of fertile plants were observed in the self-pollinated progeny of this selection (Table 2). In 2002, which was also characterized by strict drought during microsporogenesis, the percentage of fertile plants in this selection was 80%; its testcross populations with [M35]Pishchevoye-614 were also characterized by high level of male fertility.

Thus, as a result *of* genetic recombination and subsequent selection at regime of drought during microsporogenesis we could create reliable lines-fertility restorers capable for restoration of male fertility of the F_1 hybrids in the M35 cytoplasm under conditions of moisture deficiency.

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Sweet Sorghum: Characteristics and Potential

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Introduction

Sweet sorghum *(Sorghum bicolor)* is similar to common grain sorghum with a sugar-rich stalk. Sweet sorghum is characterized by wide adaptability, drought resistance, waterlogging tolerance, saline-alkali tolerance, rapid growth, high sugar accumulation, and biomass. Lengthy growing period and high water requirement are the disadvantages in sugarcane (*Saccharum officinarum*) and sugarbeet *(Beta vulgaris),* the main sources of sugar production in the world. These factors along with the comparative disadvantage of molasses (higher price, and water and air pollution) are expected to increase the interest in sweet sorghum. The water requirement of sugarcane is about 36000 m^3, which is double that of sugarbeet while that of sweet sorghum, due to its extensive root system and short growing period, is about 8000 m^3 (Soltani and Almodares 1994). Variability has been recorded in sweet sorghum for grain yield from 1.5 to 7.5 t ha^{-1}, for brix ranging from 13 to 24%, for sucrose from 7.2% to 15.5%, for stalk yield from 24 to 120 t ha^{-1} and for biomass yield from 36 to 140 t ha^{-1} (Almodares et al. 1997). Sweet sorghum has a biomass production capacity equal or superior to sugarcane in the tropics (Monk et al. 1984). Alcohol is produced at 6106 L ha^{-1} from sweet sorghum while only 4680 L ha^{-1} from sugarcane is produced. There are several advantages of using sweet sorghum instead of sugarcane for alcohol production. These are: sweet sorghum is harvested in four months (whereas, the first cut of sugarcane is 18 months after planting); sweet sorghum production can be completely mechanized; the crop can be established from seed; the grain may be used as either food or feed; the stillage from sweet sorghum has a higher biological value than the bagasse from sugarcane when used as forage for animals. Stillage obtained after extraction of juice from the stalks of sweet sorghum contains similar levels of cellulose as sugarcane bagasse; therefore, it has a good prospect as a raw material for pulp product. It could be processed as a feed for ruminant animals (Sumantri and Edi Purnomo 1997). Furthermore, it is rich in micronutrients and minerals (Seetharama et al. 2002). Singh and Singh (1986) reported that jaggery prepared from sweet sorghum juice contained 78.1% sucrose and 8.8% reducing sugars while that from sugarcane contained 84.2% sucrose and 7.5% reducing sugars. They also reported that starch in sweet sorghum juice, a major problem for sugar production, can be removed up to 93.7% with the use of flocculent truefloc S-3 (500 ppm) and by heating the juice to 55°C and adjusting its pH to 8.5. The quality of sorghum juice, sugarcane juice, and the mixed juice is given in Table 1. Cultivation of sweet sorghum will only lead to value addition and a shift in utilization and it will not hamper the grain (from panicle similar to grain sorghum) production.

Table 1. Comparative quality of juice of sweet sorghum and sugarcane[1].

Sample	Brix (%)	Purity (%)	Reducing sugar (% brix)	Starch (pprn)	Ash (%)
Sorghum juice	18.45	77.3	8.71	1685	1.26
Sugarcane juice	20.21	82.4	5.22	251	0.46
Mixed juice[2]	19.30	79.3	7.14	363	0.72

1. Adapted from Edi Purnomo and Sumantri (1997).
2. Sorghum juice and sugarcane juice mixed in the ratio of 1:5.

Programs

ICRISAT has initiated research, though limited, taking the future needs into consideration. Several programs (listed below) arc being taken up to accelerate the cultivation of sweet sorghum. Research in sweet sorghum is being carried out in several parts of the world lor different objectives as listed below:

ICRISAT:

- Development of ratoon and multicut high biomass yielding sweet sorghum lines.
- Development of ratoon and multicut dual purpose sweet sorghum lines.
- Development of ratoon and multicut sweet sorghum hybrid parental lines.

Worldwide programs:

- Breeding on grain and stalk, yield and quality characters of sweet sorghum (Romania, India, China, Indonesia, Greece, southern Italy, southern Spain, Pakistan, Argentina, Australia, Hungary, Zimbabwe).
- Exploitation of sweet sorghum in fodder sorghum breeding (China, Europe, India, Italy, Hungary).
- Studies on the effects of feeding sweet sorghum to livestock (China, India, Japan).
- Standardization of processing techniques for end products (India, China, Indonesia, Romania, Italy, Zambia, Egypt, France, Iran, London).
- Identification of cultivars desirable for development of end products (India, China, Italy, Ukraine).

Two major problems that occur during sweet sorghum production are the crop's sensitivity to chill and lodging of plants when mature. Ravi et al. (1997) reported that intermating sweet sorghum with grain sorghum having high stalk sugar content and stay green trait is likely to improve the grain productivity without affecting stalk sugar content. Sorghum stalks are ideal for ethanol production, as the ethanol from sorghum is significantly cleaner than that from sugarcane. Potable alcohol can also be produced from mold affected rainy season sorghum grain (Seetharama et al. 2002).

Products

The reasons for decline in the area under grain sorghum are: (1) progressively reducing per capita consumption of sorghum; and (2) absence of alternate demand for grain. Sweet sorghum is a multipurpose crop. Apart from grain and fodder, several alternate products such as forage/silage, syrup, jaggery, alcohol, fuel for bioenergy production, sugar, wine, vinegar, pulp and paper, sweetener and natural pigments (dark red color) can be made. Thus, it can create demand through value addition to the sorghum crop.

Potential

Sweet sorghum can produce from a single crop 3 t ha^{-1} grain, 2.03 t ha^{-1} sugar, white spirit (65% alcohol) 1.605 t ha^{-1} and vinegar 11.741 ha^{-1} (Liu Guifeng et al. 1997). Net income from sorghum is 38% higher than sugarbeet (Almodares and Sepahi 1997). Other products reported from sweet sorghum are:

Alcohol: 45.4 L of alcohol from one t of chopped stalk, 42.1 L from one t of shredded stalk, and 39.6 L from one t of juice extracted before fermentation is obtained (Charlie et al. 1983) or 2760 L ha^{-1} (Ravi et al. 1997). Somani and Pandrangi (1993) reported that 384 L of ethanol can be produced from one t of sorghum.

Sugar: 3.8 to 5.9 t ha^{-1}(Cosentino et al. 1997).

Biomass: 56.24 to 65.24 t ha^{-1} (Jingshan et al. 1997).

Wine: One hectare of sweet sorghum produces 3.24 t of malt sugar obtained after extracting crystal sugar, which produces 1.61 t of spirit (Liu Guifeng et al. 1997).

Vinegar: After refining sugar obtained from one ha of sweet sorghum, the remaining waste can be used to produce 1.74 t of vinegar (Liu Guifeng et al. 1997).

Silage: The effect of silage made of sweet sorghum is better than maize (*Zea mays):* 17.85 t ha^{-1} of silage is obtained. The output of milk is 65% more with a saving of 7% green forage compared to maize (Bolin 1997).

Energy production: Cultivation of approximately 250 ha of sweet sorghum would result in 500 kW_{el} power production (Chiaramonti and Taviani 1997).

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Grain Yield and Stover Fodder Value Relations in *Rabi* Sorghum

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Introduction

Both sorghum *{Sorghum bicolor)* grain and stover contribute to livelihoods of poor in India (Hall and Yogand 2000). Stover utilization as fodder can provide for up to 50% of the income from cropping (Rama Devi et al. 2000). In response to farmers' demand for sorghum stover with high fodder value new sorghum improvement programs aim at integrating stover value as an additional trait into sorghum breeding and selection. The success of this multidimensional sorghum improvement depends on two essential conditions: (1) genotypic variability for stover yield and quality is high enough to positively impact on on-farm fodder resources; and (2) relations between desirable traits, for example, grain yield and stover value (yield and quality) are clarified and traits are not, or at least not overly, competitive. These two conditions were found to hold widely true in sorghum grown in the rainy (*knarif*) season in India (Bliimmel et al. 2003) but little information is available about sorghum types grown under the more harsh conditions in the postrainy *(rabi)* season. This work investigates relationship