Project Title: **Feed production from sweet sorghum residues after extraction of juice for ethanol**
Project Type: Research Proposal Development /Seed Grant/
Lead Center: ICRISAT
Lead Principal Investigator: Dr. Belum VS Reddy
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Activity	Individual(s) responsible	Activity description	Due date	Follow up (status, date)
1.1	P Parthasarathy Rao, Venku Reddy, Heraldo Layaoen	GIS will be used for overlaying areas of potential sorghum production, existing and planned distilleries, livestock populations and feed demand to map demand-domains for sweet sorghum according to production emphasis that is the preferred traits for example grain or ethanol or fodder.	June-07	Database is assembled and necessary analysis is being carried out
2.1	BVS Reddy, A Ashok Kumar	Data on sweet sorghum varieties and hybrids will be pooled and drafted from International Crops Research Institute for the Semi-arid Tropics, Patancheru, India; National research Centre for Sorghum, Rajendranagar, India; Hybrid Seed consortium, India.	July-07	Sweet sorghum is one of the most efficient dryland crops for converting atmospheric CO2 into sugar. This makes it a promising feedstock for ethanol production. The sugar rich juice obtained from the stalks of sweet sorghum is used for ethanol production. It can be grown throughout the year with minimum water supply. In addition, it is a seed-propagated short-duration crop with hybrid technology in place that can be grown well in a variety of environments both under rainfed and irrigated situations. Compared to the sugarcane or maize, the two major feedstocks used for ethanol production globally, ethanol production from sweet sorghum is cheaper, quicker and poses little risk to the environment. The biggest advantage with sweet sorghum is that the food/feed value of grain need not be compromised for the sake of ethanol production, unlike when maize is used for this purpose. The cane for juice extraction, the grain for human food and the bagasse and the leaves for livestock feed are three economic products that come from sweet sorghum and therefore the farmers get more

				income from sweet sorghum cultivation than from grain sorghum (Reddy et al 2005). Each potential distillery would have a capacity of producing 40,000 liters of ethanol per day from about 25 ha of sorghum, i.e. pertaining to a total area of about 3,200 ha for a crop cycle of 120 days. This provides a tremendous market opportunity for smallholder sorghum farmers. The Livestock producers will benefit through increased supply of feed in the forms of bagasse and leaves. Thus, the sweet sorghum cultivation contributes to improving livelihoods of sorghum growers, the mixed crop-livestock farming community, and fuel consumers while sustaining the environment. An analysis of comparison of income from sweet sorghum compared to that from grain sorghum showed that the farmers can generate on average US$ 79 additional income per year per hectare (over two seasons) from sweet sorghum cultivation when compared to that from grain sorghum (Table 1). To produce the target of 35-40 KLPD of ethanol, the unit requires 800-875 tons of sweet sorghum stalks per day. This will require about 2400 ha area in rainy season and 4000 ha area in the postrainy season to supply stalks for over 105 days in each season thereby, engaging about 3200 small-scale farmers (approximately 2 ha holding size) (Table 2). Sweet sorghum is the cheapest and environmentally safe feed stock compared to the sugar cane or maize the major feed stocks globally at present(Table 3). According to the Rusni Distilleries (P) Ltd., the present sale price is about US$ 0.5 to US$ 0.57 which can fetch a profit of about US$ 5000 per day (@ US$ 0.15 liter-1). Considerable progress has been made in breeding for improved sweet sorghum lines with higher millable cane and juice yields in India. A few of these cultivars have been released, for example SSV 84, SSV 74 and NSSH 104. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) located at Patancheru in Andhra Pradesh, India, has developed several improved lines with high stalk sugar content and a few of these lines are being tested in pilot studies for sweet sorghum-based ethanol production in India, the Philippines and Uganda. One of the partnership varieties NTJ 2 is very promising and is currently used by Rusni distilleries for ethanol production. During the rainy season 2006-07 nine farmers belonging to different villages

				have grown NTJ 2 under both black soils and red soils. The fresh stalk yields of NTJ 2 in farmers fields ranged from 7.0 t ha -1 to 26.3 t ha-1 where as the dry stalk yield ranged from 2.9 t ha -1 to 10.9 t ha-1. The range for dry matter percentage was from 30.4 to 47.1. The bagasse (crushed stalks of NTJ 2) obtained from Rusni distilleries are made in to feed blocks and the in vitro digestibility studies are in progress at ILRI (Patancheru). During the rainy season 2007 a total of 2000 acres is sown with sweet sorghum (NTJ 2 variety). Currently the harvesting and crushing is in progress.
2.2	BVS Reddy, A Ashok Kumar, P Parthasarathy Rao, Venku reddy, Heraldo Layaoen	Based on agro-ecological zones and likely demand priorities for grain, ethanol or fodder, the inventory will be used for the development of best bet options of sweet sorghum cultivars	August-07	Compilation of best bet practices from various experiments is in progress.
3.1	Michael Blummel, AR Palanisamy, SM Karuppanchetty	Relationships between morphological, chemical and in vitro laboratory traits of unprocessed and processed (bricketed and pelleted) bagasse and stover leaf will be investigated in sweet sorghum cultivars currently used by Rusni Distillery, India, using the feed processing facilities of Sri Venkateshwara Veterinary University, Hyderabad, India and of ICRISAT-Agro-Business Incubator and ILRI animal experimental facilities at ICRISAT. Required inputs (power and	August-07	As a first step towards the development of a full fledged research proposal on “Feed production from sweet sorghum residues after extraction of juice for ethanol” the sweet sorghum bagasse was compared with normal stover in the commercial blocks for daily intake and weight gain in ruminants. Daily intake and weight gain studies on sweet sorghum: Comparison of commercial feed blocks (normal sorghum stover + concentrates, 50:50 by weight) with bagasse block (normal sorghum replaced by bagasse while the concentrates remained the same) and sorghum stover alone showed no significant differences in intake and body weight gain between bagasse block and commercial feed block (Table 4). The results have clearly indicated that sweet sorghum bagasse after extraction of the juice can be used as animal feed without any reduction in daily intake or weight gain. This will pave way for the

		machinery) into feed processing will be evaluated together with the feed quality assessments.		effective whole plant utilization of sweet sorghum. It is a normal practice that the distilleries purchase sweet sorghum stalks from farmers for ethanol production and bagasse after extraction of the juice is used for cogeneration in the process. The project envisages establishment of decentralized crushing units in the villages/clusters so that the bagasse will be left with the farmers which he can directly use as animal feed or can sell to a feed manufacturer for additional revenue.
4.1	BVS Reddy, A Ashok Kumar, AR Palanisamy, SM Karuppanchetty	Recommendations for appropriate processing and conversion of distillery residues into marketable feedstuff available	October-07	A consistent interest of all distilleries is the possibility of using the leaf and sheath strippings and the residues (bagasse) from the stems after extraction of juice for ethanol for livestock feed, since feed shortages are severe in all three countries. In preliminary work (ICRISAT 2004, Seetharama et al 2006), we investigated 25 fodder sorghum cultivars including sweet sorghum developed by ICRISAT and 37 cultivars (19 varieties and 18 hybrids) of sweet sorghum developed by the National Research Center for Sorghum (NRCS) and ICRISAT through conventional breeding methods, large genotypic variability for grain yields, stover yields, bagasse yields and potentially fodder yield (bagasse plus stripped stover leaves) and fodder nutritional quality were found. For example, bagasse plus leaf residues ranged from 4.5 to 8.1 t/ha (mean 6.6 t/ha) in the varieties and from 3.8 to 7.9 t/ha (mean 5.8 t/ha) in the hybrids. In the varieties in vitro digestibility ranged from 42 to 50.4 % (mean 46.6%) and in hybrids from 39.3 to 49.1% (mean 44.6%). Sorghum stover, the residue after harvest of grain - is intensively traded in India. The yearly mean stover prices ranges from 3 Indian Rupees per kg of dry residue (Blümmel and Parthasarathy, 2006). The bagasse can also be traded in these lines that help mitigate the fodder shortages and increase the net returns from sweet sorghum cultivation. Recent studies on in vitro digestibility of sorghum varieties /hybrids developed at ICRISAT and NRCS (AICSIP), India indicated significant genetic difference among the genotypes.

5.1	BVS Reddy, A Ashok Kumar, AR Palanisamy, SM Karuppanchetty, Venku reddy, Heraldo Layaoen	Data obtained from activities 1 to 4 compiled and a full detailed project document on Feed production from sweet sorghum residues after extraction of juice for ethanol developed	December-07	Organized an international workshop on 'Feed production from sweet sorghum bagasse' at ICRISAT, Patancheru from 17 – 19 September, 2007. A total of 13 scientists from SVVU, Hyderabad, India (2), MMSU, Batac, the Philippines (1), NIAN and P, Banglore, India (1), Miracle feeds and fodder, Shamshabad, India (2), Rusni industries, Sanga Reddy, India (1), BAIF, Mahaboobnagar, India (1), ICRISAT-Patnacheru, India (4) and ILRI at ICRISAT (1) participated. In consultation with all the participants a concept note was developed and submitted for funding by the Asian Development Bank (Annexure 1).