PRODUCTION SYSTEM OF SOYBEAN FARMS IN THE SOUTHWEST OF PARANÁ, BRAZIL

Thomas Newton Martin [1], Glauber Monçon Fipke [2], Paulo Sérgio Pavinato [3], Lindolfo Storck [4]

[1]Federal University of Santa Maria. E-mail: martin.ufsm@gmail.com
[2]Federal University of Pampa. E-mail: gm.fipke@hotmail.com
[3]University of São Paulo – ESALQ/USP. E-mail: pavinato@usp.br
[4]Federal Technological University of Paraná -UTFPR. E-mail: lindolfostorck@gmail.com

ABSTRACT

This study aimed at characterizing the production system of the soybean crop in Southwestern Paraná, Brazil to subsidize research and development programs. The study was conducted by applying a questionnaire to 446 farms in three consecutive agricultural years (2008 to 2010). The information requested concerned the characterization of the farm, crop management, destination of production, and the perspectives of farmers. Data were grouped by class and estimated the position and dispersion statistics. Soybean production in the Southwest Paraná is based on small farms, with average cultivation area ranging from 19 to 23 ha, using certified seed, and 55% using inoculation at soybean seeds. Soybean grain yield in the region is above 3,000 kg ha^{-1} in years without drought. Among the practices that can be implemented include the inoculation, control of pests, diseases, and weeds.

Keywords: *Glycine max*, limitations, management, tillage, yield

SISTEMA PRODUTIVO DA SOJICULTURA NO SUDOESTE DO PARANÁ, BRASIL

RESUMO

Objetivou-se com esse trabalho caracterizar o sistema produtivo da cultura da soja no Sudoeste do Paraná, para subsidiar programas de pesquisa e desenvolvimento agrícola. O estudo foi realizado com a aplicação de um questionário a 446 propriedades rurais em três safras consecutivas (2008 à 2010). As informações solicitadas referiam-se a caracterização da propriedade, manejo da cultura, destino da produção e as perspectivas dos produtores. Os dados foram agrupados por classes e estimou-se as estatísticas de posição e de dispersão. A produção de soja na região Sudoeste do Paraná está baseada em pequenas propriedades rurais, com área de

cultivo média variando de 19 á 23 ha, uso de sementes certificadas e inoculadas em 55% das propriedades. A produtividade de grãos na região está acima de 3.000 kg ha^{-1} nos anos sem seca. Dentre as práticas de manejo que podem ser implementadas destacam-se a inoculação, controle de pragas, doenças e plantas daninhas.

Palavras-chave: *Glycine max*, limitações, manejo, cultivo, produção

INTRODUCTION

In the last decades (1995-2015), the State of Paraná, Brazil, presented an economic performance above the national average. Contrary to economic theories, this performance has strong participation of the agricultural sector by the intensive use of technology. It should be considered that soybean cultivation was introduced in the Southwestern region of Paraná by southern immigrants in the 1950s gaining socioeconomic importance and helping in the formation of regional society. Moreover, over the years, soybean has been a vector of changes in social, economic and technical relations in the region.

The State of Paraná has a very diversified agricultural agenda, with emphasis on soybeans. With a total production of 17.2 million tons in 5.2 million hectares, Paraná presented an average yield of 3,294 kg ha^{-1} in the 2014/2015 harvest (CONAB, 2015). In addition to direct participation, soybean cultivation promotes extremely dynamic industrial complexes both downstream and upstream of the farm, improve to importance for the economy of Paraná (IBGE, 2011).

The soybean produced in Paraná has significant variations in grain yield, a fact that can be explained by distinct environmental and/or socioeconomic conditions in the State territory. It is observed, for example, that the Southwest region of Paraná presented in the 2009/2010 harvest a lower average grain yield (2,099 kg ha^{-1}) in the north of the State (2,260 kg ha^{-1}), a region with similar conditions (unpublished data). The preferential period for sowing corresponds to the month of November, but the region has favorable agroclimatic zoning between October 15th to December 15th (MAPA, 2016). Early sowing is practiced in warmer regions of the State, where there is humid winter, high fertility soils, and temperatures favorable to the emergence of plants since the beginning of October. These conditions are more common in the western region of Paraná, in the areas of lower altitude, closer to the Paraná River, located between the Piquiri and Iguaçu Rivers (ALBRECHT et al., 2008).

Some factors that may influence soybean cultivation are water availability, poor control of pests, diseases and weeds, as well as soil fertility and productive potential of the cultivar (SANDINI & FANCELLI, 2000). Other factors that also influence is socioeconomic, such as the landing module, the technical assistance and the regional infrastructure, among other conditions, that favor the dynamism of the activity and the generation of innovations (SANTOS, 2011).

The objective of this work was to characterize the productive system of the soybean crop in the southwest of Paraná, to subsidize research and development programs, as well as to contextualize the changes based on the inferences obtained in the evaluated properties.

MATERIAL AND METHODS

The present study was carried out with the application of a questionnaire to 446 farms located in the Southwest of Paraná and some counties in neighboring regions (Table 1), in three consecutive agricultural years (2008, 2009 and 2010). Each farm was sampled only once in the assessed period.

The interviews were conducted prior to the soybean harvest in each of the years. The territorial area covered by the survey was 1,036,526 ha. The climate of the region is classified as Cfa (Humid Subtropical Climate), with an average of the hottest month exceeding 22ºC and, in the coldest month, below 18ºC, with no defined dry season, hot summer and less frequently frosts) according to the classification of Köppen (PEEL et al., 2007).

The questionnaire focused on the identification of the area of use of each farm with the soybean crop. In the sequence, the productive system of each farm was characterized, emphasizing the management of the crop and the inputs used, as well as the perspectives of the soybean producers. The information requested referred to: 1) area of the farm; 2) area of soybean production; 3) seed origin; 4) use of inoculant in the seeds; 5) use of transgenic cultivars; 6) use of fungicides; 7) weed control; 8) most frequent diseases; 9) diseases of most difficult control; 10) other agricultural activities that it performs on the property; 11) destination of soybean production; 12) presence of technical assistance; 12) origin of technical assistance; 13) average production of the farm; 14) farmers interest in training courses; 15) relation of possession with the field area; 16) cultivation system used; 17) major inscts pests; 18) major weeds; 19) row spacing; and 20) growth cycle of the cultivars.

Table 1. Number of rural properties evaluated (NRPE); total population (POP), area (AREA), total soybean production (TSP), average yield (AY) and area of cultivation (AC) in each county*.

Counties*	NRPE			POP	AREA	TSP	AY	AC
	2008	2009	2010	(mil)	(km²)	(tonne)	(tonne ha^{-1})	(mil ha)
Bela Vista da Caroba	6	3	0	3.9	148,107	5.4	1.800	3
Boa Esperança Iguaçu	6	10	15	2.8	151,986	4.6	1.955	2.3
Bom Sucesso do Sul	0	3	6	3.3	195,867	25.6	2.491	10.3
Capanema	0	14	27	18.5	418,705	38.4	2.400	16
Cascavel	1	1	0	286.2	2,100,105	214.2	2.550	84
Catanduvas	0	2	3	10.2	581,754	43.7	3.080	14.2
Chopinzinho	0	1	1	19.7	959,692	68.8	2.775	24.8
Coronel Vivida	2	1	0	21.7	684,417	67.7	2.462	27.5
Cruzeiro do Iguaçu	5	5	5	4.3	161,493	4.2	1.750	2..4
Dois Vizinhos	37	32	30	36.2	418,320	32.4	2.025	16
Francisco Beltrão	1	1	0	78.8	35,266	26.4	2.237	11.8
Guaraniaçu	1	1	0	14.5	1,225,607	37.21	2.331	15.9
Guarapuava	0	1	1	167.5	3,115,329	124.4	2.498	49.8
Ibema	4	2	0	6.1	145,442	13.3	3.000	4.4
Marmeleiro	11	5	0	13.9	387,680	30.1	2.369	12.7
Nova Esp. Sudoeste	1	1	0	5.1	208,472	3.7	2.500	1.5
Nova Laranjeiras	5	5	5	11.2	1,145,485	13.7	2.490	5.5
Nova Prata do Iguaçu	5	3	1	10.4	352,565	25.2	2.297	10.9
Peróla D'Oeste	25	17	0	6.8	206,048	14.6	1.800	8.1
Planalto	1	1	0	13.7	345,740	29.7	2.479	12
Porto Barreiro	5	3	0	3.6	361,982	20.2	2.593	7.70
Quedas do Iguaçu	0	3	5	30.6	821,503	30.6	2.094	14.6
Realeza	8	4	0	16.3	353,415	14.0	2.250	14
Salto do Lontra	11	5	0	13.7	313,290	18.2	2.427	7.5
Santa Izabel d'Oeste	7	8	10	13.1	321,169	22.2	1.876	11.8
São João	0	5	4	10.6	388,060	52.9	2.607	20.3
Sao Jorge do Oeste	0	6	13	9.1	379,047	13.8	1.594	8.6
Saudades do Iguaçu	0	0	1	5.0	152,084	4.9	2.000	2.5
Sto. Antônio Sudoeste	3	4	5	18.9	325,672	17.2	1.792	9.6
Verê	0	7	15	7.9	312,418	19.1	1.893	10.1
Total	145	154	147	863.6	16,716,720	1.036,52		440.1

*Source: IBGE (2011a), IBGE (2011b), PNUD (2011), IPARDES (2010), IBGE (2002).

The responses were tabulated creating a database in the Excel® application. From this, each questionnaire question was treated in a simple way, classifying (mean, minimum and maximum) and dispersion statistics (standard deviation, variance and coefficient of variation).

RESULTS AND DISCUSSION

The total area of soybean producing farms in the Southwest of Paraná varies from 38.6 to 47.4 ha (Table 2). As the introduction of soybean cultivation was carried out from the 50's, due to the arrival of southern imigrants, there were changes in the land structures of the place as well as valorization of the agricultural areas. Thus, over the years there has been a change in the social, economic and technical relations caused by the introduction of soybean cultivation in the region.

The difference in the size of the year-to-year farms are due to random sampling among the properties that grow soybean, and therefore, there is no replacement in the number of properties. The average size of the areas with soybean varies from 19.4 to 23 ha, that is, approximately half of the total area of the farms is destined for this purpose. In this sense, there is a great variability in the size of the farms and in the soybean growing areas. In addition, most properties have less than 500 ha, with a maximum of 470 ha and a minimum of 2.5 ha. Thus, it is verified that only two farms evaluated have more than 200 ha, conferring a characterization of small family farms.

It was observed that in the first two years, 90% of the farms had up to 50 ha, however, in the last year of research (2010), the same percentage of farms was only reached when the area was enlarged to 100 ha. However, the highest frequency of farms (total area) is up to 10 ha. In the last year presented the highest frequency of properties in areas of 10 to 20 ha. For the cultivation area, the highest frequency of farms was verified between 10 and 20 ha, now except for the first year (2008). This characterization indicates that the farms that own the soybean as one of the cultures within its productive system are, in general, small properties, with restricted areas of cultivation.

Soybean farmers in the Southwestern region of Paraná use (> 86%) seeds purchased from certified farms, which may correspond to genetic, physical, physiological and phytosanitary quality (Table 3). Thus, farmers are aware that it is necessary to use superior genotypes with high productive potential to obtain better yields.

Table 2. Area of cultivation (AC, ha) and total area of properties (TA, ha) and position and dispersion statistics and frequency table, number of properties with area smaller than given size and number of properties with area within certain Limits.

Statistic	2008		2009		2010		General	
	AC	TA	AC	TA	AC	TA	AC	TA
Average	19,4	38,6	23,9	47,4	23,1	42,4	22,1	42,8
Minimum	0,5	2,5	1,0	4,0	2,0	4,8	1,2	3,8
Maximum	266,0	338,0	270,0	470,0	240,0	320,0	258,7	376,0
Standart deviation	35,1	54,1	42,2	68,1	28,6	46,3	35,3	56,1
Coefficient of variation	180,7	140,1	176,4	143,7	124,1	109,3	160,4	131,0
<10 ha	80	16	69	13	51	7	200	36
<20	112	66	110	53	96	48	318	167
<30	122	96	122	89	115	79	359	264
<50	136	120	136	117	127	110	399	347
<100	142	136	144	135	144	134	430	405
<150	144	140	146	143	146	141	436	424
<200	144	141	147	146	146	144	437	431
<500 (Total)	146	146	151	152	147	147	444	445
0-10 ha	80	16	69	69	13	7	162	92
10-20	32	50	41	41	40	41	113	132
20-30	10	30	12	12	36	31	58	73
30-50	14	24	14	14	28	31	56	69
50-100	6	16	8	8	18	24	32	48
100-150	2	4	2	2	8	7	12	13
150-200	0	1	1	1	3	3	4	5
200-500	2	5	4	4	6	3	12	12

However, there is a share of up to 10% of farmers who produce their own seed, but the important thing is that this percentage has gradually declined over the three years evaluated. The use of certified seeds by the producers means that there is an increase in the total cost of the crop of approximately 10% for the 2010/2011 crop year (AGRIANUAL, 2010); however, the benefits attributed to the use of certified seeds are much higher than the referred to above.

Table 3. Origin of soybean seeds used by rural producers in the Southwest of Paraná, the number of farmers (NF) and percentage of seed utilization (%).

Origin of soybean seeds	2008		2009		2010		General	NP
	NF	%	NF	%	NF	%		%
Own production	15	10.3	12	7.8	7	4.8	11.3	7.6
Farm shop - certified	125	86.3	139	90.3	132	89.8	132.0	88.8
Farm shop – no certified	0	0.0	1	0.6	5	3.4	2.0	1.3
Bought / won	4	2.8	1	0.6	2	1.4	2.3	1.6
Swapped with the neighbor	1	0.7	1	0.6	1	0.7	1.0	0.7
Total	145	100	154	100	147	100	148.6	100

Management action	2008		2009		2010		General
	Yes	No	Yes	No	Yes	No	% Yes
Use of inoculants	55.2	44.8	52	48	56.5	43.5	54.5
They answered (Total)	143		154		147		148
Use of transgenic cultivars	81.2	18.8	96	4	89.8	10.2	89
They answered (Total)	144		151		147		147.3
Use of fungicide	61.1	38.8	56.7	43.2	55.6	44.3	57.8
They answered (Total)	144		148		142		144.6
Weed control	91.7	8.2	94.1	5.88	93.1	6.81	93.0
They answered (Total)	145		153		147		148.3

When considering the historical series from 1976 to 2010, it is verified that soybean yield increases about 32 kg ha^{-1} on average for the State of Paraná and 36 kg ha^{-1} on the Brazilian level (CONAB, 2011). This evolution in average productivity was due to the genetic improvement of soybean cultivars and the management used in the crops, with better fertilization and better control of pests, diseases and weeds.

In the interviewed properties, the sowing is done more frequently to 45 cm (62.9%) and 40 cm (28.4%) between rows, with the other spacings varying over 45 cm. Spacings between rows smaller than 40 cm were not evidenced in this study (DALLEY et al., 2004) and the reduction of soil, water loss through evaporation (CALISKAN et al., 2007). However, this reduction practice is not included in the recommendation guides for the crop and is not a reality in the Southwestern

region of Paraná due to the fact that the producers have not used the recommended fertilizer dose, which can reduce the productivity of the crop in smaller row spacing.

About the growth cycle of the cultivars, the preference for genotypes of the medium cycle (69.3%) was verified, followed by short cycle (17.3%) and long cycle (13.3%). The preference for medium cycle is due to the greater productive potential in relation to the short cycle cultivars. Long-cycle cultivars are deferred due to the use of many areas for the second harvest, or for early wheat cultivation in the winter, which causes the need for early soybean harvesting.

As far as the cultivation system used, no-tillage sowing is almost constant and unanimous, with 95.7% of the crops using this technique, 2.9% using conventional tillage and 1.4% minimum cultivation. The no-tillage sowing system is used due to its characteristics favorable to the development of the crop, such as the reduction of costs due to the practices of soil preparation, maintenance of soil moisture for a longer period, better soil conservation, among other advantages. Derpsch et al. (1991) indicate that the no-tillage system provided increases in grain yield of 19 and 35% relative to conventional tillage in wheat and soybean crops, respectively. This can be caused by a number of factors, such as the emergence speed of soybeans, which is higher in direct seeding compared to conventional seeding, maintenance of humidity, lower losses of soil and nutrients with rains, among others (LIMA et al., 2010).

Although there are several studies in the literature indicating the efficiency of the use of inoculants in the soybean crop, this management practice was used in little more than 50% of the properties. The inoculation practice increases the grain yield of the crop by an average of 4.5% (HUNGRIA et al., 2006a), associated to fungides and micronutrients in the treatment of seeds, in the first year of cultivation, thus increasing soybean nodulation (VIEIRA NETO et al., 2008).

The present results on inoculation indicate that the advantages in relation to this practice have not been widely disseminated so far in the region, and practically half of the producers still do not use it (Table 3). One of the hypotheses of this fact can be justified because the bacterium is present in the soils due to the intensification of soybean cultivation, thus occurring the symbiosis with native bacteria in the soil itself. It should be noted that such bacteria do not have the same efficiency as those given commercially for inoculation, they are selected for such characteristics (HUNGRIA et al., 2006b).

According to Miyamoto (2007), the area cultivated with transgenic soybeans, at the Brazilian level, for the 2007/2008 harvest was 40%. However, there is an annual increase in

cultivated areas with this technology. In the present study, it was verified that 81.6 to 96% of the producers used transgenic soybean seeds in the three evaluated years (Table 3), being therefore widely used by the producers. This is one of the technologies that can be used to control weeds, which as a rule is a problem for the production of Brazilian and Paraná soybeans. Despite the intense cultivation of RR soybeans (Roudup Ready®, resistant to glyphosate), the cost of production (per bag produced) of conventional soybeans is lower than that of transgenic soybeans (FURLANETO et al., 2008). A hypothesis for the production of transgenic soybeans should be related to the incidence and control of weeds.

In terms of diseases, between 55 and 61% of the farmers carry out the application of fungicides to control them. According to the farmers, the most frequent disease among the three mentioned was "soybean rust" (*Phakopsora pachyrhizi*), however interesting information is that a significative of the farms interviewed (Table 4). In the case of the most difficult control, "soybean rust" was the main one reported in 71% of the farmes interviewed (Table 4). In this situation there is an important point that should be highlighted, since the incidence of diseases in soybean is, in general, very great, as well as its potential to reduce yield. When considering leaf diseases caused by fungi, these can reduce yield, but when considering specifically "soybean rust", losses can reach 75% of production (YORINORI, 2002). Perhaps farmers misunderstanding of disease identification may have contributed to many failing to make the proper applications of pesticides.

Table 4. Percentage of the most frequent diseases (MFD) and more difficult to control (MDC).

	Soybean rost[1]	Powdery mildew [1]	Mildew[1]	No one	Number of respondents
			2008		
MFD	48.9	13.1	0.0	37.9	145
MDC	71.0	4.8	0.0	24.1	145
			2009		
MFD	29.9	17.5	0.6	51.9	154
MDC	42.9	3.9	0.6	52.6	154
			2010		
MFD	33.3	2.0	1.4	63.3	147
MDC	51.0	1.4	0.7	46.9	147
			Geral		
MFD	37.4	10.9	0.7	51.0	148

MDC	54.9	3.4	0.4	41.2	148

[1] soybean rost (*Phakopsora pachyrhizi*), powdery mildew (*Microsphaera diffusa*), mildew (*Peronospora manshurica*).

Regarding the labor force verified in the farms, for the years 2008 and 2009 more than 80% had its origin in the family itself. However, as mentioned previously, the properties evaluated in 2010 are larger, with a smaller participation of family labor (69.38%), being larger in extension and in cultivated area. In this case, the participation of hiring labor is considered natural, due to the extensions of the properties. The hiring of day laborers occurs exporadically, and can reach up to 3% of the properties. According to Martin et al. (2011), for maize, the use of family labor in the Southwestern region of Paraná is the majority, and these rural properties represent between 76 and 78%.

Regarding the relation of possession of the farms, it is verified that the soybean is cultivated in own land in 81 to 91% of the properties, depending on the year evaluated. The lease occurs only between 9 and 19% of the properties, with a higher frequency in the year 2010. Among the complementary activities carried out on the evaluated farms, it is verified that the maize crop is one of the most used, arriving to be present in more than 89% of the farms interviewed (Table 5). Smoke has high concomitants in the first year, being considered that the presence of tobacco in the farms is related to the property characteristics of the farms (small and family labor), in addition to the remuneration that the tobacco companies make available for the culture, which turn out to be more attractive than other crops that require more investment in machinery. In addition, there is intensive technical assistance for this crop, which is supplied by the industries under contract, and they are responsible for the purchase of the production. However, the annual variation in tobacco use is also due to the fluctuation of prices offered by the industry, which varies greatly from year to year.

Table 5. Percentage of complementary agricultural activities on the property (in addition to soybean cultivation): maize (MA), beans (BE), wheat (WH), tobacco (TO), sorghum (SO), poultry (PO), swine (SW), beef cattle (BC), dairy cattle (DC).

Year	MA	BE	WH	TO	SO	PO	SW	BC	DC
					%				
2008	91.7	51.7	22.7	91.0	10.3	15.2	8.3	2.7	76.5
2009	91.5	31.8	27.3	8.4	7.1	14.9	7.1	8.4	48.7
2010	89.1	55.8	12.2	27.9	10.2	14.3	10.9	13.6	46.2

General	90.8	46.4	20.7	42.4	9.2	14.8	8.8	8.3	57.2

For livestock production, dairy cattle are present in at least 46% of farms, especially the first year that surpassed 76% of the evaluated farms. Poultry is present at around 14% of farms and lower values are verified for pig farms and beef cattle. This is certainly one of the most promising regions for milk and poultry cattle production, requiring a considerable amount of soybean and corn for production in this way. However, such soybeans and corn are minced by the region's feed industries, which make it feed for animals.

Among the most difficult to control pests are the bugs, with 38.5% and the caterpillars, with 23.6%. However, 73.6% carried out applications for insect control and the rest did not. As for weeds, *Ipomoea* sp. (51.7%), *Euphorbia heterophylla* (23.6%), *Conyza* sp. (17.1%) are outstanding the most important and most difficult to control. Lazaroto et al. (2008) highlighted the reduction of yield, which could reach 83% when the infestation is very high. All species have already shown some resistance to glyphosate herbicide, which is widely used in crops with transgenic soybean (TREZZI et al., 2011; VARGAS et al., 2013). The cost of production related to weed control ranges from 17 to 40% of the variable cost. However, currently it is considered between 17 to 27% for conventional soybean, and 8 to 12% for cultivars with RR technology (AGRIANUAL, 2010).

From the data presented in Table 6, it can be seen that the majority of farmers gives soybean production to the cooperatives (more than 66%), and as a second option for individuals or cereal farmers. However, for the maize crop, this trend is not verified (Southwestern Paraná), because the maize is consumed in the own farms by the characteristics of exploitation of them, varying from 28 to 42% (MARTIN et al., 2011).

The participation of cooperatives in soybean production in the Southwestern region of Paraná is quite intense, as verified by technical assistance received (Table 6). More than 89% of farmers use technical assistance to improve their production rates. This technical assistance comes from a large part of the cooperatives (58%), to which these farmers are cooperating. Another large portion of the technical assistance is allocated to the farm shop, who present technical assistance within a technology package for the sale of inputs. However, educational institutions do not provide (mostly) direct technical assistance to farmers, but work in the training of technicians, agronomists, zootechnicians and veterinarians, who will work in technical assistance. In addition, they will be staffed by private companies and Emater, which will contribute to the technical assistance related

to soybean cultivation in the region. More efforts at national levels should be made possible to strengthen these two entities, aiming particularly at improving the quality of information available to farmers through extension actions. However, public companies, mainly universities, act directly in the training of human resources that are working in the private sector. Thus, the effective participation of universities in the technical orientation of these properties is emphasized.

Table 6. Destination of soybean production in the Southwest of Paraná and a number of producers assisted by technicians in different entities.

Destination of production	2008	2009	2010	General
Cooperative	75,2	68,1	66,2	69,8
Individuals / Cerealists	24,1	31,8	33,1	29,7
Industry	0,7	0,0	0,0	0,2
Consumption on the farm	0,0	0,0	0,7	0,2
Number of respondents	137	138	139	138

	2008		2009		2010		General
Entity	Yes	No	Yes	No	Yes	No	% Yes
TA	123 (84,8)*	22 (15,2)	141 (91,5)	13 (8,4)	137 (93,2)	10 (6,8)	133,7 (89,8)
CO	75 (60,9)		82 (58,1)		76 (55,5)		77,6 (58,2)
EM	3 (2,4)		7 (4,9)		6 (4,4)		5,3 (3,9)
FS	45 (36,6)		52 (36,9)		55 (40,2)		50,7 (37,9)
Total	145		154		147		

* represents the percentage in relation to the total value, technical assistance (TA), cooperative (CO), Emater (EM), Farm shop (FS).

The average productivity of the soybean crop in the three years was 2,666 kg ha^{-1} (44.4 sc ha^{-1}), but considering only the first and third year, it is verified that these production arrived to approximately 3,100 kg ha^{-1}, with a lower value in the second year (1,923 kg ha^{-1}). This variability was due to contrasting climatic conditions in this second year, as well as different management practices used in the soybean crop. In this sense, it can be seen that the farmers seem satisfied with the average yield obtained. If we consider the average of Paraná soybean yield (2001-2010), it is verified that the average obtained in the farms interviewed in this second year was lower than the State average (2,774 kg ha^{-1}) (CONAB, 2011).

When asked if there is interest in conducting a training course that involves soybean cultivation, between 50 and 60% of respondents indicate that they are not interested. This should

be viewed with concern, as farmers with relatively small areas, with no productive capital and with no productive interest in training courses, may be potential migrants to the cities, characterizing the exodus of agricultural and livestock farms. According to CESB (2011), the production of maximized soybeans, even in small farms, depends on a number of factors, for example: searching for technical support and information through experienced agronomists and / or agronomists and using technical information to maximize productivity in order to enable the plant in a favorable climate to express its maximum potential.

CONCLUSIONS

Soybean production in the Southwest region of Paraná is based on small farms (19 to 23 ha), areas owned by the farmer himself and his family, constituting the essential labor force. Certified seed inoculated with *Bradyrhizobium* spp. (55%). The average productivity in the region is above 2.5 tons of ha^{-1} grains in the years without water deficit.

Among the practices that can be implemented to improve yield are inoculation, control of pests, diseases, and weeds.

ACKNOWLEDGEMENTS

To the Araucária Foundation, CNPq and Federal Technological University of Paraná (UTFPR), Campus Dois Vizinhos.

REFERENCES

ALBRECHT, L. P.; BRACCINI, A. L.; ÁVILA, M. R.; SUZUKI, L. S.; SCAPIM, C. A.; BARBOSA, M. C. 2008. Teores de óleo, proteínas e produtividade de soja em função da antecipação da semeadura na região Oeste do Paraná. **Bragantia**, Campinas, v.67, n.4, p.865-873.

AGRIANUAL – Anuário da Agricultura Brasileira, 2010. **Soja.** São Paulo, Agra FNP Pesquisas Ltda. 520p.

CALISKAN, S.; ARSLAN, M.; UREMIS, I.; CALISKAN, M. E. 2007. The effects of row spacing on yield and yield components of full season and double-cropped soybean. **Turkish Journal of Agriculture and Forestry**, Ankara, v.31, n.1 p.147-154.

CESB - Comitê Estratégico Soja no Brasil, 2011. **Conheça o que há em comum entre o recordista de alta produtividade da soja nos Estados Unidos e no Brasil**. Available in: <http://www.cesbrasil.org.br/noticias/paralelo-produtores.aspx> Access in: March 23, 2011.

CONAB – Companhia Nacional de Abastecimento, 2011. **Séries históricas relativas às safras 1976/77 a 2009/2010 de área plantada, produtividade e produção**. Available in:

<http://www.conab.gov.br/conteudos.php?a=1252&t=2&Pagina_objcmsconteudos=2#A_objcmsconteudos> Access in: April 11, 2011.

CONAB – Companhia Nacional de Abastecimento, 2015. **Levantamento de Safra: 3º Levantamento de Grão Safra 2015-16, dezembro de 2015**. Available in: < http://www.conab.gov.br/OlalaCMS/uploads/arquivos/15_12_11_11_02_58_boletim_graos_dezembro_2015.pdf>. Acces in: January 06, 2016.

DALLEY, C. D.; KELLS, J. J.; RENNER, K. A., 2004. Effect of glyphosate application timing and row spacing on corn (*Zea mays*) and soybean (*Glycine max*) yields. **Weed Technology**, Fayetteville, v.18, n.1, p.165-176.

DERPSCH, R., C.; ROTH, H.; SIDIRAS, N.; KÖPKE, U. 1991. **Controle de erosão no Paraná, Brasil: Sistemas de Cobertura do Solo, Plantio Direto e Preparo Conservacionista do Solo.** GTZ/IAPAR, Londrina. 272p.

FURLANETO, F. P. B.; RECO, P. C.; KANTHACK, R. A. D.; ESPERANCINI, M. S. T.; OJIMA, A. J. R. O. 2008. Soja transgênica versus convencional: estimativa dos custos operacionais de produção na região do Médio Paranapanema, Estado de São Paulo. **Ciência e Agrotecnologia**, Lavras, v.32, n.6, p.1935-1940.

HUNGRIA, M., FRANCHINI, J. C., CAMPO, R. J., CRISPINO, C. C., MORAES, J. Z., SIBALDELLI, R. N. R., MENDES, I. C.; ARIHARA, J. 2006a. Nitrogen Nutrition of Soybean in Brazil: Contributions of Biological N2 Fixation and of N Fertilizer to Grain Yield. **Canadian Journal of Plant Sciences**, Ottawa, v.86, n.4, p.927-939.

HUNGRIA, M., CAMPO, R. J.; MENDES, I. C.; GRAHAM, P. H. 2006b. **Contribution of biological nitrogen fixation to the N nutrition of grain crops in the tropics: the success of soybean (*Glycine max* (L.) Merr.) in South America**. In: SINGH, R. P.; SHANKAR, N.; JAIWAL, P. K. (Ed.) Nitrogen nutrition and sustainable plant productivity. Houston, Texas: Studium Press, p.43-93.

IBGE – Insituto Brasileiro de Geografia e Estatística, 2002. **Área Territorial Oficial. Resolução do Presidência do IBGE de n°5 (R.PR-5/02) de 10 de outubro de 2002.** Available in: <http://www.ibge.gov.br/home/geociencias/cartografia/default_territ_area.shtm> Access in March 26, 2011.

IBGE – Instituto Brasileiro de Geografia e Estatística, 2011a. **CENSO, 2010.** Available in: <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/tabelas_pdf/total_populacao_parana.pdf> Access March 26, 2011.

IBGE – Instituto Brasileiro de Geografia e Estatística, 2011b. **Produto Interno Bruto.** Available in:<http://www.ibge.gov.br/home/estatistica/economia/pibmunicipios/2004_2008/defaulttab.shtm> Access in: March 26, 2011.

INSTITUTO PARANAENSE DE DESENVOLVIMENTO ECONÔMICO E SOCIAL - IPARDES. 2010. **Cadernos municipais.** Available in: <http://www.ipardes.gov.br>. Access in: April 11, 2010.

LAZAROTO, L. A.; FLECK, N. G.; VIDAL, R. A. 2008. Biologia e ecofisiologia de buva (*Conyza bonariensis* e *Conyza canadensis*). **Ciência Rural,** Santa Maria, v.38, n.3, p.852-860.

LIMA, C. R. L. M.; REINERT, D. J.; REINCHERT, J. M.; SUZUKI, L. E. A. S. 2010. Produtividade de culturas e resistência à penetração de Argissolo Vermelho sob diferentes manejos. **Pesquisa Agropecuária Brasileira**, Brasília, v.45, n.1, p.89-98.

MARTIN, T. N., VENTURINI, T.; API, I.; PAGNOCELLI, A.; VIEIRA JÚNIOR, P. A. 2011. Perfil do manejo da cultura de milho no sudoeste do Paraná. **Revista Ceres**, Viçosa, v.58, n.1, p.1-8.

MAPA – Ministério da Agricultura, Pecuária e Abastecimento, 2016. **Zoneamento agroclimático**. Online. Availale in: <http://www.agricultura.gov.br/politica-agricola/zoneamento-agricola> Access in: January 12, 2016.

MIYAMOTO, Y. 2007. **Estimativa da área com soja transgênica no Brasil**. Available in: <http://www.caminhosdocampo.ondarpc.com.br>. Access in: November 20, 2007.

PEEL, M. C.; FINLAYSON, B. L.; MCMAHON, T. A. 2007. Updated world map of the Köppen-Geiger climate classification. **Hydrology and Earth System Science**, Karlsruhe, v.11, n.5, p.1633-1644.

PNUD – Programa das Nações Unidas para o Desenvolvimento, 2011. **Índice de Desenvolvimento Humano - Municipal, 1991 e 2000**. Available in: <http://www.pnud.org.br/atlas/ranking/IDH-M%2091%2000%20Ranking%20decrescente%20(pelos%20dados%20de%202000).htm> Access in: March 26, 2011.

SANDINI, I. E.; FANCELLI, A. L. 2000. **Milho: estratégias de manejo para a região sul**. Guarapuava, Fundação Agrária de Pesquisa Agropecuária. 209 p.

SANTOS, R. A. 2011. Território e modernização da agricultura no Sudoeste do Paraná. **Revista Espaço Acadêmico**, Maringá, v.10, n.118, p.114-122.

TREZZI, M. M., VIDAL, R. A.; XAVIER, E.; ROSIN, D.; BALBINOT JR, A. A.; PRATES, M. A. 2011. Resistência ao glyphosate em biótipos de buva (*Conyza* spp.) das regiões oeste e sudoeste do Paraná. **Planta Daninha**, v.29, p.1113-1120.

VARGAS, L., NOHATTO, M. A.; AGOSTINETTO, D.; BIANCHI, M. A.; PAULA, J. M.; POLIDORO, E.; TOLEDO, R. 2013. Práticas de manejo e a resistência de *Euphorbia heterophylla* aos inibidores da ALS e tolerância ao glyphosate no Rio Grande do Sul. **Planta Daninha**, Viçosa, v.31, n.special, p.427-432.

VIEIRA NETO, A. S., PIRES, F. R.; MENEZES, C. C. E.; MENEZES, J. F. S.; SILVA, A. G.; SILVA, O. S.; ASSIS, R. L. 2008. Formas de aplicação de inoculante e seus efeitos sobre a nodulação da soja. **Revista Brasileira de Ciência do Solo**, Viçosa, v.32, n.2, p.861-870.

YORINORI, J. T. 2002. **Ferrugem asiática da soja (*Phakopsora pachyrhizi*): ocorrência no Brasil e estratégias de manejo**. In: XXIV Reunião da Pesquisa de Soja da Região Central do Brasil. Londrina, Embrapa soja (Documentos, 186).

Received in: February, 25, 2016
Accepted in: December, 12, 2019