be validated on their fields to develop standardize location-specific production technologies so that the productivity and soil health will sustain in long run. These innovative farmers would be able to educate and transfer the viable technologies more effectively among the other sorghum growers in rice-fallows as change agents.

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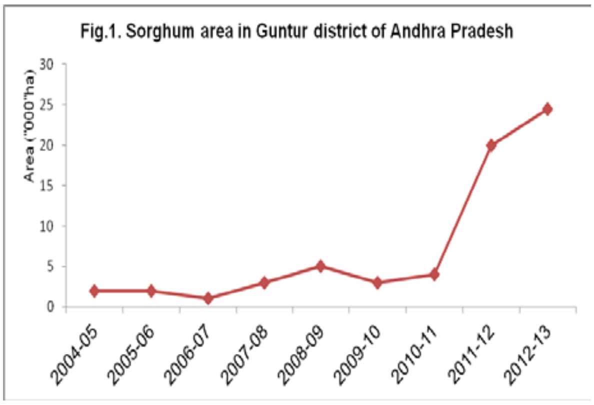

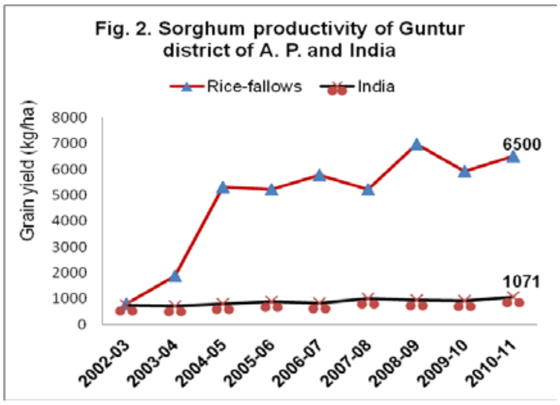

Fig.3 Blackgram in rice-fallows is infested with YVM disease and weeds

Fig. 4. Sowing of sorghum in rice-fallows

Fig. 5. Tractor-drawn hole making implement for sowing

Fig. 6. Fertilizers application to sorghum at 30-35 days

Fig. 7. Sorghum infestated with grassy weeds (left) and treated with weedicides, atrazine + paraquat (0.50+1.0 kg/ha) (right)

Fig. 8. Furadon application in leaf whorl at 30-35 day after sowing

Fig. 9. A field view of sorghum in rice-fallows at maturity