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In this issue...

RSV 1006: A high yielding dual purpose rabi variety for irrigated condition

The rabi sorghum variety RSV 1006 derived from the cross CSV 216 x SPV 1502 has high grain and fodder yield potential. It is a medium tall variety (225 cm height) suitable for irrigated condition and matures in 120 days. It is tolerant to shoot fly and charcoal rot. In the Maharashtra state multi-locational trials, the grain yield of RSV 1006 was 4.9 t/ha, higher than that of national check CSV 18 (3.5 t/ha) and local check Phule Yashoda (3.7 t/ha).

It also recorded higher fodder yield (12.2 t/ha) as compared to

RSV 1006: Dual purpose rabi variety for irrigated cultivation

सारांश

सिंचित अवस्था हेतु उच्च पैदावार युक्त द्विउद्देश्य रबी क़िस्म : आर एस वी 1006 सिंचित अवस्था में उच्च खाद्यान्न तथा चारा पैदावार युक्त रबी ज्वार क़िस्म है। महाराष्ट्र में बहु-स्थानीक परीक्षणों के अन्तर्गत राष्ट्रीय व राज्य स्तर के चैकों की अपेक्षा आर एस वी 1006 में खाद्यान्न व चारा पैदावार अधिक थी। यह आशा की जाती है की यह सिंचित खेती हेतु महाराष्ट्र के कृषकों में लोकप्रियता प्राप्त करेगी।

ज्वार जीनोटाइपों के गुंधे आटे व रोटी की गुणवत्ता : चार स्वतंत्र विश्लेषण के आधार पर तुलनात्मक अध्ययन दर्शाता है कि हाल ही में रबी खेती हेतु लोकार्पित लाइनों के साथ कई उन्नत प्रजनन लाइनें, उच्च खाद्यान्न पैदावार के साथ, चारा पैदावार व गुणवत्ता हेतु समझौता किए बिना रोटी की गुणवत्ता में एम 25-1 से श्रेष्ठ थीं।

बाजार में चयनित रबी कृषि जोपजातियों का मूल्य विश्लेषण : एम 35-1 किस्म, बाजार में अत्यधिक लोकप्रिय श्रेणी में आती है तथा इससे उच्चतम मूल्य प्राप्त होता है। यद्यपि डी एस वी-5 तथा सी एस वी-18 से एम 35-1 की अपेक्षा थोड़ा ज्यादा मूल्य प्राप्त होता है, जो कृषकों के उच्च लाभार्थ, बडे पैमाने पर कृषि हेतु इन क़िस्मों के प्रसार किए जा सकने की संभावनाओं की ओर संकेत करता है।

रबी ज्वार पैदावार के पूर्वानुमान हेतु फसल पैदावार-मौसम प्रतिमानः फसल पैदावार-मौसम प्रतिमान का विकास करके, महाराष्ट्र के सोलापुर ज़िले हेतु रबी ज्वार की पैदावार को प्रभावित करने वाले महत्वपूर्ण मौसम प्राचलों (पैरामीटरों) का पता लगाने के लिए प्रयास किया गया। वर्ष 1990 से 2005 के फसल-मौसम आँकड़ों के आधार पर इस प्रतिमान की स्थापना की गई। इस प्रतिमान के आधार पर 2004-05 तथा 2005-06 हेतु रबी ज्वार पैदावार के संबंध में किए गए पूर्वानुमान में 55% सत्यता पाई गई।

ज्वार उन्नति हेतु अंतर विशेष संकरण : अंतर विशेष संकरण के कार्यान्वयन तथा तद्नंतर उससे आए आनुवंशिक परिवर्तन, फसल पैदावार बढ़ाने की अधिकतम सीमा को पीछे छोड़ सकते हैं। एस. बाईकलर के उपयोग के द्वारा जंगली प्रजातियों के उपयोगर्थ पराग-जायांग असंगति को दूर किया गया, जिससे पराग नलिकाओं व विदेशी ज्वार प्रजातियों की वृद्धि हो सकेगी। एस. बाईकलर के वर्तिकाग्र पर कुछ जंगली प्रजातियों के पराग-प्रकीर्णन (डस्टींग) के बाद संकर प्राप्त किए गए।

ज्वार में पौध ओज विशेषकों व आनुवंशिक परिवर्तन के मध्य अंतर संबंध : बारानी फसल प्रणाली में कृषि जोपजातियों में उच्च पौध ओज खड़ी फसल हेतु लाभदायक है। 296 बी तथा आई एस 18551 के संकरण से निर्मित पुनर्योगज अंतःप्रजात क्रमों (रिकांबिनेंट इनब्रेड लाईनों) की पौध-ओज विशेषताओं में आनुवंशिक भिन्नताओं व समानताओं का पता लगाने हेतु अध्ययन किया गया।

दसवीं योजना के अंतर्गत ज्वार प्रजनक बीज प्रणाली : रा.ज्वा.अनु.कें. में दसवीं योजना के अंतर्गत प्रजनक बीजों के उत्पादन, शुद्धता परीक्षण, भंडारण एवं वितरण के सुचारु संचालन हेतु बीज प्रणाली विकसित की गई। कृषि एवं सहकारिता विभाग की माँगों को पूरा करने तथा भा.कृ.अनु.प. मानदंडों के अनुसार बीज उद्योगों को आनुवंशिक रूप से शुद्ध बीज सामग्री प्रदान करने हेतु प्रजनक बीज कार्यक्रम की विभिन्न गतिविधियाँ कार्यरत है।

जैवीक नाइट्रीकरण नियंत्रण के द्वारा ग्रीन हाउस गैसों के उत्सर्जन में कमी हेतु ज्वार : बारानी फसलें, जैसे ज्वार में नाइट्रोजन के उपयोग की दक्षता तथा वसूली बढ़ाने में, नाइट्रोजन की क्षति को कम करने हेतु नाइट्रीकरण का नियमन एक प्रमुख नीति हो सकती है। हाल ही में कई फसलों में जैवीक नाइट्रीकरण नियंत्रण क्षमता हेतु किए गए अध्ययन दर्शाते हैं कि यह क्षमता ज्वार में अत्यधिक है।

Performance of RSV 1006 in Maharashtra state multilocation trials (2006-07 and 2007-08)

Yield trait	Cultivar	Grain yield (ton/ha)	% increase over
Grain yield (Q/ha)	RSV 1006	4.9	-
	CSV 18	3.5	39.2
	Phule Yashoda	3.7	32.5
Fodder yield (t/ha)	RSV 1006	12.2	-
	CSV 18	11.3	7.8
	Phule Yashoda	10.2	19.3

both checks. Due to its high yield potential, suitability for irrigated conditions and tolerance to shoot fly and charcoal rot, RSV 1006 is expected to gain popularity amongst the farmers of Maharashtra who possess irrigation facilities.

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Dough and roti making qualities of sorghum genotypes

Sorghum is a staple cereal in many parts of the country. Though sorghum grains are nutritious, the consumption of this cereal is decreasing due to the popularity and easy availability of (read "highly subsidized"), and convenience for preparing foods from fine cereals. The other major reasons are: dying food habits related to traditional, especially rural foods, requirement of special skill for preparing sorghum rotis (unleavened pancake) and non-availability of ready-made flour and suji from sorghum in the market. There is a need to popularize sorghum foods. Sorghum with its rich fibre and low starch digestibility makes an ideal food for diabetic and obese population especially in the urban areas. Usually sorghums with pearly white or yellow bold grain types are preferred for roti preparation. Pericarp colour, endosperm type, and endosperm texture have significant effects on roti quality. Corneous grains, in general, exhibit higher density and breaking strength, lower percentages of water absorption, and better dough and roti quality (Murthy et al, 1981).

In India, sorghum is traditionally consumed in the form of roti (bhakri). For many years, sorghum eating population particularly those in rabi growing areas who often believe that cultivars bred in recent times were generally rated as low for roti quality, thereby fetching lower price in market. The roti made from Maldandi types such as that from M35-1 is widely believed as the best for taste and softness; we used results from four independent studies made on the dough and roti quality of sorghum genotypes to find out how elite cultivars differ from M 35-1 for dough and roti making qualities. These independent studies included following

I. ICRISAT study, 1981, genotypes tested, n = 15 (Murthy and Subramanian, 1981)

II. ICRISAT study, 1981 genotypes tested, n = 25 (Murthy et al, 1981)

III. NRCS study 2006-07 genotypes tested, n = 38 (Ratnavathi and Kamatar, 2006-07)

IV. MPKV, Rahuri study 2007-08 genotypes tested, n = 15 (Chavan et al, 2007-08).

Taste panels consisting of 5-15 members trained for tasting and scoring rotis was used for the assessment of roti quality in all the four studies.

Dough quality: For the preparation of roti, the quality of the dough is very important. The dough quality was assessed by 1) water required for dough preparation, 2) kneading quality (scored on a scale of 1-3; 1 = poor, 2 = medium, 3 = very good), 3) time required for baking, 4) rolling quality (diameter of the roti that is expanded with an equal amount of flour), 5) diameter of the roti after baking and 6) Percent moisture retained in the roti.

The dough quality of genotypes was compared in three studies (I, II, III) in which most genotypes in each study varied. Some genotypes were similar in all the studies and M 35-1 is the check genotype used for above dough characteristics. The three parameters (water requirement, rolling quality and kneading quality) were common in all the three studies (ICRISAT and NRCS).

The water required to make dough in M 35-1 (control) was 26.2 ml/30g in study- II; 30ml/30g in study III; the overall range observed in four studies was 22.8- 32.8 ml/30g flour. The studies showed that 36 out of 77 genotypes studied were superior to M 35-1 for the water requirement. IS 12611 (study I), Dobbs (study II), and SPV 1766 (study III) were the genotypes which had highest water requirement for dough preparation. The rolling quality ranged from 17.0 to 25.5 cm, and 29 genotypes out of 77 were superior to M 35-1for this parameter. The rolling quality of the genotypes CSH 8 (study I), IS 158 (study II), and SPV 1762 and SPV1766 was highest among the 29 genotypes. The kneading quality ranged from 1.0-3.0 and 31 genotypes were found to be superior to M 35-1 (Table-2). CSH 8, CSH 6, IS 7943, IS 12611, M 36082, PJ 33 K , IS 11024 (study II), and E 35-1, Swarna, S 29, S 13, IS 2317 (study II) have showed kneading

Jowar roti

Comparison of quality parameters of sorghum dough and roti

Parameter	ICRISAT 1981[1]			ICRISAT 1981[2]			AICSIP (Rabi) 06-07[3]			AICSIP (Kharif) 07-08[4]		
	n=15			n=25			(n =37)			n= 15		
	Dough quality											
Parameter	Max.	Min.	M35-1	Max.	Min.	M35-1	Max.	Min.	M35-1	Max.	Min.	Local check
Water requirement (ml/30g)	32.8	22.8	26.2	30.9	24.4	26.1	31	25	30.7	-	-	-
Rolling quality (cm)	25.5	17	22.3	23.7	18.1	23.7	24.1	19.5	23.8	-	-	-
Diameter after baking (cm)	-	-	-		-	-	22.0	18.07	21.8	-	-	-
Kneading quality (1-3)	3	0.5	1.1	1	3	1	3	1	3	-	-	-
Time of baking (min)	-	-	-	-	-	-	2.67	2.17	2.2	-	-	-
Moisture (%)	-	-	-	-	-	-	18.2	11.0	12.7	-	-	-
	Roti quality											
Roti colour & appearance (1-5)	-	-	-	-	-	-	1.1	4.9	1.7	5.0	1.7	1.7
Keeping Quality (1-5)	2.4	3.9	2	2	3.7	1.5						
Roti Texture (1-5)	1.4	3.3	2.1	1.5	3.3	1.5	1	4.8	1.7	4.8	2.0	2.0
Roti taste (1-5)	1.7	3.7	1.6	1.3	3.7	1.3	2.6	5	2.9	4.7	2.2	2.2
Roti flavour (1-3)	1.2	2.7	1.4	1	2.7	1	1	3	1	1	3	1
Grade of the product (1-5)	-	-	-	-	-	-	1.55	5	1.9	-	-	-
Over all acceptability	-	-	-	-	-	-	2.4	4	2.9	4.4	1.7	1.7

Note:- a) Roti colour & appearance : 1 good , 2 fair, 3 average, 4 bad, very bad , b) Keeping quality: 1- good, 2- fair, 3- average, 4- bad and 5- very bad, c) Texture: 1-very soft; 2-soft; 3-average; 4-hard; and 5-very hard, d) Taste: 1-good; 2-fair; 3-average; 4-bad; and 5-verybad, e) Roti flavour: 1-pleasant; 2-moderate; 3-un pleasant, f) Grade of the product : 1 excellent, 2 very good, 3 good, 4 average, 5 poor, g) Overall acceptability: 1 excellent, 2 very good, 3 good, 4 average, 5 poor.

List of superior genotypes in dough and roti quality

Parameters dough quality	Range	Genotypes reported as superior to M 35 1 in different studies
Water requirement ml/30g	22.8- 32.8	IS 7943, CK 60B, T-SS-47, IS 12611, M 36082, IS 2328, PJ 33K, CSH 5, M 50009, M 50013, M 35052, M 50297, Mothi, E 35-1, WS-1297, Swarna, S 29, S 13, IS 2317, IS 7035, IS 7055, IS 9985, IS 8743, Dobbs, SPV 1762, SPV 1766, CSH 15 R, SPV 1768, SPH 1500 , SPH 1449, SPV 1709, SPV 1626, SPV 1712, SPV 1769, CSV 14R, CSH 6 (Total = 36)
Rolling quality (cm)	17.0-25.5	CSH 8, CSH 5, M 35052, CO 4, P.Jonna, IS 138, Swarna,. S 29, S 13, IS 2317, IS 8743, Segaolane, Market -1, SPH 1583, SPV 1762, SPV 1758, SPH 1582, SPV 1763, SPH 1579, SPV 1757, SPV 1755, SPH 1580, SPV 1759, SPV 1761, SPV 1766, SPV 1767, CSV 216R, CSH 15R, CSV 14R (Total = 29)
Kneading quality (1-3)	0.5-3.0	CSH 8, CSH 6, IS 7943, IS 12611, M 36082, PJ 33 K, E 35-1, Swarna, S 29, S 13, IS 2317,CS 3541, Segaolane, SPV 1768,SPH 1500, SPV 1709, SPV 1626, SPH 1456, SPV 1672, SPH 1504, SPV 1769, CSV 14R, CSV 216R, SPV 1762, SPH 1582, SPV 1766, SPV 1768, SPV 1672, SPV 1680, SPH 1504, SPV 1769 (Total = 31)
Roti texture (1-5)	4.8-1.4	IS 12611, CSH 5, IS 158, SPV 1768, SPH 1449, SPV 1668, SPV 1680, SPH 1504, SPV 1769, CSV 14R, SPH 1583, SPH 1582, SPV 1762, SPV 1760, SPV 1756, SPV 1763, SPH 1579, SPV 1765, SPV 1757, SPV 1759, SPV 1766, SPV 1767, CSH 15R (Total = 23)
Roti taste (1-5)	5.0-1.3	M 36082, CSH 5, IS 158, M 50009, M 50013, M 35052, M 50297, E 35-1, Swarna, CS 3541, Segaolane, SPV 1709, SPH 1501, SPV 1668, SPH 1504, SPH 1583, SPH 1581, SPV 1762, SPV 1760, SPH 1582, SPV 1756, SPV 1763, SPV 1765, SPV 1766, SPV 1767, CSV 14R (Total = 26)
Roti flavour (1-3)	3.0-1.0	M 36082, CSH 5, IS 158, M 50009, M 50013, M 35052, M 50297, E 35-1, Swarna, CS 3541, Segaolane, SPV 1709, SPH 1501, SPV 1668, SPH 1504, SPH 1583, SPH 1581, SPV 1762, SPV 1760, SPH 1582, SPV 1756, SPV 1763, SPV 1765, SPV 1766, SPV 1767, CSV 14R (Total = 26)

quality superior to M 35-1. This in depth analysis made these studies indicate that many genotypes are superior to M 35-1 in dough quality.

Roti quality: Roti prepared in the traditional method was used for analyzing the taste and sensory properties. The taste and sensory properties were measured on a hedonic scale. The properties used for sensory evaluation were colour and appearance of roti, its texture, flavor, grade and acceptability.

Out of 102 genotypes (pooled from all 4 studies) the range for roti texture ranged from 1.0 4.8, and 5 genotypes were having texture superior to M 35-1.The genotypes are IS 12611 (study I), IS 158 (study II), SPV 1769 (study III) and SPV 1600 (study IV). The range for the roti taste varied from 1.4 -5.0, and 26 genotypes among the 4 different studies were superior to M 35-1. The genotypes with most superior roti taste identified are M 36082 (study I), Mothi and S 29 (study II), SPV 1765, SPV 1709 (study III), SPV 1616 (Study IV). The range for roti flavour was observed as 1-3 and 25 genotypes were on par with M 35-1 for the roti flavour.

Conclusion: These comparative studies based on four independent analyses showed that many of the improved breeding lines including all those released for rabi cultivation (III study at NRCS) in the recent times were superior to M 35-1 for roti quality, and so must receive due attention. Therefore, the farmers, traders, and the urban consumers, should be made aware of this finding, since recent releases give significantly higher grain yield than M 35 1 without sacrificing fodder yield or quality. Even some exotic materials exceeded M 35-1 for the component traits associated with dough or roti quality can be found (ex: M 35052, Dobbs, CK 60B, M 50009, M 50013, M 50297, T-SS-47, IS 7943, IS 2328, IS 12611, IS 1755, M 36082, E 35-1, IS 138, IS 158, IS 2317, IS 8743, WS 1297, IS 7035, IS 7055, IS 9985, IS 8743, Segaolane). This suggests that such exotic germplasm needs to be brought into the rabi breeding program, arresting fear that exotic material may decrease roti making quality of grain. Use of such exotic materials in breeding is essential to increase diversity in parental lines, and for increasing the heterosis among rabi hybrids for grain and fodder yield.

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An analysis on prices of selected rabi cultivars across markets

The consumption of sorghum in our country declined during the past three decades. The decline was mainly in case of Kharif sorghum. A sharp rise in market price of sorghum is seen in recent years. Currently, the retail sorghum grain prices (especially rabi sorghum) are on par with wheat and rice in many urban markets. Therefore, an attempt is made to examine and ascertain the latest trend in market prices of rabi sorghum grain by conducting a survey in the markets located in major sorghum growing states of Maharashtra, Karnataka and AP. In this study we assessed the price expectation of 11 rabi cultivar samples (farmer grade) collected from Solapur and compared with the prices of samples for selected markets.

A total of 34 samples belonging to 11 rabi sorghum cultivars were obtained from farmer's fields in Solapur district for the assessment of their market prices during 16th -21st May 2007. Six markets located in three major states were selected as they are known for rabi sorghum trade viz: Pune and Solapur in Maharashtra, Bijapur and Gulbarga in Karnataka, and Kurnool and Hyderabad in Andhra Pradesh. Two traders were randomly selected in the market of each location and their buying and selling prices were studied.

Variation in prices of the entries across the farmer grade samples of 11 Rabi cultivars:

a) **Across cultivars:** DSV-5 received highest price of Rs.1190/quintal (100 kg), closely followed by CSV-18 (Rs.1183/ q (100 kg)) and farmer grade M35-1, the most popular cultivar has received the third highest price of Rs.1164/ q. The least price is secured for SPH-1449 with Rs.1028/q and the range of market prices for various rabi sorghum cultivars is Rs.161/ q. It is observed that, the hybrid varieties ranked less prices when compared with varieties proving the popular belief and this is mainly due to inferior quality in terms of shape, grain hardness and luster.

b) **Across markets:** When the average prices of all cultivars were put together, the variation across markets indicated highest mean price of Rs.1256/ q by Solapur market followed by Hyderabad market with Rs.1204/q and the least mean price was obtained in the Kurnool market with Rs.948/q.

Current trading scenario of rabi sorghum grain:

The rabi sorghum grain trading scenario (based on the market survey), reveals that the grain is mainly sourced from production regions surrounded by the markets.

The peak price fetched for rabi grain was Rs 1950/q in Hyderabad market which is almost the same in Pune and Kurnool markets. The peak arrivals are in March-April, just after the rabi season harvest. The variations across the markets indicated highest mean for peak price is Rs.1808/q and lowest is Rs.1050/q.

The top three market grades of rabi sorghum grain (whose prices are mentioned) in each market is identified. In general, local land races of rabi such as gavran, barsi, dadar and maldandi received highest market prices ranging from Rs 1450-1900/q. Second quality was Mahendra male, the price difference between first and third quality ranged from 36 -61% across the markets. We made an attempt to compare the price/q of M35-1 which is brought from two different sources viz., farmer grade and the market grade. The price difference (Rs/q) ranged from 340-913. In Kurnool market the price difference is the highest while it is lowest in Solapur market.

Procurement of rabi sorghum produce in different locations: (Rs./q)

Market	Catchment areas	Peak price	Low price
Gulbarga	Gulbarga, Raichur	2000	1000
Solapur	Solapur, Jalgaon, Vidarbha	1600	1300
Pune	Jamkhed, Nandyal, Ahmed Nagar, Barsi.	1900	1200
Bijapur	Bijapur district	1500	900
Kurnool	Allagadda, Gadwal, Adoni,	1900	1000
Hyderabad	Barsi, Nandyal, Solapur	1950	900

Note: only rabi sorghum is discussed here; Source: Market price survey of rabi cultivar samples 2008, NRCS, Hyderabad.

An overall situation of all the markets indicated that market grade rabi sorghum of M35-1 received 32.52% higher price over farmer grade samples. On enquiry, traders attributed the price difference between market grade and farmer grade rabi sorghum samples to superior quality of the former in the sense of its size, color, lustre etc.

The traders are of opinion that following desirable characters of sorghum grain will fetch higher price in the market due to their 1. Bold and uniform sized and round in shape, 2. Pearl white colored, 3. Machine cleaned and 4. Higher 1000 grain weight. It is clear that farmer grade samples could not receive prices on par with that of market grade sorghum. It calls for primary processing of grain which will in turn bring value-addition for the farmer grade sorghum produce in the market. Further, in the prevailing rabi sorghum prices in all the markets is higher than that of wheat. It indicates that there is a good scope for sorghum cultivation due to surge in demand for rabi sorghum for human consumption. However, we need to ensure if it is a short-term phenomena or trend of sustainable nature.

Variation in the market prices of M 35-1 cultivar from two different sources (Farmer's sample and market)

Markets	Sourced from (in Rs/q)		Difference	Percent of
	Market grade (A)	Farmer grade (B)	(A-B) (Rs/q)	difference (%)
Gulbarga	1600	1013	587	36.69
Solapur	1600	1260	340	21.25
Pune	1900	1324	576	30.32
Bijapur	1500	1090	410	27.33
Kurnool	1900	987	913	48.05
Hyderabad	1900	1302	598	31.47
Mean	1733	1162	570	32.52

Source: Market price survey of rabi cultivar samples 2008, NRCS, Hyderabad.

Sorghum grain (CSV 216R)

Conclusions and future thrust:

1. The variety M-35 still enjoys the status of the best and the most popular grade in the entire markets surveyed fetching highest price. However, farmer grade rabi cultivars such as DSV-5 and CSV-18 fetched slightly higher price than M 35-1 due to seed size and luster (2% higher price). It indicates that the latter varieties can be promoted for large scale cultivation to secure higher profits to the farmers.
2. The price differences between farmer grade and market grade rabi sorghum grain points at major lacunae of primary processing at farm level itself, which calls for primary processing such as cleaning, grading, dehulling, etc. Such efforts will surely raise the quality standards and meets the expectations of modern consumer needs and will automatically fetch higher profits. Such efforts will lead to value-addition in grain trading and the farmers can have increased share in the consumer rupee.

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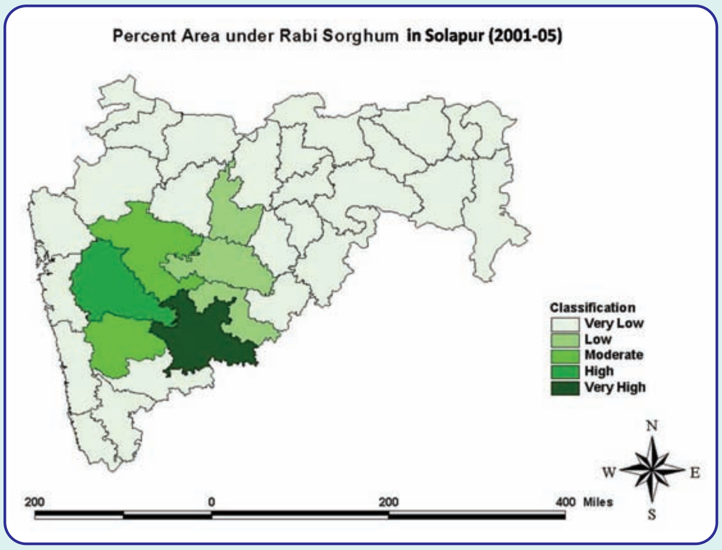
Crop yield-weather model for estimating rabi sorghum yields

Rabi sorghum is mostly a rain-fed crop. The identification of weather conditions in the crucial crop growth periods that influence the crop yield is more important for rabi crops where rainfall has little role to play as the residual effect of the rainfall of South-West monsoon prevails. In this context, an attempt was made to identify the crucial weather parameters by developing crop yield-weather model to rabi sorghum of Solapur district of Maharashtra. The formulation of crop-yield model depends on the time trend in the yields in addition to weather parameters influencing the crop yields.

The rabi sorghum yields exhibited no specific trend in the data, 1990 to 2005 (Data were collected from the web-site http://agri.mah.nic.in/agri/stat/aspstat/mainframeagristat.htm for area, production and yield and agro-meteorological data collected from CRIDA, Hyderabad). The model was developed by taking only the weather parameters in the crop period.

The weather variables considered for the model were 1) Total South-West monsoon rainfall, 2) rainfall, maximum and minimum temperature, relative humidity and 3) sunshine hours recorded during October to December.

The model was fitted on the basis of crop-weather data for the years 1990 to 2005. Out of the weather variables considered for the model - rainfall, Maximum temperature & Relative Humidity (RH1) recorded during October month were found to have significantly influencing the crop yields.



Based on the above variables an attempt was made to fit multiple regression equation

$$Y = 3259.27 - 159.69*t1 + 56.96*t2 + 3.43*r - 62.27*t3 + 85.55*t4 - 60.45*t5$$

where Y is grain yield (kg/ha), r is the total rainfall of 37th meteorological week, t1 is the minimum temperature of 31st week, and t2, t3, t4 and t5 are maximum temperatures of 37th, 41st, 43rd and 45th week.

On the basis of the above model the forecast of rabi sorghum yields corresponding to the years i.e., 2004-05, 2005-06 were obtained. It was observed that the yields could be forecasted with an accuracy of 55%.

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Inter-specific hybridization for sorghum Improvement

Genetic variation of quantitative traits is the raw material for plant breeding. Tremendous effort has been made to study genetic variation at the population level or below, but very little has been made on the study at species level in Sorghum. The knowledge of species differences and resistance factors observed among wild relatives can help utilize them in the crop improvement. Implementing the technique of interspecific hybridization and subsequent gain of genetic variation can circumvent the ceiling on crop yield improvement.

It may be noted that many of the wild relatives have excellent resistance to insect pests and diseases and tolerant to abiotic stresses. The genus Sorghum has 25 species forming two lineages: one with 2n = 10 relatively large genome species and polyploid relatives (subgenera Para-sorghum and Stiposorghum); the other with 2n = 20 and 2n = 40 species with smaller genomes (Subgenera Eu-sorghum, Chaetosorghum, Heterosorghum). Strong reproductive isolation barriers have prevented successful hybridization of *S. bicolor* with any Sorghum species classified in subgenera other than Eu-sorghum.

Pollen-pistil incompatibility is the primary reason why hybrids were not be produced. This incompatibility mechanism was overcome by using a *S. bicolor* genotype that allows growth of pollen tubes of alien Sorghum species. Hybrids have been recovered after dusting the stigmas of *S. bicolor* with pollen from diverse species such as *S. angustum*, *S. nitidum* and *S. macrospermum*. Yet another technique employed was utilization of CMS line to act as a female. Hybrids between sorghum and sugarcane / maize / rice were produced in this way.

Among the candidate species which are useful for purposes of breeding *S. matarankense*, *S. australiense*, *S. usumbarense* and *S. versicolor,* though pose some initial problems of genome imbalance, have a host of useful traits to consider seriously. These are highly resistant to shoot pests.

In one way sorghum is considered to be highly crossable across genera which are totally distant, in that hybrids were obtained between sorghum and sugarcane (both reciprocals), rice. Sugarcane is a candidate species to look forward for imparting (combining) several useful genes such as shoot fly resistance, borer resistance, increase in brix, adaptability, agronomic

S. bicolor F1 *S. usumbarense*

Panicle of *S. bicolor* (female) x *S. usumbarense* (male) and F1.
Note the intermediate nature of the florets and amount of sterility

performance, low water requirement and increase in biomass production / day photosynthesis.

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Genetic variation and inter-relationships among seedling vigour traits in sorghum

Cultivars with high seedling vigour are advantageous for crop stand establishment in dryland cropping system. Rabi sorghum grown for its valued grain and fodder is often planted with stored soil moisture. Under these conditions, the genotypes with higher seedling vigour are essential for quick stand establishment, and to suppress the weeds competing for available soil moisture. Simple plant characteristics such as kernel weight, percentage germination, and seedling weight and height have been identified as good indicators of seedling vigor (Acevedo et al., 1991; Regan et al., 1992). Seedling vigor in sorghum has been assessed by direct measurement of seedling dry weight, which was highly correlated to leaf area, leaf number, and plant height (Maiti et al., 1981). The purpose of our study was to understand the genetic variation that has been uncovered in a set of 160 F_7 recombinant inbred lines (RIL) derived from cross 296B and IS18551, and to understand the association between the seedling vigour traits. All the recombinant inbred lines were evaluated in 4 replications in laboratory for traits related to seedling vigour (germination, root and shoot length, seedling dry matter) and then an index on seedling vigour (Abdul Baki and Anderson, 1973) was calculated.

Genetic variation

Analyses of variance were used to examine differences among RILs for all traits measured. Highly significant differences were observed among the RILs for the seedling vigour traits. The differences between the parents (296B and IS18551) were significant for the seedling vigour index and dry seedling weight 296B had significantly higher seedling vigour index and shoot dry weight as compared to IS18551. However, the parents did not differ for the germination and root and shoot lengths. Good amount of genetic variation was observed among the RILs.

Performance of RILs for seedling vigour traits in sorghum

Trait	Parental lines		RI lines	
	296B	IS18551	Mean	Range
Germination (%)	63	62	66.0 ± 0.2	41-81
Root length (cm)	6.7	6.5	8.3 ±0.1	1-14
Shoot length (cm)	19.2	19.4	21.1 ± 0.1	13-3
Dry seedling weight (mg)	21.3	12.1	15.1 ± 0.1	9 -22
Seedling vigour index	1699	945	1257 ± 9	647-1884

Correlation between seedling vigour traits

Highly significant genetic correlation of seedling vigour index was observed with germination, shoot length and dry seedling weight. Shoot length, as expected showed positive significant relation with seedling dry weight. Similar relation between seedling dry weight and seedling height was reported (Cisse and Ejeta, 2003). The root length did not show significant association with shoot length, dry weight and seedling vigour index except with germination.

Correlation between the components of seedling vigour

Trait	Root length	Shoot length	Seedling dry weight	Seedling vigour index
Germination	0.273**	0.383**	0.131	0.460**
Root length		0.063	-0.070	0.020
Shoot length			0.282**	0.393**
Seedling dry wt.				0.938**

** Significant at 1% level

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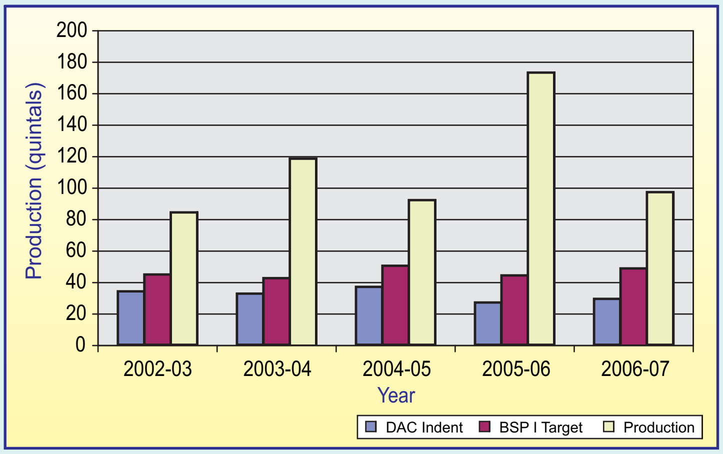
Sorghum breeder seed systems during X plan

During X plan, the 'seed systems' were developed at NRCS for transparent and smooth functioning of production, purity testing, storage and distribution of breeder seed. Various activities of breeder seed program were streamlined at NRCS and also in national program in order to meet the DAC indents and to supply the genetically pure seed material to the seed industry as per ICAR norms.

Breeder seed production: There was surplus production of allocated breeder seed lines at NRCS during X plan (2002-03 to 2006-07). The BSP programme as per BSP-I targets was organized at different field isolations and activities as per



Total breeder seed production trend during X plan at AICSIP centers

calendar were performed. The genetic purity of the breeder seed was confirmed by conducting grow-out tests every year.

Coordination of BSP program at AICSIP centres: NRCS coordinated the nucleus and breeder seed production program of grain sorghum at centres in the national program (AICSIP). In pursuance of DAC indent, the breeder seed production of sorghum varieties and parental lines were planned at AICSIP centres. There was surplus production of breeder seed for most of the allocated lines and varieties at AICSIP centres. The nucleus seed was produced by the AICSIP centres as per set targets.

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New findings in sorghum research

Sorghum to mitigate emission of green house gases through biological nitrification inhibition

Sorghum, like other dryland crops, has preference for NO_{-3} over NH_{+4} as nitrogen source. Nitrification, where ammonium nitrogen (NH4-N) is converted into nitrate nitrogen (NO3-N), results in substantial losses to agricultural systems through nitrate leaching and nitrous oxide emissions. As much as 50 to 70% of the fertilizer-N can be lost because of nitrification-associated processes and annual economic losses to agricultural systems are estimated at US$ 16.4 billion. Nitrification releases fertilizer-N to the environment contributes significantly to global warming, destruction of the ozone layer in the stratosphere through nitrous oxide emissions, and serious nitrate pollution of surface and ground water bodies. Therefore, regulation nitrification could be the key strategy in improving nitrogen recovery and NUE particularly in dry land crops like sorghum.

Although the existence of plant derived nitrification inhibition has been known for several decades, but much less attention have been focused on the capacity of plants to modify nitrification *in situ*. Recently, Subbarao and coworkers at JIRCAS (Japan international research center for agricultural sciences), in a series of neat and elegant studies have confirmed that a tropical grass species, *Brachiaria humidicola*, produces chemicals that suppress nitrification in soil and shown evidences that production of these chemicals are under genetic control. A major breakthrough has been the development of innovative detection tools by JIRCAS researchers that facilitated the practical exploitation of this natural biological phenomenon. Recently, a number of species have been identified which have detectable BNI ability. Among the tested cereal and legume crops, sorghum, pearl millet and groundnut showed detectable BNI in root exudates, with sorghum had highest specific BNI of 5.2 AT units g-1 root dry weight. This indicates that sorghum can play a vital role in mitigating the impact of global warming by regulating the emission of N_2O to atmosphere. Therefore, sorghum can be a suitable crop species to study further the process of biological nitrification inhibition and its scope in enhancing the nitrogen use efficiency.

Further reading: Zakir et al. (2008) Detection, isolation and characterization of a root-exuded compound,methyl 3-(4-hydroxyphenyl) propionate, responsible for biological nitrification inhibition by sorghum. New Phytologist 180 (2): 442-451 (October 2008).

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