QUALITY OF SOYBEAN SEEDS UNDER TILLAGE WITH DIFFERENT AMOUNTS OF WASTE OF BLACK OATS, COMMON VETCH AND FORAGE TURNIP

Márcia Maria Mauli, Lúcia Helena Pereira Nóbrega, Danielle Medina Rosa and Gislaine Piccolo de Lima

SUMMARY

Adjusting the cover crop to the agricultural system is essential to reach success during a crop introduction, since this management can influence development, productivity and produced seeds quality. For the soybean cultivar CD 202, traditional, half, and double amounts of crop waste produced by black oats, and a consortium of black oat, common vetch and forage turnip, were evaluated. Tests comprised emergence (emergency speed index (ESI) and emergence rate (ER)), development, field productivity and quality of seeds (germination percentage, accelerated aging, purity, 100-seed weight, and water content). The experimental design was of split plots and the mean values were compared through the Scott-Knott test at a 5% significance level, totaling seven treatments with five replications each. No differences were found in germination percentage, water content, and final height of plants. Some treatments differed in germination and waste use increased ESI; ER was superior for black oats and the best productivity was found under double amount of straw, on both cover crops. The seed strength decreased the under consortium, as shown by accelerated aging under the consortium. The purity of seeds was lower for black oats, decreasing with the least amount of crop waste. The 100-seed weight was lower with the double amount in oats; however, under the consortium the use of cover crop increased their weight. Thus, these species can be a good alternatives for soybean rotation on winter.

Introduction

Agriculture must base its practice on scientific knowledge, which allows a rational exploration of available resources and the preservation of environment, considering the social, economical, and environmental aspects involved. The understanding of the interactions that happens between the cultivated species and other species found in the agricultural systems has a great importance for maximizing the production of commercial crops. There are many species and among them there are the ones used as cover crops, which release secondary compounds that interfere, positively or negatively, in the plant community. This phenomenon is called allelopathy (Rice, 1974). The interference may, and must, be used in agriculture, in order to bring benefits to producers and the environment, and to reduce the use of pesticides.

According to EMBRAPA SOJA (2005), in order to obtain the highest efficiency in the agricultural system and the best improvements in the productive capacity of the soil, it is required, above all, a planning of the cultures to be implanted, considering plants with great amounts of biomass production and aimed to mulching, cultivated in single condition or in consortium and also with commercial purposes. Mulching has been extensively used on autumn/winter by farmers that adopt the no-tillage system. These species are implanted in the intercrop of the commercial Summer cultures in areas that would commonly have no use, remaining idle, and, that way, they help decreasing the infestation of, weeds because some of them have a previously reported allelopathic potential (Souza and Pires, 2002).

Besides, when the culture is aimed to seed production, it becomes necessary to adopt techniques that guarantee the production of high-quality seeds, which must be monitored in all stages, so that the farmers can properly use them in the field, obtaining an adequate sample. According to Nedel (2003) the quality of seeds can be influenced by the environmental conditions observed before or after the physiological maturation of the culture. If the seeds are exposed to improper conditions before reaching their physiological maturation, there may occur limitations in mass, viability, and strength. Quality, sustainability and environmental preservation are central factors that define the new rules of production and commercialization (EMBRAPA SOJA, 2000). Thus, the aim of this study was to verify possible interferences related to the amount of crop residues produced by black oat and also by the consortium

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Márcia Maria Mauli. Biologist, Master and Doctoral student, Universidade Estadual do Oeste do Paraná (UNIOESTE), Brazil. Address: Unioeste. Rua Universitária (Unioeste), 2069, Jardim Universitário, 85819-110, Cascavel, Paraná, Brasil. e-mail: márcia.m.mauli@gmail.com

Lucia Helena Pereira Nóbrega. Agronomical Engineer and Master in Seed Technology and Production, Universidade Estadual Paulista, Brazil. Doctor in Agricultural Engineering, Universidade Estadual de Campinas, Brazil. Professor, UNIOESTE, Brazil. e-mail: lucia.nobrega@unioeste.br

Danielle Medina Rosa. Biologist, Master and Doctor in Agricultural Engineering, UNIOESTE, Brazil.

Gislaine Piccolo de Lima. Biologist, Master and Doctor in Agricultural Engineering at UNIOESTE, Brazil.

CALIDAD DE LAS SEMILLAS DE SOYA BAJO CULTIVO CON CANTIDADES VARIABLES DE COBERTURA DE AVENA NEGRA, FRIJOL Y NABO FORRAJERO

Márcia Maria Mauli, Lúcia Helena Pereira Nóbrega, Danielle Medina Rosa y Gislaine Piccolo de Lima

RESUMEN

La adecuación de la cobertura vegetal al sistema de cultivo es esencial para alcanzar el éxito durante la implantación de un cultivo, ya que su manejo puede influir en el desarrollo, productividad y calidad de las semillas producidas. Se evaluaron, en el cultivar de soya CD 202, cantidades tradicional, mitad y doble de cobertura producida con avena negra y con un consorcio de avena negra, frijol y nabo forrajero. Se determinaron los efectos en emergencia (índice de velocidad de emergencia (IVE) y tasa de emergencia (TE)), desarrollo, productividad en campo y calidad de las semillas (porcentaje de germinación, envejecimiento acelerado, pureza, peso de 100 semillas y contenido de agua). El diseño experimental fue de parcelas divididas y se compararon los promedios obtenidos con la prueba de Scott-Knott a un nivel de significancia de 5%, en un total de siete tratamientos con cinco repeticiones cada uno. No hubo diferencias en porcentaje de germinación, contenido de agua y peso final de las plantas. La emergencia difirió en algunos tratamientos y los residuos incrementaron el IVE; la TE fue superior con avena negra y la mayor productividad se obtuvo con doble cantidad de cobertura, en ambas coberturas. El vigor de las semillas disminuyó bajo el consorcio, evidenciado por un envejecimiento acelerado. La pureza de las semillas fue menor en avena negra, disminuyendo con la menor cantidad de cobertura. El peso de 100 semillas fue menor con doble cantidad de avena; no obstante, el uso del consorcio lo incrementó. Estas especies son una buena alternativa para cultivos rotatorios de soya en invierno.

QUALIDADE DE SEMENTES DE SOJA SOB CULTIVOS COM QUANTIDADES VARIÁVEIS DE AVEIA PRETA, ERVILHACA COMUM E NABO FORRAGEIRO

Márcia Maria Mauli, Lúcia Helena Pereira Nóbrega, Danielle Medina Rosa e Gislaine Piccolo de Lima

RESUMO

Adequar a cobertura vegetal ao sistema agrícola é um dos fatores indispensáveis para alcançar sucesso na implantação de uma cultura, pois pode influenciar no desenvolvimento, produtividade e a qualidade da semente desta. Assim, quantidades normal, metade e dobro de resíduos vegetais produzidos por aveia preta e consórcio de aveia preta, ervilhaca comum e nabo forrageiro, na emergência (IVE, VE), desenvolvimento, produtividade, em campo e qualidade das sementes (porcentagem de germinação, envelhecimento acelerado, pureza, massa de 100 sementes e teor de água), em laboratório foram avaliadas para soja, cultivar CD 202. O delineamento experimental foi em parcela subdividida com médias comparadas por Scott-Knott a 5% de significância, sendo sete tratamentos, com cinco repetições cada. Não foram observadas diferenças na porcentagem de germinação, teor de água e altura final das plantas. Os tratamentos diferiram quanto à emergência, porém, a adição de resíduos aumentou o IVE; o VE foi maior sob aveia preta, e a maior produtividade foi sob a quantidade dobro de palha, nas duas coberturas. O vigor das sementes diminuiu, avaliado pelo envelhecimento acelerado, sob consórcio. A pureza das sementes foi menor sob aveia preta e diminuiu com a menor quantidade de resíduos vegetais. A massa de 100 sementes foi menor na quantidade dobro, na aveia preta; e sob consórcio, a adição de cobertura aumentou a massa de 100 sementes. Sendo assim, as espécies estudadas podem ser alternativas para o inverno em rotação na cultura da soja.

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of black oat, common vetch, and forage turnip concerning seedling emergence, plant height and soybean productivity, besides quality of the harvested seeds.

Materials and Methods

Experimental area

The field experiment was carried out in the municipality of Catanduvas, western Parana state, Brazil, at 25°18'16.0''S, 53°11''34.1''W, with an average altitude of 465m. The soil is classified as eutrophic Red Latosol, with average annual precipitation of 1600mm and average annual temperature of 20°C.

The sowing of black oat, common vetch, and forage turnip mulches was held on July 2007. After about 100 days, the mulch was mowed and rested on the soil for 20 days. After this period, seven treatments were distributed, with five replications each, quantifying the fresh mass obtained (normal amount) for black oat and consortium and, from this value, the amounts half and double were formed in the following manner. T1: Fallow (no mulch); T2: Black oat (amount of normal straw produced), 6.62t·ha^{-1}; T3: Black oat (half straw). 3.31t·ha^{-1}; T4: Black oat (double straw), 13.21t·ha^{-1}; T5: Consortium (amount of normal straw produced), 18.42t·ha^{-1}; T6: Consortium (half straw), 9.21t·ha^{-1}; T7: Consortium (double straw), 36.84t·ha^{-1}.

Later, the soybean cultivar COODETEC 202 with 80% of germination was implanted, on the mulches crop residues, under the no-till farming system. The spacing used between lines was 45 cm, and the density was 22 seeds per linear meter. Fertilization was 300kg·ha^{-1} in the sowing, from the formula 8-20-20 (NPK). The control received a similar preparation, just like the other treatments. However, the area remained under fallow, in other words, with natural vegetation. The harvest was manual and it was done separately, in each part of each treatment. The amelioration was also manual. The harvested seeds were packed in paper bags, identified, and taken to laboratory for strength and availability evaluations.

Field evaluations

The emergency speed index (ESI) was evaluated in the field, calculated in accordance with Maguire (1962), and the results were expressed in number of seedlings emerged per day; emergence rate (ER) accord-

TABLE I
AVERAGE EMERGENCY SPEED INDEX (ESI) AND EMERGENCE RATE (ER) OF SOYBEAN SEEDLINGS CULTIVATED UNDER MULCH AND STRAW

Treatment		ESI (Plants/day)	ER (Days)
Coverage	Black oat	28.7 a	9.4 a
	Consortium	32.3 a	8.3 b
Amount of straw	Control	20.9 b	9.7 a
	Normal	32.9 a	8.9 a
	Half	32.6 a	8.9 a
	Double	35.5 a	7.8 a

Averages followed by the same letter in a column do not differ from each other according to the Scott-Knott test at 5% probability level.

TABLE II
HEIGHT (m) OF SOYBEAN PLANTS IN THREE MONTHLY EVALUATIONS, CULTIVATED UNDER MULCH AND STRAW

Treatment		Days after sowing		
		30	60	90
Coverage	Black oat	0.42 b	0.99 a	1.12 a
	Consortium	0.47 a	0.93 a	1.11 a
Amount of straw	Control	0.43 b	1.09 a	1.12 a
	Normal	0.42 b	1.01 b	1.03 a
	Half	0.44 b	1.02 b	1.09 a
	Double	0.48 a	0.93 c	1.17 a

Averages followed by the same letter in a column do not differ from each other according to the Scott-Knott test at 5% probability level.

ing to Edmond and Drapalla (1958), with results expressing the number of days the seedlings took to emerge; plant height, as determined by the measure of soybean plant aerial part, considering the distance from the soil to the apical meristem in the main stem, of ten plants randomly chosen, in each part, after 30, 60, and 90 days from sowing. The results were expressed in meters and, the seed yield was obtained as the seed mass of each part and transformed into $kg \cdot ha^{-1}$. All values were then adjusted to a water content of 13%.

Laboratory evaluations

The qualitative analysis of the harvested soybean seeds was performed in the Plants and Seeds Assessment Laboratory (LASP), Exact Sciences Center (CCET), Universidade Estadual do Oeste do Parana, Cascavel Campus, in 2008. The tests performed were: germination percentage, purity, 100-seed mass and water content, with the methods described in MAPA (2009), and the accelerated aging test according to Marcos Filho *et al.* (1987).

The experimental design consisted of subdivided plots, with seven treatments and five replications for each treatment. The collected data were submitted to variance analysis and the means were compared by the Scott-Knott test at 5% probability level, processed by means of the *Sisvar* software (Ferreira, 1999).

Results and Discussion

Table I shows the average values of the emergency speed index (ESI) and the emergence rate (ER) of soybean seedlings. The soybean ESI did not differ statistically among the different mulches, only with the amount of straw used in the experiment, being lower, however, for the control. Such results corroborate those by Martins (2006) and Nobrega *et al.* (2009), who did not find significant differences between the mulches of black oat and a consortium of black oat, common vetch and forage turnip, in experiments carried out in sand boxes in the laboratory, before soybean sowing. In field experiments with the same species Piccolo (2008) concluded that the black oat consortium, the common vetch and the forage turnip benefited the soybean ESI. Therefore, the use of these species was recommended in order to provide the emergence of stronger seedlings.

The ER was affected by the amount of straw placed on the soil, and decreased when subjected to the consortium. However, analyzing the mulch type, it can be seen that there was no significant difference in any of the parameters concerned. The same was obtained by Piccolo (2008), whose field results show a change in the ER of soybean seedlings subjected to vegetal mulches of black oat and a consortium of black oat, common vetch and forage turnip, with no variation in the amount of straw. In contrast, Bortolini and Fortes (2005) found, in laboratory experiments, a decrease in the ER of soybean seeds exposed to the aqueous extract of black oat.

According to Marcos Filho (1999) there is a direct relation between the germination velocity and the strength of seeds. That means the seeds presenting higher ER are stronger.

Table II shows the height of soybean plants, evaluated after 30, 60 and 90 days from sowing. By observing the mulch factor, it can be reported that only after 30 days from soybean sowing there was a significant difference among the treatments, given that in this evaluation, under consortium, the plants showed the highest averages.

As for the amount of straw factor, the statistical difference is verified at 30 and 60 days from sowing. After 30 days, the greatest height measurements were reported under the consortium, for the double amount of straw. At 60 days, the values inverted, and a progressive decrease occurred as the amount of deposited straw increased. At 90 days, all height averages became equal, indicating that the treatments did not interfere in the final height of the plants. According to COODETEC (2009) the average height reached by the variety CD 202, in Parana, is about 80cm. The plants cultivated under all treatments reached values that were higher than the average for the variety in the region. Results by Nobrega *et al.* (2009) showed a lower development of seedlings under the studied mulches. However, such action in plant development was not observed in this experiment, as there was no difference between the control and the treatments.

According to Souza Filho and Alves (2002), the allelopathic agent influences especially the size and weight of the stricken organism. Cell division and elongation may be the starting point for the action of these agents.

Table III shows the averages related to the data explanation of soybean productivity, cultivated under treatments of vegetable cover. Among the covers, in half consortium one can observe a higher productivity than with black oat, and among the straw amounts, there is a higher productivity with the double amount and normal. By analyzing the straw amounts in the black oat cover, one can verify a higher productivity both in normal and double amounts. Within the consortium, though, the highest value was obtained under the normal amount of straw. Com-

TABLE III
AVERAGES FOR THE DATA EXPLANATION OF PRODUCTIVITY (kg·ha^{-1}) OF COLLECTED SOYBEAN, CULTIVATED UNDER MULCH AND STRAW

Amount of straw	Mulch		Averages
	Black oat	Consortium	
Control	3,189 Ab	3,189 Ab	3,189 c
Normal	3,753 Aa	3,674 Ab	3,713 b
Half	3,106 Bb	3,503 Ab	3,304 b
Double	4,139 Aa	4,073 Aa	4,106 a
Average	3,547 B	3,610 A	

Averages followed by a similar letter small-sized in a column and capitalized in a row do not differ from each other according to the Scott-Knott test at 5% probability level.

paring this to the results obtained for the height of plants, it is possible to find out that developed plants are the most productive ones.

When considering the covers within each amount of straw, a significant difference can be observed only for the normal amount, and the productivity was higher when cultivated under consortium. It can thus be inferred that the highest soybean productivity was obtained when cultivated under consortium, at the normal amount of straw produced of 18.42kg·ha^{-1}.

According to IBGE (2009) and CONAB (2009), the national productivity of soybean was 2816kg·ha^{-1} in the 2007/2008 harvest, and in the state of Parana, according to SEAB (2009) it reached 3023kg·ha^{-1}, bringing inferior results than the ones obtained in this study.

For the region of the town of Catanduvas, Parana state, the soybean yield was of 3491kg·ha^{-1} (IBGE, 2009), that is, higher than the values obtained for control and the treatment with black oat mulch using the half amount of straw, which allows to infer that the use of the mulches considerably raised the productivity of soybeans in this region.

After the wheat, white oats and black oats crops, the soybean presented higher grain yield values than those obtained in the fallow treatment, although no significant difference could be observed, as reported by Kubo *et al*. (2007). Such difference, as claimed by the authors, might be related to the recycling of nutrients, which could have influenced their higher availability for the crops. There was also a higher production of dry matter in the winter cultures with regard to the fallow.

Table IV shows the values related to the percentage of soybean germination collected under the treatments with vegetable covers. It can be seen that there was no significant difference among the analyzed parameters, i.e., cover and straw amount, for normal, abnormal, and dead seedlings. According to EMBRAPA SOJA (2000), in Parana the minimum percentage of germination for normal seedlings of soybean is 80% and all the treatments analyzed in this experiment presented a percentage of germination ≥90%, meeting the recommended patterns.

In laboratory experiments Correia *et al*. (2005) also observed that the germination of soybean seedlings was not affected by the leaf, stem, and root extracts of five grain hybrids of sorghum cultivated under field conditions.

Analyzing the cover factor, a reduction can be observed in the germination of normal seedlings when they were cultivated under consortium, and also a higher percentage of abnormal seedlings, as presented in Table V. This was also observed by Tokura e Nóbrega (2006) and by Nóbrega *et al*. (2009).

TABLE IV
GERMINATION PERCENTAGE OF NORMAL AND ABNORMAL SEEDLINGS AND DEAD SEEDS OF SOYBEAN CULTIVATED UNDER MULCH AND STRAW

Treatment	Normal	Abnormal	Dead
Mulch			
Black oat	90 a	8 a	1 a
Consortium	91 a	9 a	0 a
Amount of straw			
Control	89 a	11 a	0 a
Normal	93 a	6 a	0 a
Half	90 a	10 a	0 a
Double	91 a	8 a	1 a

Averages followed by the same letter in a column do not differ from each other according to the Scott-Knott test at 5% probability level. The data presented are those obtained from the original observations, followed by the letters obtained in the comparison of averages with the transformation into arcosine$^{1/2}$.

As for the dead seeds, just as for the straw amount factor, there was no significant difference. The aging test is based on the deterioration of seeds, accelerated by adverse temperature and humidity. Thus, the seed samples of low strength present a higher fall in viability when exposed to such conditions. The strongest seeds are less affected and show a higher capacity to produce normal seedlings (Marcos Filho *et al*., 1987).

Table VI contains the means related to the purity of collected soybean seeds, cultivated under treatments with mulches. The data presented were only those related to the pure, rotten, and bitter seeds, because the rest of the ratings were not expressive.

Considering the mulch factor, it is noteworthy that the consortium showed the highest percentage of pure seeds and the lowest per-

TABLE V
STRENGTH DETERMINED BY THE TEST OF ACCELERATED AGING (%) OF COLLECTED SOYBEAN SEEDS, CULTIVATED UNDER MULCH AND STRAW

Treatment		Normal	Abnormal	Dead
Mulch	Black oat	81 a	10 b	9 a
	Consortium	78 b	12 a	10 a
Amount of straw	Control	83 a	9 a	8 a
	Normal	79 a	13 a	8 a
	Half	77 a	14 a	9 a
	Double	79 a	10 a	11 a

Averages followed by the same letter in a column do not differ from each other according to the Scott-Knott test at 5% probability level. The data presented are those obtained from the original observations, followed by the letters obtained in the comparison of averages with the transformation into arcosine$^{1/2}$.

TABLE VI
PERCENTAGE OF PURITY OF COLLECTED SOYBEAN SEEDS CULTIVATED UNDER MULCH AND STRAW

Treatment		Pure	Bitter	Rotten
Mulch	Black oat	86.73 b	9.02 a	4.20 a
	Consortium	89.52 a	6.54 b	3.95 a
Amount of straw	Control	86.86 b	8.90 a	3.63 a
	Normal	88.91 a	7.38 b	3.92 a
	Half	87.68 b	7.52 b	4.69 a
	Double	89.04 a	7.33 b	4.09 a

Averages followed by the same letter in a column do not differ from each other according to the Scott-Knott test at 5% probability level.

TABLE VII
AVERAGES OF THE MASS DEPLOYMENT OF 100 SOYBEAN SEEDS (g) CULTIVATED UNDER MULCH AND STRAW

Amount of straw	Mulch		Averages
	Black oats	Consortium	
Control	17.45 Aa	17.45 Aa	17.45 a
Normal	17.65 Aa	16.81 Bb	17.24 a
Half	17.17 Aa	17.04 Ab	17.11 a
Double	16.58 Ab	16.84 Ab	16.71 b
Average	17.21 A	17.03 A	

Averages followed by a similar letter small-sized in a column and capitalized in a row do not differ from each other according to the Scott-Knott test at 5% probability level.

TABLE VIII
WATER CONTENT (%) OF COLLECTED SOYBEAN SEEDS, CULTIVATED UNDER DIFFERENT MULCH AND STRAW

Treatment		Water content
Mulch	Black oat	13.35 a
	Consortium	13.47 a
Amount of straw	Control	13.39 a
	Normal	13.46 a
	Half	13.57 a
	Double	13.24 a

Averages followed by the same letter in a column do not differ from each other according to the Scott-Knott test at 5% probability level.

centage of bitter seeds, perhaps for having enabled a higher control of other species during the development of soybean. There was no significant difference for weak seeds. As for the straw amount factor, the highest amount of pure seeds occurred with the normal and double amounts and the bitter seeds developed best with the control. There was no significant difference for weak seeds.

The percentage of physical purity for seeds inspected in the state of Parana is 99%, according to EMBRAPA SOJA (2008). However, none of the treatments evaluated reached the required value in this study, for there was a big amount of bitter and weak seeds. That is due to a great rainfall activity that occurred in the harvesting period, something that damages the quality of seeds.

Table VII shows that there was no significant difference among the mulches. However, as for amounts of straw, the double amount showed the smallest 100-seed mass. It can also be appreciated that for the black oat the double amount resulted in the lowest 100-seed mass. However, for the consortium the lowest mass was a control. The cover analysis in each straw amount showed a significant difference only in the normal amount of straw, and it was lower for the consortium, the rest did not differ. The treatment that presented the highest 100-seed mass was the black oats, in the normal amount of straw. This treatment did not show higher productivity (normal amount division???), and neither did it show the highest height of plants, as there was no significant differences in the final height of soybean plants. As the mass variable of 100-seed is a parameter for estimating the strength of seeds, it became evident that the quality of seeds is not directly related to the productivity.

The mean value for a 100-seed mass of the soybean cultivar CD 202 ranges from 12.4 to 16.4g, according to the data from COODETEC (2009), being lower than those found in all the treatments analyzed. This corroborates the study of Lopes *et al.* (2007), who reported that the values for 100-seed mass of soybeans differed statistically among the treatments with cover (oats, turnip, vetch, peas, millet and lupine) and fallow crops. They also verified that the portions under single oat and oat + millet and oat + lupine were the ones that showed the highest values.

Table VIII shows that there was no significant difference in the analyzed parameters, i.e., there was no variation in water content. Therefore, it can be concluded that this factor did not influence the 100-seed mass, nor the productivity of the treatments under study.

The water content influences seed behavior in many different situations, as the physiological activity of the seed depends on its water content. Therefore, it is important to know it, in order to choose the adequate procedure for harvesting, drying, beneficiation and stocking. The water content is also important for trading, because it is directly associated to the weight of the purchased good (Marcos Filho *et al*., 1987).

Most of the papers related to the productivity of cultures using cover plants and the no-tillage system do not report results and studies with information on the physiological quality of the seeds produced under such conditions (Nunes *et al*., 2007). Thus, essays like the present may lead to future research in this area. The species utilized can be a valid alternative for winter mulches in the soybean crop rotation, with no harm at all to the productivity and quality of seeds and, starting from the results of one single harvest, it is important to highlight the need for studies with longer periods in order to confirm the results.

Conclusions

Because of the conditions under which this experiment was carried out, it is possible to infer that the height and the productivity of soybean are not harmed by the presence of the cover crops, neither by the straw amounts. Actually, an increase in productivity could be observed when cultivated under consortium.

As for the quality of the collected seeds, there is still a need for more studies with regard to their strength, because of the low percentage of germination obtained after exposure to adverse conditions, which however, in this case, might be due to excessive rain during the harvesting. The remaining parameters are not significantly affected.

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