Developing sustainable agricultural systems: determinants, future approaches and roles of different partners, as viewed from the soybean breeding program for human nutrition, at the National Soybean Research Center of EMBRAPA

Mercedes Concordia Carrão-Panizzi, Leones A. Almeida, Romeu A. de Souza Kiihl, Luiz C. Miranda and Akio Kikuchi

Introduction

Brazil is responsible for more than 20% of the world soybean production, being second to USA. During the past 30 years, soybean production in Brazil increased considerably due to the expansion of the cultivated area and to the higher productivity of new soybean cultivars. In the 2000 cropping season, over 31 million metric tons were produced on more than 13 million hectares (Table 1). Soybean cultivation in Brazil extends from latitude 30° S and up to 7° S with conditions for expansion beyond the Equator. Varieties grown in the country range from maturity groups V to X. Soybean production under low latitude areas (below 23° S) became possible with the introduction of special traits, allowing late flowering under short-day conditions. This technology has enabled the expansion of the soybean frontier in Brazil (Fig.1). The National Soybean Research Center, together with other public and private research organizations, developed a soybean research network covering the entire country, which promotes annual soybean yield increases by the release of new soybean varieties. The implementation of partnership is responsible for the great success of EMBRAPA varieties (more than 60% of the Brazilian soybean seed industry uses varieties developed by EMBRAPA).

In Brazil, most of the soybean production is exported. In general, 25% of the production is exported as

Table 1 Evolution of Brazilian soybean production

	World			Brazil		
Year	Area[1]	Productivity[2]	Production[3]	Area[1]	Productivity[2]	Production[3]
1970	30.00	1.48	44.28	1.32	1.14	1.51
1980	49.85	1.63	81.03	8.77	1.73	15.15
1990	54.34	1.92	104.29	11.55	1.74	20.10
2000*	74.42	2.26	168.53	13.33	2.37	31.44

[1] In million ha
[2] In tons/ha
[3] In million tons

Sources: * The Production, Supply, and Distribution (PS&D) - USDA - July, 2000.
Indice de Indicadores de Precos, CONAB, Maio, 2000

National Soybean Research Center of EMBRAPA - Brazilian Agricultural Research Coorporation, Londrina, PR Brazil

grain, while 75% goes to the crushing industry for production of meal (80%) and oil (20%). As for soybean meal, Brazil exports 70% of its production. The remaining 30% of soybean protein is used for the internal poultry and swine agroindustry, as well as, for the production of TVP (Texturized Vegetable Protein), defatted soy flour, isolated and concentrate protein. Soybean for direct food uses is not significant in Brazil, accounting for less than 1% of the production.

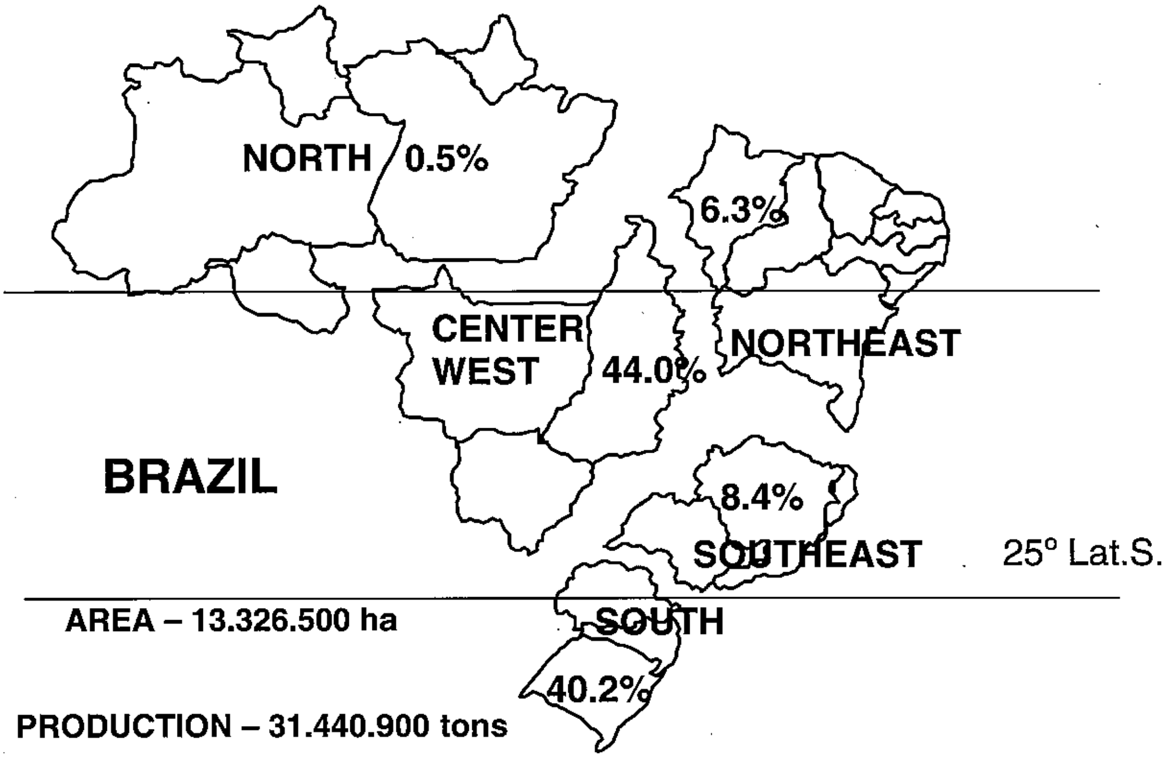

Fig. 1 Soybean production in Brazilian regions, 1999/2000

Soybean consumption in Brazil

Despite its availability and its excellence in nutritive value and benefits to human health, soybean is not widely accepted yet in the country. Flavor is being reported as the main limiting factor, associated with other inadequate characteristics of the Brazilian cultivars, that are important for processing of good-quality soybean products. In the Brazilian market, for direct food uses, only very few soybean products are offered, which include soymilk, TVP, and some soy flour. This low availability of soy products should be changed, since an increased demand for soybean products is occurring. Health benefits have increased the number of people interested in soybean. In order to allow an effective interaction with food industries and facilitate direct consumption, a breeding program for specialty soybean is considered to be important. Increased availability of specialty soybean cultivars will boost the development of high- quality new soybean products in the country.

Soybean breeding program for human nutrition

A breeding program to develop specialty soybean cultivars is being carried out at the National Soybean Research Center, in Brazil. In the cross combinations, high-yielding cultivars adapted to the different soybean production regions, and genotypes with special traits such as better flavor (through absence of lipoxygenase), high protein content, reduced trypsin inhibitor, appropriate seed size (large or small), and hilum color (yellow), are being considered to improve soybean for human consumption.

In spite of the quality characters of the specialty lines, such as absence of lipoxygenases (L1L3), high protein content (46%), small seed size for natto production, large-sized grains with yellow hilum and seedcoat, and resistance to insects, seed yields in these lines are not as high as those of the standard cultivars. As a result, in the 2000 soybean season, a specific yield evaluation trial was carried out under different growing systems (conventional, organic and no-tillage) at different locations in Paraná State (Capanema, Palmas, Londrina, and Ponta Grossa). This evaluation system is conducted in collaboration with private institutions and farmers interested in producing soybean for human consumption. Results from these evaluations will allow the release for commercial cultivation in 2001 of the lines BRM95-51635 which have a small seed size (10g/100 seeds) and are suitable for natto production, and BRM94-52273 which has a large seed size (> 20g/100 seeds) and yellow hilum, and has a good texture and flavor for tofu production. These lines do not yield as much as the commercial cultivars, but may be useful in organic growing systems, which adds increased value to the soybean product (Table 2).

Line BR96-25337 which is a L-1, L-2, and L-3 null lipoxygenase genotype, with high yield potential (3,500 kg/ha) will also be released for commercial cultivation in 2001.

'BRS-155' was the first cultivar released from this special program and recommended for sowing in Paraná and Santa Catarina States. In 28 locations, it yielded an average of 3,100 kg/ha, only 1.3% less than 'IAS 5', the standard commercial cultivar. It shows a reduced trypsin inhibitor activity (30%), which could decrease processing costs or be suitable for low processing animal feed.

Among the Brazilian cultivars, there is a significant genetic variability for isoflavone concentrations,

Table 2 Seed yield (kg/ha) and weight of 100 grains in advanced lines sowed in yield trials in different locations of Paraná State, EMBRAPA Soybean, 2000.

Lines[1]	Palmas	Ponta Grossa	Capanema	Londrina	Mean	Weight* 100 grains			Oidium **
BRQ95-799	2937.7 abc	2592.0 ab	2429.7 abc	3683.7 a	2910.8 a	15.8	R	R	2
BR 36	3275.0 ab	2933.7 ab	2283.3 abc	2796.0 abcd	2822.0 ab	23.8	HS	R	1
FEPAGRO-RS 10	2429.3 cd	2792.0 ab	3058.7 a	2458.7 abcd	2684.7 ab	24.7	R	S	4
BRM95-50363	3262.7 ab	3283.7 a	1808.7 bc	2196.0 bcd	2637.8 abc	21.1	S	R	4
BRQ94-7287	2392.0 cd	2388.0 ab	2741.7 abc	2746.0 abcd	2566.9 abc	15.3	R	R	3
BRQ94-7951	2458.7 bcd	2608.3 ab	2987.7 ab	3050.3 abc	2559.6 abc	13.8	R	R	4
BRM9 4-52273	2391.7 cd	2013.0 ab	2446.0 abc	3217.0 ab	2541.9 abc	26.8	MR	S	2
BRM96-50459	2879.7 abcd	2654.7 ab	2671.0 abc	1833. 7 bcd	2509.8 abcd	21.8	HS	R	4
BRM94-51461	3429.7 a	2563.0 ab	2238.0 abc	1562.7 d	2448.3 abcd	19.8	MR	R	4
BRM94-52451	2525.3 bcd	1987.7 ab	2987.7 ab	2242.0 bcd	2435.7 abcd	19.8	R	R	4
BRM95-51635	2400.3 cd	2579.3 ab	2092.0 abc	2521.0 abcd	2423.2 abcd	11.3	R	S	3
BRM96-50293	2083.7 d	2162.7 ab	2333.7 abc	2916.7 abcd	2374.2 abcd	16.2	S	S	5
BRM95-50413	2533.7 bcd	2525.3 ab	2438.0 abc	1958.7 bcd	2363.9 abcd	24.8	HS	S	4
BRM96-50213	2850.3 abcd	2279.7 ab	2412.7 abc	1904.3 bcd	2361.8 abcd	16.5	HS	S	4
BRM95-50385	2883.7 abcd	2425.0 ab	1933.3 abc	2158.7 bcd	2350.2 abcd	22.1	R	S	4
BRS 155	2346.0 cd	2433.7 ab	2766.7 a bc	1762.7 cd	2327.3 abcd	15.0	R	S	3
BRM95-50570	2500.3 bcd	1733.3 b	2313.0 abc	1800.3 bcd	2086.8 abcd	26.3	HS	R	2
BRM96-50565	2288.0 cd	2062.7 ab	1616.7 c	1787.7 cd	1938.8 abcd	25.4	HS	R	3
Mean	2659.3 A	2445.4 B	2377.3 B	2372.0 B					

Mean values followed by the same capital letters in lines and the same small letters in columns are not significantly different (Tukey P£0.05).

[1] Mean of three replicates.

* Weight of 100 seeds (g) in Palmas, ** ranking from resistant (1) to highly susceptible (5).

which are highly influenced by environmental conditions. Cultivar IAS 5 showed higher concentrations of total isoflavones in the grains than did cultivar BR-36. In Londrina (Northern Paraná State), the concentrations in these cultivars were 120.5 and 48.9 mg/100g, respectively, while in Ponta Grossa (Southern Paraná State), they were 152.4 and 58.5 mg/100g of total isoflavone, respectively. This difference was probably due to distinct local mean temperatures (23℃ in Londrina and 20℃ in Ponta Grossa) (Carrão-Panizzi *et al.*, 1998). Environmental effects on isoflavone concentrations were also observed. ′IAS 5′ had the highest concentration of total isoflavone (218.7 mg/100g) when grown in Vacaria, Rio Grande do Sul State (28° 30′ S latitude, 19℃), compared to 106.0 mg/100g observed in Palotina, Paraná State (24° 27′ S latitude, 24℃). Therefore, by choosing the location, it is possible to manipulate the concentration of these compounds in soybean cultivars (Carrão-Panizzi *et al.*, 1999).

Conclusion

Farmer-researcher-extension-private sector partnerships for technology development and dissemination are the key point for developing and releasing soybean cultivars adapted to human consumption. In this process, farmers have contributed to identify research needs, as well as to improve or develop new technologies, through their empirical observations. Farmers have provided research areas (land), equipment and labor force to carry out evaluations outside the National Soybean Research Center experimental fields. They are also responsible for most of the marketing of commercial varieties. Future contributions from farmers to improve the research process include: development of a check-off program to support soybean research, implementation of partnerships with the private sector, and utilization of farmer's political influence to promote research and development activities.

In 1997, a collaborative program was set up between Japan International Research Center for Agricultural Sciences (JIRCAS) and the National Soybean Research Center (CNPSo/EMBRAPA) to evaluate genetic resources and breeding genetic lines, by improving chemical constituents of soybean seeds. This technical collaboration can lead to a better evaluation of a technology (specialty varieties), ultimately changing farming systems or soybean processing. It will also allow: development of new and more effective strategies to increase domestic consumption of soybean in Brazil, implementation of strategies to increase farmer′s income by adding value to farm products, and development of studies on social and economic impact of the new technologies.

References

1) Carrão-Panizzi, M. C., Almeida, L. A., Kiihl, R. A. S., Miranda, L. C., Kikuchi, A., Mandarino, J. M. G., Bordignon, J. R., Shimanuki, S., Degawa, H. and Tsukamoto, C. (2000): Breeding efforts for nutrittional and food processing quality of soybean at Embrapa, Brazil. In International Soybean Processing And Utilization Conference, 3, 2000, Tsukuba: Proceedings, Tsukuba, The Japanese Society for Food Science and Technology, 2000, p. 37-40.
2) Carrão-Panizzi, M. C., Kitamura, K., Beleia, A. D. P. and Oliveira, M. C. N. (1998): Influence of growth locations on isoflavone contents in Brazilian soybean cultivars. Breeding Sci. 48, 409-413.
3) Carrão-Panizzi, M. C, Beleia, A. D. P., Kitamura, K. and Oliveira, M. C. N. (1999): Effects of genetics and environment on isoflavone contents of soybean from different regions of Brazil. Pesq. Agropec. Bras. Brasilia 34(10), 1787-1795.