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A N I N T E R N A T I O N A L J O U R N A L

Relationships Among Oil Content, Protein Content and Seed Size in Soybeans

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ABSTRACT

During 1995/96 and 1996/97, experiments were carried out at Londrina State University, aiming at quantifying the oil and protein contents in two groups of soybean genotypes; estimating the phenotypic, genotypic and environmental correlations existent among oil, protein content and seed size, and identifying genotypes for direct human consumption with high protein content. The evaluated characters were Weight of a Hundred Seeds (WHS), expressed in grams/100 seeds, Oil Content (OC) and Protein Content (PC), expressed in %. In the experiment carried out in the field, OC ranged from 12 to 20.37 % and PC from 35.66 to 41.75% while in the experiment carried out in the greenhouse OC ranged from 12.26 to 21.79 % and PC from 32.95 to 41.56 % . The correlations between oil and protein were negative and significant. The relationship among WHS with OC and PC was low and higly affected by the time effect. Due to their high protein content and stability to oil and protein contents, there were distinction among the treatments carried out in the field (GA23 and GA20), and those carried out in the greenhouse (PI408251, Waseda, B6F4 (L-3 less), PI423909 and Tambagura).

Key words: Soybean, *Glycine max*, Seed composition, Seed size, Oil content, Protein content

INTRODUCTION

The importance of soybean [*Glycine max* (L.) Merrill] worldwide is due mainly to its high oil and protein contents. Soybean breeders have looked for genotypes with high oil and protein contents along with high grain yield. Knowledge of the genetics concerning interesting traits of one specie is very important for breeding improvement. According to Vencovsky & Barriga (1992), the examination of the nature and extent of relationships among traits is important. A breeding program, commonly, does not look for the genetic improvement of isolated traits, but for the genetic

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improvement of a set of traits, since it is interesting for the breeder to know how the intervention in one trait can cause alteration in others.

Many attempts have been made through breeding to elevate grain yield. However, other traits related to seed composition have been little studied. The negative correlation existent between oil and protein contents as well as the negative correlation between protein and yield is a problem in obtaining cultivars with high yield and high protein contents. In the so called food-type soybean, the big seeds are used in the production of, for example, tofu and miso and the small seeds are used in the production of sprouts and natto. Knowledge of the relationship between seed composition and seed size would be, therefore, useful in developing these type of cultivars.

The objectives of this study were: (1) to quantify the oil and protein content in two groups of soybean genotypes, (2) to estimate the phenotypic, genotypic and environmental correlation among oil, protein content and seed size in these genotypes, and, (3) identify genotypes with high protein content for direct human consumption.

MATERIAL AND METHODS

Two experiments were carried out at Londrina State University (Londrina, Paraná State, Brazil). One in the field, at School Farm, and another in the greenhouse during the agricultural years of 1995/96 and 1996/97. The experiment carried out in the field used 25 lines (F_9 and F_{10} generations) from topcrosses between food-type soybean and two grain-type soybean testers, Doko and FT-2, plus the FT-Monsanto cultivar, totalling 28 treatments. The Genetic Dept of ESALQ/USP provided the populations that originated these lines (Table 1).,

In the first year, sowing was carried out on Nov. 07, 1995 and in the second year on Nov. 05, 1996. Treatments were arranged in a randomized complete block experimental design, with three replications. Each plot was made up of a 5.0-m single row. Spacing among plots was 1.0-m. One hundred seeds per plot were used. The seedlings were thinned at V_c stage (Vegetative cotiledonar stage of the scale of Fehr & Cavines, 1977), leaving 50 seedlings per plot. The soil type of the experiment area is “Structured Terra Roxa” (HAPLUDULT). Normal spraying with insecticides was used to control caterpillars and stink bugs, as required. Immediately before sowing, seeds were inoculated with *Bradyrhizobium japonicum*. Approximately 15 days after plants had reached harvesting maturity (R_8 stage of the scale of Fehr & Caviness, 1977) they were manually harvested and mechanically threshed.

The experiment carried out in the greenhouse (Dept of Agronomy, Londrina State University) was composed of 39 genotypes, among lines and cultivars of food-type soybean (Table 2), most of these provided by EMBRAPA/CNPSoja. Sowings took place on Dec. 06, 1995 and Nov. 04, 1996, respectively.

Table 1 - List of 28 soybean genotypes assessed at field. Londrina, PR. Sowing on November 07, 1995 and November 05, 1996.

01. GA1 (Cross 6 – PI229343 x Doko)	15. GA16 (Cross 117 – Tadacha x Doko)
02. GA2 (Cross 15 – Hogyoku x Doko)	16. GA17 (Cross 119 – IAC Santa Maria 702 x Doko)
03. GA3 (Cross 27 – PI80441 x Doko)	17. GA18 (Cross 119 – IAC Santa Maria 702 x Doko)
04. GA4 (Cross 27 – PI80441 x Doko)	18. GA19 (Cross121 –Stwart x Doko)
05. GA5 (Cross 54 – Pluto x Doko)	19. GA20 (Cross 18 – Imperial x Doko)
06. GA6 (Cross 60 – PI 230970 Sel x Doko)	20. GA21 (Cross 18 – Imperial x Doko)
07. GA7 (Cross 63 – PI 165676 x Doko)	21. GA22 (Cross 18 – Imperial x Doko)
08. GA8 (Cross 69 – Tamba x Doko)	22. GA23 (Cross 18 – Imperial x Doko)
09. GA9 (Cross 72 – Late Giant x Doko)	23. GA24 (Cross 24 – PI 80459 x Doko)
10. GA10 (Cross 78 – Japão 2 x Doko)	24. GA25 (Cross 55 – Pluto x FT-2)
11. GA11 (Cross 87 – Biloxi 252 N x Doko)	25. GA15 (Cross 101 – Ivaí x Doko)
12. GA12 (Cross 93 – Aliança Preta x Doko)	26. FT-2
13. GA13 (Cross 93 – Aliança Preta x Doko)	27. Doko
14. GA14 (Cross 101 – Ivaí x Doko)	28. FT- Monsanto

The experimental design was the same as used in the field experiment, but a three-plant vase constituted each plot.

Evaluated characters:
Weight of a hundred seeds (WHS): The seed size was given by weighting a sample of 100 seeds, expressed in grams.
Oil content (OC): The oil content was determinated gravimetrically after extraction using petroleum ether, in a Soxhlet instrument, technique 920.85 (AOAC, 1990), expressed in dry matter %.
Protein content (PC): The protein content was obtained by total nitrogen determination, according to the micro Kjeldahl method, technique 920.87 (AOAC, 1990), using a 6.25 conversion factor and expressed in dry matter % as well.

Table 2 - List of 39 soybean genotypes assessed at greenhouse. Londrina, PR. Sowing on December 06, 1995 and November 04, 1996.

01. BR-27	11. Faz. Progresso	21. Soja Feira 86-14	31. PI205085
02. F82-5722A	12. F83-8185	22. PI423909	32. PI408251
03. F82-5722P	13. F83-8192	23. Tambagura	33. B6F4 (L-1 less)
04. F82-5769	14. TMV	24. BR 92-15360	34. B5F5 (L-2 less)
05. F82-5782	15. Ivaí	25. BR 92-22106	35. B6F4 (L-3 less)
06. F82-5813	16. Delsta	26. 91K 208-3-1	36. Kunitz 1
07. F82-7843	17. F83-8207^{A}B	27. Late Giant	37. Kunitz 2
08. F83-8017	18. Soja Feira 86-13	28. FT-Monsanto	38. Natto
09. Majos	19. Easycook	29. Tamahomare	39. Paranagoiana
10. Sel. Stwart	20. F83-7977	30. Waseda	

Variance analysis and its component parts: Statistical analysis were made using the software Genes (Cruz, 1997). The variance analysis was carried out using traditional proceedings. OC and PC data were transformed by Arc Sen$\sqrt{x/100}$ which is, according Gomez & Gomez, 1984, the most appropriate transformation for data expressed in %. Individual and combined analysis of variance (ANOVA) were performed according to the system proposed by Cruz (1997) and Cruz & Regazzi (1997), respectively, considering that genotype was a fixed effect and environment (year) and genotype x years effects were random effects. Genetic variances were estimated among treatments ($\hat{\phi}_g$), among years ($\hat{\sigma}^2_y$), among treatments x years ($\hat{\sigma}^2_{gy}$) and error ($\hat{\sigma}^2_e$).

Comparison among means: Mean comparisons were carried out using criteria proposed by Scott & Knott (1974).

Correlations estimation: The phenotypic (r_P), genotypic (r_G) and environmental (error) (r_E) correlations were calculated using the following formula:

$$r_P = \frac{\hat{COV}_{\bar{P}(x,y)}}{\sqrt{\hat{V}_{\bar{P}(x)} . \hat{V}_{\bar{P}(y)}}}$$

$$r_G = \frac{\hat{COV}_{G(x,y)}}{\sqrt{\hat{V}_{G(x)} . \hat{V}_{G(y)}}}$$

$$r_E = \frac{\hat{COV}_{E(x,y)}}{\sqrt{\hat{V}_{E(x)} . \hat{V}_{E(y)}}}$$

Where: $\hat{COV}_{\bar{P}(x,y)}$, $\hat{COV}_{G(x,y)}$ and $\hat{COV}_{E(x,y)}$; correspond to phenotypic, genotypic and environmental covariance among the characters x and y; and $\hat{V}_{\bar{P}(x)}, \hat{V}_{\bar{P}(y)}, \hat{V}_{G(x)}, \hat{V}_{G(y)}, \hat{V}_{E(X)}$ and $\hat{V}_{E(Y)}$ corresponds to phenotypic, genotypic and environmental variances for characters x and y. The significance of the phenotypic correlation was checked by a t-test, with n-2 degrees of freedom.

Parting of treatments x years interaction: The parting of treatments x years (TxY) interaction was made according to the system proposed by Banzatto & Kronka (1989).

RESULTS AND DISCUSSION

Correlations among characters: Table 3 shows the estimated phenotypic, genotypic and environmental correlation. It is important to emphasize at this point that the estimated genetic correlation from combined analysis offers a better evaluation of the real relationship between characters, since it uses a genetic variance isolated from year variance and from TxY interaction variance. This doesn't happen in individual analysis where the genetic variance includes these two other variances.

In the field experiment, for the combined analysis, the r_F between WHS and OC, WHS and PC, and OC and PC were 0.69**, -0.42* and -0.59**, respectively. The rG between WHS and OC was 0.82, and between WHS and PC –0.84. Combined analysis showed a high, positive and significant r_P between WHS and OC, a medium-high and highly significant r_P between OC and PC, however negative (-0.59**). The negative r_P between WHS and PC was relatively low, although significant (-0.42*).

Table 3 - Phenotypic (r_P), genotypic (r_G) and environmental (r_E) correlations among three characters in two soybeans populations. Londrina, PR. Individual (1995, 1996) and combined analysis (1995+1996).

Year	Characters	r_F	r_G	r_E
		Field		
1995		0.79**	0.87	-0.19
1996	WHSxOC	0.51**	0.56	0.13
1995+1996		0.69**	0.82	0.01
1995		-0.36	-0.44	0.12
1996	WHSxPC	-0.25	0.50	0.13
1995+1996		-0.42*	-0.84	0.12
1995		-0.43*	-0.56	0.04
1996	OcxPC	-0.28	-0.62	0.02
1995+1996		-0.59**	-	0.03
		Greenhouse		
1995		0.32*	0.41	-0.18
1996	WHSxOC	0.09	0.09	0.14
1995+1996		0.20	0.24	-0.03
1995		0.05	0.09	-0.10
1996	WHSxPC	-0.03	-0.04	0.17
1995+1996		0.02	0.04	-0.003
1995		-0.19	-0.23	0.13
1996	OcxPC	-0.43**	-0.45	-0.34
1995+1996		-0.45**	-0.65	-0.22

*, ** indicate significance by t-test at 5% and 1% level of probability.

Looking at the correlation estimated individually (year by year), it was observed that r_P and r_G between OC and WHS had a significant fall in 1996, compared to 1995. The correlation between PC and OC changed from one year to other as well. Genotypic correlation became a bit more pronounced from 1995 to 1996 (-0.56 to -0.62), and r_P fell (-0.43* to -0.28).

In general based on, the correlation resulting from individual analysis as well as results from combined analysis, it was found that r_G presented higher values with the same orientation as those of phenotypic correlations. These results agreed with results obtained by Johnson et al. (1955), Anand & Torrie (1963), Kwon & Torrie (1964), Smith & Weber (1968), Byth *et al.* (1969), Freire Filho (1988) and Zimback (1992) and indicated that the phenotypic expression from association between characters was reduced due to environmental effects. Among the r_F values, all of them differed from zero by the t-test, however, the correlation between WHS and PC differed at 5% level, and between WHS and OC and between WHS and PC at 1% level.

Regarding the relationship between WHS and OC, and WHS and PC, various researchers obtained similar results. Tinius *et al.* (1993) reported phenotypic values for seed size and oil content in three subpopulations as 0.87, 0.94 and 0.97 and for seed size and protein content in two soybean subpopulations as -0.97 and -0.86. Pantalone *et al.* (1996) evaluating a F_2 generation estimated a genotypic correlation of 0.21±0.16 for seed size and oil content. However, Miranda (1994) obtained negative estimates for this correlation (-0.24 and -0.29) while Mayor & Soto (1985) obtained positive estimates for seed size and protein content, with correlation values at 0.11 (winter) and 0.21 (summer). The literature shows a large variation in correlation magnitudes among these characters due to differences among environments and evaluated populations.

In the greenhouse, combined analysis showed a genetic correlation between WHS and OC, WHS and PC, and OC and PC of 0.24, 0.04 and -0.65, respectively. Phenotypic correlation values were 0.20, 0.02 and -0.45**, respectively. This showed that the correlation between WHS and OC, and WHS and PC tended to disappear, while the correlation between OC and PC reached medium and negative values (r_P = - 0.45**, r_G = -0.65).

The combined analysis presented a low and highly significant phenotypic correlation between OC and PC (r_P = -0.45**), a low and not significant r_P between WHS and OC (r_P = 0.20) and a null r_P (not significant) between WHS and PC (r_P = 0.02). This suggested that although different populations were used under field and greenhouse conditions, the greenhouse conditions (more stable) tended to reduce the correlations among WHS, OC and PC. The genetic correlations was slightly higher than phenotypic correlation between WHS and OC (r_G = 0.24), and WHS and PC (r_G = 0.04). However, the genetic correlation between OC and PC was higher than phenotypic in magnitude (r_G = - 0.65).

By examining the relationships among characters, under greenhouse conditions, during evaluated years, we could verify that the correlations between WHS with OC and PC was, in general, very low, specially that between WHS and OC. The correlations between WHS and PC in spite of remaining practically null on both years, was negative in 1996. The correlation between OC and PC in 1995 had low values and in 1996 presented medium values, indicating that this relationship was highly affected by years. These results were to those obtained by Johnson *et al.* (1955), Kwon & Torrie (1964), Tinius *et al.* (1993) and Pantalone *et al.* (1996).

Variance analysis: Individual analysis showed highly significant differences among treatments on both years for WHS and OC, while PC showed this result only for 1995 (Table 4). The mean square (MS) among treatments were similar for both studied years considering the character WHS (112 e 129) and very different to OC and PC, showing that the variability of WHS was not so affected by years (Table 4). The same thing did not happen to PC, which was expensively reduced in 1996 with no significant differences among treatments. Individual analysis at greenhouse showed highly significant differences among treatments on both studied years for all studied characters (Table 4). The relationship between the biggest and the smallest MS of error from the field individual analysis were 1.00, 3.08 and 1.35 to WHS, OC and PC, respectively, neither exceeding the relation 4:1 established by Box (1954) nor the relation 7:1 suggested by Banzatto & Kronka (1989) for the performance of combined analysis. It meant that the relationship between extreme MS of error indicated the homogeneity of environments, and, therefore indicated that data could be submitted to combined analysis.

The behavior of treatments, years and TxY interaction were significantly different as shown by the combined analysis, except for PC that did not show significant differences among treatments (Table 4). MS magnitudes emphasized that the variability for years was many times superior than that for the effect of interaction, reaching the extreme of being 32 times higher for OC. The high variance for the TxY interaction showed differences among genotypes behavior on both evaluated years to all characters.

For the greenhouse experiment, the relationship among the biggest and the smallest MS of error were 1.94, 1.72 and 1.43, respectively for WHS, OC and PC, indicating that the environments were homogeneous and could be submitted to combined analysis. Combined analysis showed significant differences among treatments and TxY interaction in the three characters. Years showed significant differences for PC, but not for WHS and OC. The significant TxY interaction and the high value of this interaction showed that the genotypes behaved differently on both studied years in all three characters (Table 4).

According to the Scott & Knott (1974) grouping system, the field experiment showed, in the combined analysis, that treatments were more clearly distinguished in the WHS character (Table 5).

Table 4 - Degrees of freedom and mean squares from individual (1995, 1996) and combined analysis (1995+1996) for three characters. Field and greenhouse experiments. Londrina, PR.

	SOURCES OF VARIATION							
	B/R/Y		Treatments		Years		TxY	
Year	DF	MS	DF	MS	DF	MS	DF	MS
				Field				
				Weight of hundred seeds				
1995	2	1,37	27	112,86**	-	-	-	-
1996	2	5,63	27	129,04**	-	-	-	-
1995+1996	4	3,50	27	237,67**	1	68,40*	27	4,22**
				Oil content				
1995	2	0,08	27	6,75**	-	-	-	-
1996	2	0,33	27	15,81**	-	-	-	-
1995+1996	4	0,21	27	17,50**	1	163,65**	27	5,06**
				Protein content				
1995	2	1,10	27	6,54**	-	-	-	-
1996	2	9,20	27	3,57 NS	-	-	-	-
1995+1996	4	5,16	27	5,86 NS	1	27,36*	27	4,25*
				Greenhouse				
				Weight of Hundred Seeds				
1995	2	3,96	38	232,85**	-	-	-	-
1996	2	3,28	38	307,31**	-	-	-	-
1995+1996	4	3,62	38	513,43**	1	0,20 NS	38	26,72**
				Oil Content				
1995	2	0,20	38	6,03**	-	-	-	-
1996	2	8,57	38	11,64**	-	-	-	-
1995+1996	4	4,39	38	13,78**	1	17,35 NS	38	3,89*
				Protein Content				
1995	2	1,40	38	4,05**	-	-	-	-
1996	2	0,08	38	6,88**	-	-	-	-
1995+1996	4	0,74	38	8,04**	1	13,50*	38	2,90**

*, ** indicate significance at 5% and 1% level of probability; and NS not significant, by F test.

Table 5 - Original means from three replicates of 28 assessed genotypes in two years. Field, Londrina, PR. Sowing on November 07, 1995 and November 05, 1996.

Treatments	WHS	OC[a]	PC[a]	Treatments	WHS	OC[a]	PC[a]
GA10	30.35 a	18.08 a	39.42 a	GA11	20.08 f	17.42 a	37.28 b
GA4	27.67 b	18.71 a	38.95 a	GA19	19.12 g	16.83 a	39.46 a
GA3	26.89 b	14.61 b	37.89 b	FT-2	18.07 g	18.44 a	35.66 b
GA6	26.14 c	17.04 a	38.53 a	Doko	17.90 g	18.28 a	37.63 b
GA1	25.73 c	17.28 a	39.32 a	GA5	17.01 h	15.18 b	37.01 b
GA9	25.04 d	18.18 a	39.14 a	GA15	16.01 h	17.81 a	36.96 b
GA7	24.59 d	17.89 a	39.76 a	GA18	13.80 i	15.16 b	39.51 a
GA12	23.84 e	19.08 a	35.71 b	GA17	13.75 i	15.11 b	41.75 a
GA16	23.16 e	16.66 a	36.33 b	GA25	13.44 i	14.44 b	38.33 a
GA13	23.02 e	17.74 a	38.49 a	GA24	10.93 j	12.75 c	40.57 a
GA14	21.27 f	20.37 a	36.00 b	GA21	10.03 j	12.80 c	39.56 a

FT-Monsanto	21.22 f	19.77 a	38.41 a	GA23	08.76 l	14.68 b	41.16 a
GA8	20.83 f	17.38 a	38.61 a	GA20	08.63 l	14.70 b	40.55 a
GA2	20.22 f	17.03 a	38.43 a	GA22	08.58 l	12.00 c	41.57 a
Average	19.14	16.62	38.64	VC (%)	05.56	05.72	03.92

Means followed by the same letter don't differ from one another by Scott & Knott, 1974 at 5% level of probability.

[a] Means test with transformed data by Arc Sen $\sqrt{x/100}$.

Table 6 - Original means from three replicates of 39 assessed genotypes in two years. Greenhouse, Londrina, PR. Sowing on December 6, 1995 and November 04, 1996.

Treatments	WHS	OC [a]	PC [a]	Treatments	WHS	OC[a]	PC [a]
Tambagura	58.73 a	19.52 b	39.08 a	F82-5813	22.63 h	20.14 a	34.30 c
F83-8192	41.84 b	17.61 c	38.44 a	Faz. Progresso	22.04 h	19.54 b	35.36 c
F83-8185	40.31 b	16.99 c	36.15 b	Soja Feira 86-14	21.95 h	15.71 c	39.42 a
Late Giant	36.86 c	19.26 b	37.20 b	PI423909	21.93 h	17.59 c	38.39 a
F82-5722P	36.18 c	16.52 c	34.32 c	TMV	21.42 h	18.89 b	35.33 c
Soja Feira 86-13	34.05 d	18.02 b	36.41 b	BR 92-22106	21.20 h	19.27 b	36.54 b
F83-8207AB	33.78 d	21.79 a	35.54 c	Kunitz 1	20.88 h	16.76 c	36.28 b
F82-5769	31.99 e	16.36 c	37.48 b	Ivaí	20.82 h	18.63 b	34.97 c
F83-8017	30.72 e	16.27 c	37.26 b	91K 208-3-1	20.48 h	19.13 b	36.12 b
F82-5722A	29.98 e	16.88 c	33.90 c	Kunitz 2	19.83 h	18.71 b	36.93 b
FT-Monsanto	27.61 f	18.22 b	35.97 b	BR-27	19.65 h	16.59 c	34.82 c
Tamahomare	27.56 f	17.07 c	34.84 c	Sel. Stwart	18.16 i	21.02 a	36.74 b
Waseda	27.54 f	16.89 c	39.66 a	Easycook	17.84 i	15.64 c	36.95 b
F82-5782	27.52 f	17.63 c	39.56 a	Majos	15.72 j	18.63 b	36.22 b
F83-7977	27.10 f	19.24 b	35.81 b	BR 92-15360	15.53 j	18.92 b	36.79 b
B6F4 (L-3 less)	26.60 f	14.96 c	39.17 a	Paranagoiana	15.27 j	17.44 c	32.95 c
B6F4 (L-1 less)	26.40 f	16.44 c	38.23 a	PI205085	13.42 l	12.26 d	41.08 a
F82-7843	24.59 g	21.68 a	35.94 b	Natto	12.43 l	16.10 c	37.29 b
B5F5 (L-2 less)	24.16 g	15.64 c	35.05 c	PI408251	10.78 l	15.15 c	41.56 a
Delsta	23.97 g	20.93 a	35.30 c				
Average	25.37	17.80	36.75	VC (%)	07.85	06.11	03.38

Means followed by the same letter don't differ from one another by Scott & Knott, 1974 at 5% level of probability.

[a] Mean tests with transformed data by Arc Sen $\sqrt{x/100}$.

The average in the 28 treatments for WHS was 19.14 g. The maximum value was 30.35 g/100 seeds to GA10, which differed significantly from the others according to the Scott & Knott (1974) grouping test at 5% of significance level. The minimum observed value was 8.58 g/100 seeds to GA22, which showed no difference from GA20 and GA23 (Table 5). The combined analysis showed that the average for OC was 16.62%. The maximum obtained value for this character was 20.37% for GA14 which showed no significant difference from the other 17 treatments. The minimum value was 12% obtained by GA22 which did not differ significantly from GA21 and GA24. For PC, the average of genotypes was 38.64% and the minimum value was presented by FT-2 (35.66 %), not differing from the other eight treatments. GA17 showed the biggest PC (41.75 %) not differing significantly from the other 18 treatments (Table 5). Variation coefficients (VC) for combined analysis were 5.56, 5.72, and 3.92% for WHS, OC and PC, respectively (Table 5). Marschalek (1995) obtained VC varying from 2.45 to 3.74% for OC which were 2.49 to 3.39% by Soldini (1993). Marschalek (1995) obtained VC estimates of 6.04% for PC and 9.58% for WHS. Pulcinelli (1992) reported values of 3.8 and 4.4% for VC of PC. Thus, the precision of this experiment, evaluated by the obtained VC values, could be considered satisfactory.

In the greenhouse experiments, average for the 39 treatments for WHS was 25.37 g / 100 seeds. The maximum value was obtained by Tambagura with 58.73 g/100 seeds, differing from other genotypes significantly (at level of 5% of significance). The minimum value for the WHS characteristic was observed in PI408251 with 10.78 g/100 seeds, which did not differ significantly from Natto and

PI205085. The mean of treatments for OC was 17.80% and the maximum value of 21.79% was reached by the F83-8207AB treatment, which did not differ significantly from F82-7843, Delsta, Sel. Stwart and F82-5813.

The lower OC was presented by the PI205085 treatment, which differed significantly from the rest. The average PC for the 39 genotypes was 36.75% whereas the maximum observed value was 41.56% for PI408251, which did not differ from the other nine treatments. The lower observed value for PC was 32.95%, obtained by Paranagoiana, which did not differ significantly, by the Scott & Knott, 1974, grouping test from the other 11 treatments (Table 6). The VC values observed in the combined analysis were 7.85, 6.11 and 3.38% for WHS, OC and PC, respectively. These values showed that the experimental accuracy was satisfactory.

Table 7 - Partition of Mean Square. Behavior of the years within each treatment. Field, Londrina, PR. Sowing on November 07, 1995 and November 05, 1996.

Sources of V.	Mean Squares			Sources of V.	Mean Squares		
(Years within)	WHS	OC	PC	(Years within)	WHS	OC	PC
GA1	6.04*	8.10*	0.56^{NS}	GA16	17.20**	0.02^{NS}	0.40^{NS}
GA2	11.48**	10.45**	0.60^{NS}	GA17	0.74^{NS}	10.38*	0.06^{NS}
GA3	3.01^{NS}	58.84**	0.54^{NS}	GA18	0.10^{NS}	10.72*	2.68^{NS}
GA4	11.70**	0.21^{NS}	0.13^{NS}	GA19	2.00^{NS}	0.04^{NS}	4.13^{NS}
GA5	19.95**	45.65**	6.87^{NS}	GA20	0.02^{NS}	7.30^{NS}	2.55^{NS}
GA6	5.92*	12.67*	0.71^{NS}	GA21	1.53^{NS}	15.52**	15.81**
GA7	0.83^{NS}	16.04**	0.90^{NS}	GA22	0.29^{NS}	13.80**	6.14^{NS}
GA8	14.11**	8.47*	6.87^{NS}	GA23	0.44^{NS}	1.26^{NS}	2.57^{NS}
GA9	3.20^{NS}	4.13^{NS}	1.18^{NS}	GA24	0.01^{NS}	12.38*	0.65^{NS}
GA10	13.23**	7.50*	23.84**	GA25	0.93^{NS}	0.004^{NS}	13.32*
GA11	0.19^{NS}	22.66**	0.42^{NS}	GA15	13.86**	5.92^{NS}	17.51**
GA12	0.09^{NS}	1.57^{NS}	1.58^{NS}	FT-2	14.60**	0.98^{NS}	13.47*
GA13	1.79^{NS}	18.90**	0.34^{NS}	Doko	1.95^{NS}	0.34^{NS}	4.18^{NS}
GA14	11.15**	3.29^{NS}	3.65^{NS}	FT- Monsanto	26.08**	3.17^{NS}	10.38*
Mean error	1.14	1.88	2.27				

*, ** indicate significance at 5% and 1% level of probability; and ^{NS} not significant, by F test.

Table 8 - Partition of Mean Square. Behavior of the years within each treatment. Greenhouse, Londrina, PR. Sowing on December 06, 1995 and November 04, 1996.

Source of V	Mean Squares			Source of V	Mean Squares		
(Years within)	WHS	OC	PC	(Years within)	WHS	OC	PC
BR-27	0.0004^{NS}	0.22^{NS}	0.002^{NS}	Soja Feira 86-14	16.90*	13.74*	4.43^{NS}
F82-5722A	0.63^{NS}	0.63^{NS}	0.74^{NS}	PI423909	6.66^{NS}	4.42^{NS}	1.21^{NS}
F82-5722P	1.47^{NS}	3.00^{NS}	7.33*	Tambagura	260.83**	0.98^{NS}	2.47^{NS}
F82-5769	0.16^{NS}	0.65^{NS}	1.09^{NS}	BR 92-15360	5.51^{NS}	0.007^{NS}	0.02^{NS}
F82-5782	50.69**	1.37^{NS}	8.05*	BR 92-22106	5.17^{NS}	0.16^{NS}	2.11^{NS}
F82-5813	4.75^{NS}	7.48^{NS}	4.54^{NS}	91K 208-3-1	1.12^{NS}	5.19^{NS}	9.60*
F82-7843	0.59^{NS}	2.45^{NS}	0.98^{NS}	Late Giant	13.77^{NS}	4.23^{NS}	1.99^{NS}
F83-8017	15.26 ^{NS}	6.74^{NS}	0.71^{NS}	FT-Monsanto	1.52^{NS}	25.22**	20.50**
Majos	18.66*	0.22^{NS}	3.99^{NS}	Tamahomare	0.01^{NS}	0.82^{NS}	7.10*
Sel. Stwart	4.65^{NS}	32.85**	2.37^{NS}	Waseda	0.14^{NS}	2.90^{NS}	3.21^{NS}
Faz. Progresso	305.73**	0.95^{NS}	1.46^{NS}	PI205085	6.49^{NS}	2.61^{NS}	7.96*
F83-8185	2.32^{NS}	0.65^{NS}	0.17^{NS}	PI408251	0.14^{NS}	2.76^{NS}	0.67^{NS}
F83-8192	29.97**	8.93*	1.68^{NS}	B6F4 (L-1 less)	5.86^{NS}	1.74^{NS}	8.31*
TMV	6.51^{NS}	5.36^{NS}	0.10^{NS}	B5F5 (L-2 less)	86.26**	0.16^{NS}	3.94^{NS}
Ivaí	12.44^{NS}	1.62^{NS}	3.21^{NS}	B6F4 (L-3 less)	1.38^{NS}	0.64^{NS}	2.22^{NS}
Delsta	1.02^{NS}	1.59^{NS}	0.0005^{NS}	Kunitz 1	4.23^{NS}	0.42^{NS}	0.14^{NS}
F83-8207AB	52.69**	0.44^{NS}	0.04^{NS}	Kunitz 2	7.09^{NS}	2.09^{NS}	0.08^{NS}
Soja Feira 86-13	3.48^{NS}	2.21^{NS}	0.005^{NS}	Natto	0.39^{NS}	4.05^{NS}	0.46^{NS}

Easycook	0.55^{NS}	7.26^{NS}	5.42^{NS}	Paranagoiana	15.55*	5.88^{NS}	4.97^{NS}
F83-7977	65.01**	2.48^{NS}	0.59^{NS}				
Mean error	3.97	2.32	1.59				

*, ** indicate significance at 5% and 1% level of probability; and ^{NS} not significant, by F test.

Treatments x years interaction: Table 4 showed that TxY interaction was significant to all three characters studied on both field and greenhouse experiments, suggesting that the genotypes behavior was influenced systematically by year.

To know more about this interaction, two partitions of MS were made: one looking for the behavior of treatments within years and other searching for the behavior of years within each treatment. The behavior of years within treatments indicated the stability of characters within each treatment due to environmental differences in the years. Table 7 shows the behavior of years within treatments in the field experiment. The environmental variation of years presented either higher or lower importance to treatment performance depending on the considered character. Thus, from 28 studied genotypes, 22 did not suffer interaction within years for PC, 16 for WHS and 13 for OC. However, the treatments that were affected by this interaction, in most cases, were highly significant. For the genotypes carried out in the greenhouse (Table 8) environmental variation of years influenced only a small part of the treatments. Thus, from the 39 studied genotypes, 25 did not suffer years interaction for PC, 35 for WHS and 32 for OC. This showed that under greenhouse conditions, as expected, a bigger environmental homogeneity could be obtained for years. From the 39 studied genotypes in the greenhouse experiment, 22 were not affected by the years in the three assessed characters. They were the following genotypes: BR-27, F82-5722A, F82-5769, F82-5813, F82-7843, F83-8017, F83-8185, TMV, Ivaí, Delsta, Soja Feira 86-13, Easycook, PI423909, BR 92-15360, BR 92-22106, Late Giant, Waseda, PI408251, B6F4 (L-3 less), Kunitz 1, Kunitz 2 e Natto. All other treatments presented diferences in at least one of the assessed characters, and, among them seven genotypes [Majos, Faz. Progresso, F83-8207AB, F83-7977, Tambagura, B5F5 (L-2 less) and Paranagoiana] did not suffer the time effect as much as the oil and protein contents.

CONCLUSIONS

1) The population carried out in the field presented an average oil content of 16.62 %, ranging from 12 (GA22) to 20.37 % (GA14), and an average protein content of 38.64 %, ranging from 35.66 (FT-2) to 41.75 % (GA17). On the other hand, the experiment carried out in the greenhouse presented an average oil content of 17.80 %, ranging from 12.26 (PI205085) to 21.79 % (F83-8207AB), and an average protein content of 36.75 %, ranging from 32.95 (Paranagoiana) to 41.56 % (PI408251).

2) There was a high and negative correlation between oil and protein contents.

3) At the field experiment, the combined analysis showed a high and highly significant relationship between WHS and OC (r_P = 0.69**), whereas the relationship was low, negative and significant (r_P = -0.42*) between WHS and PC.

4) In the greenhouse experiment, the combined analysis showed a low and not significant relationship between WHS and OC (r_P = 0.20), and, between WHS and PC (r_P = 0.02). The individual analysis showed that the relationships among these characters, although low, were highly affected by the time effect.

5) Due to their high protein contents and stability to oil and protein contents, there were distinction among the treatments carried out in the field (GA23 and GA20) and those carried out in the greenhouse (PI408251, Waseda, B6F4 (L-3 less), PI423909 and Tambagura).

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RESUMO

Durante 1995/96 e 1996/97, foram conduzidos experimentos na Universidade Estadual de Londrina, visando: quantificar os teores de óleo e proteína em dois grupos de genótipos de soja tipo alimento; estimar as correlações fenotípicas e genotípicas existentes entre os teores de óleo, proteína e tamanho das sementes; e, identificar genótipos para consumo humano de forma direta, com elevado teor de proteína. Foram avaliados os caracteres Peso de Cem Sementes (PCS, expresso em gramas / 100 sementes), Teor de Óleo (TO), e Teor de Proteína (TP), expressos em %. Na população conduzida a campo, a característica TO variou de 12 a 20,4 %, e TP de 35,7 a 41,8 %. A população conduzida em casa de vegetação apresentou uma variação de 12,3 a 21,8 % para TO, e de 33 a 41,6 % para TP. As correlações entre TO e TP foram negativas e significativas. A relação do PCS com TO e TP mostrou-se baixa e muito afetada pelos efeitos dos anos. Devido aos seus altos teores de proteína e estabilidade para os teores de óleo e proteína, destacaram-se, dentre os tratamentos conduzidos a campo, GA23 e GA20; e, dentre os tratamentos conduzidos em casa de vegetação, PI408251, Waseda, B6F4 (L-3 less), PI423909 e Tambagura.

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