Scientific Electronic Archives
Issue ID: Sci. Elec. Arch. Vol. 13 (12)
December 2020
DOI: http://dx.doi.org/10.36560/131220201242
Article link
http://sea.ufr.edu.br/index.php?journal=SEA&page=article&op=view&path%5B%5D=1242&path%5B%5D=pdf
Included in DOAJ, AGRIS, Latindex, Journal TOCs, CORE, Discoursio Open Science, Science Gate, GFAR, CIARDRING, Academic Journals Database and NTHRYS Technologies, Portal de Periódicos CAPES, CrossRef, ICI Journals Master List.

ISSN 2316-9281

Correlation between productivity and centesimal composition of soybean cultivars

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Abstract: Soy soybean Glycine max (L) Merril is one of the main agricultural crops in Brazil. Thanks to the advances made by the breeding programs in recent years, the crop has achieved increasingly satisfactory results, especially with regard to the productivity of cultivated materials. One of the effects of the productive potential for the significant increase of the area planted throughout the national territory. Unfortunately one of the consequences of this genetic advance in the soybean materials produced was in relation to the chemical composition of the grains. In the last decades the centesimal composition of the soybean, especially protein, has suffered a significant discount. This is reflected in the overwhelming industries that find it increasingly difficult to produce bran with protein within the commercialized specifications, having to resort to a little profitable practice, the removal of the tegument from the grain to increase the protein in the bran produced. As the market operates through buying and selling by quantity and not grain quality, the sector begins to express concern due to uncertainties in the raw material. Thus, the present work has the objective of evaluating the existence of a correlation between productivity and the chemical composition of soybean cultivars. The cultivars were selected according to their productivity and divided into three classifications, high productivity, average productivity and low productivity, based on the work of the Rio Verde Foundation, totaling nine samples. The samples were evaluated through physicochemical analyzes to determine the percentage of coarse and fine moisture of the grains, percentage of acidity of the oil and percentage of protein and oil of the grains. All analyzes were done in triplicates and the results were submitted to analysis of variance (ANOVA), followed by a Tukey average comparison test at 5 %. The percentage of coarse moisture of cultivar 5 was the highest among all cultivars evaluated, with 10.43 %. In relation to the fine moisture, again the variety 5 obtained greater percentage among all the materials, with 9,17 %. Regarding the percentage of acidity, cultivars 4, 2 and 3 obtained the highest results with values between 0.51 % and 0.46 %. The percentage of oil of cultivar 3 obtained the highest percentage, with 21.96 %. Regarding the percentage of protein, cultivar 5 presented the highest percentage of protein among all, with 35.78 %. All results are presented within acceptable industry standards. Through the analyzes can see a tendency to low negative correlation between productivity and protein content. There is also a low negative correlation between oil and protein dyes. Positive highlight for the performance of cultivar 5 by good correlation between productivity and protein contents.
Key-words: Acidity, Chemical composition, Feedstock, Protein, Oil.

Introduction

The culture of soy has great prominence in Brazil and in the world. On average, the composition of the grain has 40.3% protein, 21.0% oil, 33.9% carbohydrate and 4.9% ash on a dry basis (Perkins, 1995). Its main destination, both in Brazil and in the world, is the use of grain for the production of its by-products, bran and oil. Bran, the main economic use of soybeans, is rich in protein, used mainly in the poultry, pork and cattle feed industry. On the other hand, oil is used as raw material by the industry for the production of refined oil, hydrogenated fat, margarines, mayonnaise and other products (Mandarino & Roessing, 2001). More recently, it has been the main product for the production of biodiesel in Brazil (ANP, 2015) and in the USA (BiodieseL, 2015).

In the last decades, agricultural expansion in Brazil with favorable areas, adequate climate, low cost of cultivation, combined with a culture with a growing market, resulted in a large investment for genetic improvement of the plant. In corroboration, the national average soybean yield rose from 1,250 kg.ha-1 in the 1970s to 2,800 kg.ha-1 in the 2000s and, currently, the national average is around 3,000 kg.ha -1 (EMBRAPA, 2015). It is worth noting that the genetic improvement of soybeans was basically prioritized for increasing productivity, which has resulted in a negative relationship with the quality of the seed composition, especially the protein content. Genetic improvement companies have done little work on the composition of the grain. Firstly, the emphasis has been on productivity and not on the quality of the composition of the grains and, secondly, the lack of incentive to cultivate material with better compositions, since the producer receives for quantity and not for quality or by the protein and oil content of the grains (Pípolo et al., 2015).

The crushing industries, which are soybeans and their complex, composed of oil, bran and husks (Vicente et al., 2001), buy soybeans by weight and related qualities such as moisture, damage and impurities. Thus, the chemical composition of grains, protein and oil are not evaluated and considered. Despite this, the crushing process for obtaining the products, oil and bran, the soy originated in one, becoming a unique grain mass, which results in a difficulty in producing a bran with specifications required by the market, in with 48% protein. The main alternative is to adopt a strategy to remove the soybean seed coat, which corresponds on average to 7.3% of the grain weight, since this component has little protein and a lot of fiber in its composition, and when removed, it ends up raising the protein percentage of the bran produced.

Soybean productivity is strongly related to the plant's photosynthetic rate capacity. The photosynthetic rate is determined by the amount of the photosynthetic apparatus per unit of leaf area (Shibles et al., 1987). Therefore, the soybean plant must have an aerial part with great capacity for intercepting solar radiation and sufficient storage of N in the leaves to maintain the conditions for converting solar radiation into biomass and grains.

According to Pipolo et al. (2015), precisely because it is a plant with a high concentration of protein in the seeds, soy has a great demand for nitrogen. Therefore, soy remobilizes N from other vegetative organs of the plant to the seeds. The remobilization of N from vegetative organs begins around 7 to 10 days after R5, concomitantly with the accumulation of N in the grain until R7. Parallel to the decline in leaf N there is a decline in photosynthetic capacity. This is because most of the nitrogen in the leaves makes up the molecules of the physiologically active proteins, especially rubisco.

The metabolism to supply the nitrogen in its seeds causes the plant to compromise a large part of its photosynthetic rate and consequently production. Sinclair and Wit (1976) hypothesized that soy could be self-destructive, that is, the demand for N for the grain would exceed the plant's capacity to supply N, as a consequence, there would be the remobilization of N from plant tissues, especially leaves, leading to loss of photosynthetic capacity, senescence, shortening of the grain filling period and limitation of productive potential. These factors explain, at least in part, the inverse relationship between protein content and grain yield.

Despite being acquired by two main routes and are equally relevant to the plant, the targeting of nitrogen from different media is used in different ways in the plant. Zapata et al. (1987) reported that the application of 672 kg of mineral nitrogen per hectare did not change the plant's standard in remobilizing nitrogen from other parts of the plant for the grain requirement and that non-nodulated plants with application of 224 kg of nitrogen per hectare showed grains with lower N content than nodulated plants without application of N, indicating that the N of the fixation goes preferentially to the grain. Thus, the challenge to maximize both productivity and protein content in the grain is to facilitate the acquisition of N by the two main mechanisms, N-mineral and FBN.

The industrial sector has expressed concern about the difficulty of producing bran with 48% protein, resorting to the removal of the grain tegument. The low protein content in the grains is directly related to the direction given by the genetic improvement programs in soy. This fact can be explained by the greater emphasis given to increasing productivity and resistance to diseases and pests, than to the chemical composition of the grains; existence of a negative correlation between protein concentration and productivity, requiring more time and effort in genetic improvement and mainly due to the lack of economic incentives to date (Pípolo et al., 2015).

Although genetic influence results in this scenario, different studies have shown that there is an environmental influence on the concentration of protein and oil in soybeans. One explanation is the availability of nitrogen (N) for the plant, as this element is key in protein synthesis, affecting the entire plant metabolism. Harper (1987) and Hungary et al. (2005) suggested that N-mineral and FBN represent the main sources of N acquisition by soy. The latter being directly associated with the protein concentration in the grains. Therefore, special attention should be given to technologies that provide the maximum efficiency of the FBN process such as: use of high quality inoculant, correction of soil acidity, use of the No-Tillage System with soil cover, aiming to reduce temperature peaks in the soil and maintain its moisture, supply of cobalt (Co) and mobilidenium (Mo) and other nutrients that favor FBN.

In our research we seek to corroborate and correlate two important and inverse factors present in soybean culture, the productivity and quantification of the chemical composition of the grains. As mentioned, the low quality of the bran has resulted in increased costs for the transformation of products derived from soybeans with the standards established by the market. A reflection of this ends up being the increase in the price of soybean meal, the main raw material for feeding various animals and, consequently, an increase in the costs of the entire chain.

Methods

The present work was carried out in Nova Mutum - MT, located at a latitude of 30 ° 46 ’44” S and longitude 56 ° 04 ’56” W, with an altitude of 460 meters.

Samples of soybean cultivars for analysis were obtained from seed dealers in the region. The seeds had no chemical treatment for planting. For the experiment, nine soybean cultivars were obtained according to the yield characteristic, based on their commercial characteristics and on the work conducted by a Research Foundation in the 2014/15 harvest, in clayey soil in direct sowing in the residual off-season corn crop straw. . The cultivars were classified in three levels of productivity: Soy with high productivity (> 70 bags per hectare); soybean with average productivity (between 69 and 50 bags per hectare) and soybean with low productivity (> 49 bags per hectare). Then they were subjected to physical-chemical analysis to determine the composition of the seed in relation to protein content (Kjeldhal method), oil (Sebelin extraction method), moisture (greenhouse method), acidity (titratable method). All methods were reviewed by AOCS (2015).

The analyzes were performed in triplicates and analyzed by variance (ANOVA) followed by Tukey's means comparison test using the Assistat software. The variables yield, oil content and protein content of cultivars were also submitted to correlation analysis.

According to the methodology of the AOCS (American Oil Chemists' Society), the samples were divided into portions of 500 grams each. It is worth mentioning that in addition to the official methodology used in this work (physical-chemical), the samples were subjected to the Near Infrared spectroscopy (NIR) and Motomco method to determine humidity, in order to compare the results, but with the conventional method being considered in the job.

Results and discussion

Table 1 shows the results of the compositions of soybean cultivars obtained by the conventional physical-chemical methodology. All samples submitted to different methodologies, Near Infrared Spectroscopy (NIR) and for the determination of humidity the use of Motomco, presented similar results and within the acceptable deviation of 0.5%.

Table 1. Results of physical-chemical analysis of soybean cultivars evaluated

Grow crops	Thick Moisture (%)	Fine Humidity (%)	Acidity (%)	Ethereal Extract (%)	Crude Protein (%)
Plant 1	9,47 d	7,99 ef	0,33 c	20,57 d	33,95 cd
Plant 2	9,99 c	8,64 c	0,47 ab	21,19 b	33,68 de
Plant 3	9,50 d	8,11 de	0,46 ab	21,96 a	33,25 e
Plant 4	8,95 e	7,75 f	0,51 a	20,07 ef	33,67 de
Plant 5	10,43 a	9,17 a	0,31 c	20,04 ef	35,78 a
Plant 6	10,16 bc	8,83 bc	0,34 c	20,01 f	34,41 c
Plant 7	9,44 d	8,17 de	0,26 c	20,85 c	35,04 b
Plant 8	9,57 d	8,28 d	0,34 c	20,31 de	34,31 c
Plant 9	10,33 ab	9,03 ab	0,40 bc	19,98 f	33,45 de
CV (%)	0,67	1,12	9,22	0,47	0,57

* Means followed by the same letters in the columns do not differ by Tukey's test ($p < 0.05$).

Cultivar 5 had the highest coarse moisture content (10.43%) and cultivar 4 was the lowest (8.95%). Regarding the determination of fine moisture, following the results of the whole seeds, cultivar 5 again had the highest value (9.17%) and cultivar 4 the lowest (7.75%).

Considering this parameter, the humidity of the samples was satisfactory compared to what the industries look for in storage and crushing, between 12% and 9%. Values below this result in common problems in the grains, the shedding of the tegument and the breaking of the seed, promoting an increase in the attack area of oxygen and microorganisms, favoring the loss of protein and increased acidity (Mohler, 2010). Soybeans with values higher than acceptable increase the costs for crushers. According to Saio et al. (1980), grain moisture is the main factor that interferes with degradation during storage. The higher the water content in the grains, the lower the stability of the product and the more prone to deterioration due to the action of bacteria, yeasts and molds. There are also enzymatic and non-enzymatic chemical reactions, especially in the case of oilseeds, due to lipid oxidation (Ordóñez, 2005). During the crushing and production process, the by-products also have undesirable characteristics, such as, for example, increased acidity in the oil and moisture in the bran.

In this experiment, the acidity indices were higher for cultivar 4, 2 and 3, with values between 0.51% and 0.46%. The other six cultivars had similar values, between 0.40% and 0.26% of acidity index. All samples were within the standards recommended by the oil industries, according to Lacerda et al. (2008), up to 0.70%.

The acidity content is one of the main indicators of grain quality verified in the industries (Teixeira, 2001). According to Lacerda et al. (2008), the acidity of soybean oil varies naturally from 0.3% to 0.5%, when the seeds are in formation until the physiological maturation phase. As they are grains destined for commercialization and planting, with a small number of defects in the sample, naturally the expected percentage would be extremely low.

Another explanation for the expected low acidity is the grain moisture in the ideal soybean processing range, as mentioned above. Greggio & Bonini (2014) reported a strong and negative correlation between moisture and acidity content in soybeans, corroborating the idea of extreme humidity, too high or too low, can increase the acidity content. In general, the increase in acidity decreases the quality of the oil (Dorsa, 2004) and, it is for this reason that the calculation of this index is important in the evaluation of the deterioration state (hydrolytic rancidity) of the oil for consumption (Alves et al., 2009).

Regarding oil content, cultivar 3 had the highest percentage (21.96%). Another four cultivars were grouped with the lowest indexes (cultivars 9, 6, 5 and 4), with values between 20.07% and 19.98%. All results were between 8.0% and 25.4% and within the parameters found in the 16,472 accessions of the EMBRAPA SOJA Germplasm Bank. As well as the averages reported by Aparício et al. (2008), who cited values between 18 and 22%.

Protein contents were different between the cultivars evaluated. Cultivar 5 presented the highest percentage of crude protein (35.78%). Cultivars 2, 3, 4 and 9 had the worst results, being grouped between the values of 33.25% to 33.68%. The results of ether extract were between 31.7% and 57.9% and corroborated with the EMBRAPA SOJA Germplasm Bank. The values found were similar to those reported by Zanon (2007), but the results were lower than those reported by Greggio and Bonini (2014), who evaluated seeds from the State of Mato Grosso and obtained an average of 36.09% for protein in soy.

Pearson's linear correlation between yield and protein content of the soybean cultivars evaluated was -0.2. This correlation was low, negative and significant, which is consistent with the theory of other authors (Cober & Voldeng, 2000; Burton, 1987; Hartwig & Hinson, 1972; Wilcox & Cavins, 1995; Wilcox, 1998). Still, with the exception of cultivar 9, all cultivars with an average of <63 bags per hectare stood out over the cultivars with higher productivity when the ratio is protein content. The fact that cultivar 9 has a different result can be explained in part by environmental factors, since monitoring and cultivation conditions cannot be performed at work. According to Benzain and Lane (1986), depending on environmental conditions, the levels of protein, oil and acidity may increase according to the variety to be grown.

Another variable that proved to be inverse to protein contents was the oil content in the cultivars. The result of the present study corroborates the findings by Moraes et al. (2006), who evaluated two soybean strains and observed that as the oil content increased, the protein content decreased. Albrecht (2006) also reported a negative correlation between oil and protein content. One of the physiological explanations of these results is done by Pípolo (2002). According to the authors, there is a negative correlation by competition for carbon skeletons in the biosynthesis of oil and protein in soybeans.

It was evident that the measure in which productivity increased to the trend was to have a seed of lesser quality in relation to protein. The best explanation for this correlation is the hypothesis that the plant is "self-destructive" reported by Sinclair and Wit (1976), because the demand for N for the grain exceeds the plant's capacity to supply N, as a consequence, it would occur to the remobilization of N from the tissues. vegetables, mainly leaves, leading to loss of photosynthetic capacity, senescence, shortening of the grain filling period and limitation of productive potential.

Conclusions

In the conditions of this experiment it can be concluded that:

There is a low negative correlation between productivity and protein content.

There is a low negative correlation between oil content and protein content.

All analyzes had results within the specifications standardized by the industries.

Of the nine cultivars analyzed, the best performance was for cultivar 5, with a good correlation between productivity and protein levels.

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