Australian Journal of Crop Science

AJCS

AJCS 16(04):431-435 (2022) ISSN:1835-2707
doi: 10.21475/ajcs.22.16.04.p2395

Initial development and physiological potential of soybean and maize as a function of vigor level and seed size

Michele Renata Revers Meneguzzo[1], Géri Eduardo Meneghello[1], Ivan Ricardo Carvalho[2]*, Fernanda Da Motta Xavier[1], Vanessa Pinto Gonçalves[1], Diéli Witte Maass[1], Sheila Bigolin Teixeira[1], Andrea Bica Noguez Martins[1], Francine Lautenchleger[3], Nadia Canalli Lângaro[4]

[1]Universidade Federal de Pelotas, Avenida Eliseu Maciel, s/nº, CEP 96001-970 Capão do Leão, RS, Brasil.
[2]Universidade Regional do Noroeste do Estado do Rio Grande do Sul
[3]Universidade Estadual do Centro-Oeste (Unicentro)
[4]Universidade de Passo Fundo - UPF

***Correspondence: carvalho.irc@gmail.com**

Abstract

This work aimed to evaluate the initial development of soybean and maize plants due to the vigor level and the seed size used. Soybean seeds of cultivar 5855 RSF IPRO (BMX ELITE) and hybrid maize Fórmula Viptera were classified in two sizes of sieve (6.00 and 6.50 mm - soybean; 7.50 and 7.00 mm - maize) and two levels of vigor for soybean and three levels of vigor for maize. The experimental design was completely randomized in a 2 x 2 bifactorial scheme (sieve size x vigor levels) for soybean and 2 x 3 (sieve size x vigor levels) for maize, with four replications. The variables evaluated were germination, first germination count and emergence in bed. In the evaluation of seedling initial performance, shoot, root and total length, volume and dry mass were evaluated at 7, 11 and 14 days after sowing for soybean and at 7, 14 and 21 days for maize seeds. High vigor soybean and maize seeds presented high physiological quality, as well as in the development of plants, where larger and of high vigor soybean seeds showed higher plant length and dry mass. The classification of seeds through the level of vigor influences the physiological quality of soybean and maize seeds. Larger seeds with higher vigor showed greater length and initial development of seedlings, being indicated the use of seeds of something vigor.

Keywords: *Glycine max*; *Zea mays*; seedling, physiological quality.

Introduction

Soybean is the main agricultural product of Brazilian exports and is responsible for the increase of the national grain harvest, with the state of Rio Grande do Sul accounting for 32% of the soybean production. On the other hand, maize is the most produced cereal and grain in the world, Brazil being the third largest producer, with production in the 2017/18 harvest, estimated at about 80 million tons of grains (Conab, 2019).

The establishment of normal seedlings in the field is dependent on several factors, among them it is necessary that the seeds present a high physiological potential (germination and vigor), and that they present as a main characteristic a fast and uniform germination, as a function of the speed of the reserves mobilization in germination and the development of seedlings even under adverse environmental conditions (Olsen, 2016, Padua et al., 2010, Carvalho and Nakagawa, 2012, Zucareli et al., 2014).

Seed vigor is a reflection of a set of cytological and biochemical attributes, which favor seeds germinate, emerge and form normal seedlings quickly, these attributes maintain the seed development environment (Tunes et al., 2011; Marcos Filho, 2015). Exerting direct effects on initial plant growth reflects the competitive ability of weeds, which have lower growth. In addition, when in resource-maximized competition, seed vigor directly influences productivity (Dias et al., 2010).

The tests based on seedling performance were developed in order to evaluate the efficiency of repair mechanisms, acting on phases I and II of the imbibition. Thus, more vigorous seeds originate more developed seedlings, reflecting the efficiency of the mechanisms of repair, mobilization of reserves and synthesis of new tissues during germination (Marcos Filho, 2015).

Growth analysis stands out as an accurate, fast and affordable method relatively simple and low cost which does not require special equipment or deep training. It allows the study of the seedling performance under different environmental conditions and under management practices and it is possible to evaluate the contribution of different physiological processes on plant performance (Radford, 1967; Lopes and Lima, 2015). It can be used to investigate the effect of ecological phenomena on plant growth, as well as seed quality on initial growth of soybean (Aisenberg et al., 2014) and beans (Facin et al., 2014).

In order to reduce intraspecific competition and favor plant productivity, seed distribution in the sowing line should be

done to ensure equidistance between plants. In addition, non-standard seeds result in “doubles” deposition in the sowing line, increasing competition for water, nutrients and light (Schuch and Peske, 2008; Fonseca, 2007).
Standardization has become a practice adopted in Brazil and especially in the Midwest region, with producers having a preference for smaller seeds because of greater economy with transportation, seed treatment and acquisition (Lima and Carmona, 1999, Krzyzanowski et al., 1999).
Most research indicates that large seeds have higher germination speed than small seeds, because they contain larger reserves, the plants have larger mass and are more vigorous, presenting high emergence at greater depths (Carvalho and Nakagawa, 2012).
The objective of this work was to evaluate the initial development of soybean and maize plants by virtue of the vigor level and the size of the seeds used, aiming to facilitate the choice of seed size by producers and consequently their standardization for sowing.

Results and discussion

Soybean seeds had a significant effect only at the vigor levels evaluated, in the first germination (FGC), germination (G) and bed emergence € variables. Maize seeds also had only a significant effect for vigor levels, but only for the FGC and G variables.
The high vigor of the soybean seeds provided the seeds a better germination, first count and bed emergence (Table 1). The differentiation between seeds of high and low vigor occurred for the FGC and E variables. High-vigor maize seeds differed statistically from low-vigor seeds for G and FGC.
The experiment to evaluate the initial behavior of soybean plants revealed significance in vigor levels for the variables shoot length at 7 (SL7), 11 (SL11) and 14 (SL14) days of evaluations, for root length at 7 (RL7) and 11 (RL11) days of evaluations and for total length at 7 (TL7), 11 (TL11) and 14 (TL14) days of evaluations.
For the variables root volume and root dry mass, there was a significant effect for sieves in the variables root volume at 11 (V11) and 14 (V14) days of evaluations and for root dry mass at 7 (RDM7) days of evaluation. The variables volume at 7 (V7), 11 (V11) and 14 (V14) days of evaluations, and root dry mass at 7 (RDM7) days of evaluation, presented significance for vigor levels.
High vigor soybean seeds originated plants with greater shoot length and total length at 7, 11 and 14 days of evaluations, differing from low vigor seeds (Table 2). The same occurred for root length at 7 and 11 days after sowing, as well as for root dry mass at 7 days and for all root volume evaluations.
Machado (2002) verified that the reduction in the physiological quality of the seeds of white oat, caused reductions and caused unevenness of the emergence in the field. Vanzolini and Carvalho (2002) verified that the most vigorous soybean seeds produced seedlings with a longer primary and total root length of seedlings.
The results presented in Table 3, show that plants from 6.50 mm sieve seeds showed a higher root dry mass at 7 days and root volume at 11 and 14 days of evaluations, differing from plants from seeds of the 6.00 mm sieve. According to Carvalho and Nakagawa (2012), the larger seeds have well-formed embryos and larger amounts of reserves, being potentially more vigorous, which increases the probability of success in the seedling establishing.
For Pádua et al. (2010), lower soybean seeds produce plants which reach lower productivity. Meanwhile, Zucareli et al. (2014), concluded that seeds of sweet maize with larger width and certain cultivar have higher physiological quality. According to Trogello et al. (2013), observed that different sizes and formats of maize seeds do not influence seed germination and crop yield.
The summary of variance analysis of the experiment to evaluate the initial behavior of maize plants revealed a significant effect for the interaction between sieves x vigor levels for the variables shoot length at 7 (SL7) and 21 (SL21) days of evaluations. The variables root length at 7 (RL7) days of evaluations and total length at 7 (TL7) days of evaluations, revealed significant effect for sieves and vigor levels.
For the variables root volume at 14 (V14) and 21 (V21) days of evaluations and for shoot dry mass at 21 (SDM21) days of evaluations, a significant effect occurred for vigor levels. Significant interaction occurred between vigor levels x sieves for the variable shoot dry mass at 7 (SDM7) days of evaluations (Table 4).
Maize plants from high vigor seeds presented higher root and total length averages at 7 days, as well as for root volume at 14 and 21 days and for shoot dry mass at 21 days of evaluation in relation to seeds of low vigor. The high vigor level differed only in the low vigor level, with no differences occurring with the plants of medium vigor seeds, for root and total length variables at 7 days and for root volume at 14 days of evaluation (Table 4).
For root volume and shoot dry mass at 21 days of evaluations, the high vigor level was higher than the medium and low vigor levels. Evaluations of growth traits of the root system can estimate the vigor of maize seeds. For maize, both seed size and shape may influence early development (Vazquez et al., 2012). The seeds of the base and the top of the ear of maize besides having different sizes are formed under different environmental conditions, so the physiological quality between them may be different. Thus, it is essential to know the physiological behavior of seeds of each fraction of the ear (Mondo and Cícero, 2005).
Larger seeds (7.50 mm sieve) yielded maize seedlings with higher mean of root and total length at 7 days of evaluation compared to smaller seeds (7.00 mm sieve) (Table 5).
After 21 days, the shoot length of plants from seeds of the 7.00mm sieve presented a behavior similar to that of the evaluation at 7 days (Table 6). The high vigor level presented the highest mean lengths differing from the medium and low vigor levels. For maize plants, from seeds of the 7.50 mm sieve, there was no difference between vigor levels, similarly when comparing sieve sizes at all levels of vigor.
Larger seeds and with high vigor gave rise to bean plants with larger leaf area, consequently due to the greater investment of photoassimilates in the photosynthetic apparatus (Pedó et al., 2014). These plants tend to present a greater capacity of solar energy capture, collaborating for the greater production of assimilates destined to grain/seed production (Lopes and Lima, 2015).
For the evaluation of the shoot dry mass at the 7 days of evaluations, smaller seeds of high vigor, presented higher average in comparison with larger seeds of high vigor. When comparing seed vigor levels of the 7.50 mm sieve, there was no difference between the levels. For the seeds of the 7.00 mm sieve, the high vigor level was higher than the other levels (Table 6).

Table 1. Comparison of averages for the germination (G), first germination count (FGC) and bed emergence € variables as a function of the two vigor levels, for soybean and maize seedlings.

SOYBEAN			
Vigor Levels	G (%)	FGC (%)	E (%)
High	98 A	92 A	64.25 A
Low	94 A	82 B	50.87 B
CV (%)	2.22	3.58	19.73
MAIZE			
Vigor Levels	G (%)	FGC (%)	E (%)
High	98 A	94 A	97.00^{ns}
Medium	96 A	84 AB	94.50^{ns}
Low	88 B	78 B	93.87^{ns}
CV (%)	5.04	10.25	2.93

[1] Means followed by the same letter, upper case in the line, do not differ by Tukey test (p <0.05).

Table 2. Comparison of averages for the variables of shoot length at 7 (SL7), 11 (SL11) and 14 (SL14) days of evaluations, for root length at 7 (RL7) and 11 (RL11) days of evaluations, for total length at 7 (TL7), 11 (TL11) and 14 (TL14) days of evaluations, for root dry mass at 7 (RDM7) days of evaluation and for root volume at 7 (V7), 11 (V11) and 14 (V14) days of evaluations as a function of the vigor levels of soybean seeds.

Variables	Vigor Levels	
	High	Low
SL7 (cm pl^{-1})	7.21 A	5.49 B
SL11 (cm pl^{-1})	13.46 A	11.26 B
SL14 (cm pl^{-1})	15.91 A	13.36 B
RL7 (cm pl^{-1})	17.88 A	13.58 B
RL11 (cm pl^{-1})	21.43 A	19.70 B
TL7 (cm pl^{-1})	25.44 A	19.37 B
TL11 (cm pl^{-1})	35.07 A	31.27 B
TL14 (cm pl^{-1})	37.85 A	34.12 B
RDM7 (mg pl^{-1})	19.15 A	15.02 B
V7 (cm^3 pl^{-1})	0.45 A	0.31 B
V11 (cm^3 pl^{-1})	0.73 A	0.54 B
V14 (cm^3 pl^{-1})	0.70 A	0.51 B

Means followed by the same letter, upper case in the line, do not differ by Tukey test (p <0.05).

Table 3. Comparison of means for root dry mass at 7 (RDM7) days of evaluation and for root volume at 11 (V11) and 14 (V14) days of evaluations according to the sieves, for soybean seeds

Variables	Sieves (mm)	
	6.50	6.00
RDM7 (mg pl^{-1})	17.91 A	16.24 B
V11 (cm^3 pl^{-1})	0.70 A	0.56 B
V14 (cm^3 pl^{-1})	0.70 A	0.52 B

[1] Means followed by the same letter, upper case in the line, do not differ by Tukey test (p <0.05).

Table 4. Comparison of means for root length variables at 7 (RL7) days of evaluations, total length at 7 (TL7) days of evaluations, root volume at 14 (V14) and 21 (V21) days of evaluations and for shoot dry mass at 21 (SDM21) days of evaluations, depending on the vigor levels of maize seeds.

Vigor levels	RL7 (cm pl^{-1})	TL 7 (cm pl^{-1})	V 14 (cm^3 pl^{-1})	V 21 (cm^3 pl^{-1})	SDM21(mg pl^{-1})
High	13.54 a	17.96 a	1.52 a	3.06 a	68.86 a
Medium	12.37 ab	16.71 ab	1.41 ab	2.31 b	59.76 b
Low	11.10 b	15.56 b	1.24 b	2.62 b	59.86 b
CV (%)	8.98	8.32	9.48	11.55	9.46

[1] Means followed by the same letter, lowercase in the column, do not differ by Tukey test (p <0.05).

Table 5. Comparison of means for the root length (RL7) and total length variables at 7 (TL7) days of maize seedlings evaluations, due to the sieves used.

Sieves (mm)	RL 7 (cm pl^{-1})	TL 7 (cm pl^{-1})
7.50	12.98 a	17.50 a
7.00	11.70 b	15.98 b
CV(%)	8.98	8.32

[1] Means followed by the same letter, lowercase in the column, do not differ by Tukey test (p <0.05).

Table 6. Association between vigor levels x sieves for the variables shoot length at 7 (SL7) and 21 (SL21) days and for shoot dry mass at 7 (SDM7) days in maize seedlings.

Vigor levels	SL 7 (cm pl^{-1})		SDM 7 (mg pl^{-1})		SL 21 (cm pl^{-1})	
	Sieve size (mm)					
	7.50	7.00	7.50	7.00	7.50	7.00
High	4.61Aa	3.98 Aa	13.62 Ba	16.4 Aa	15.9 Aa	16.34 Aa
Medium	4.57 Aa	4.10 Aab	13.01 Aa	11.73 Ab	14.65 Aa	13.93 Ab
Low	4.15 Aa	4.76 Ab	12.57 Aa	10.72 Ab	14.97 Aa	13.70 Ab
CV(%)	11.49		14.08		5.85	

[1]Means followed by the same letter, lowercase in the column for sieve size comparing vigor levels, and uppercase in the line for sieve sizes within the vigor level, do not differ by Tukey test (p <0.05).

Larger and high vigor seeds stand out in the initial evaluation as well as the initial development of seedlings presenting high physiological quality. In view of this the use of more than one vigor test is of great importance to generate accurate information in the evaluation of seed quality.

The development of these tests of initial development of seedlings for other species may be a consistent alternative to obtain reliable results, since the procedures are relatively simple, fast and economical and can be reproduced and standardized for other species.

Materials and methods

Plant material and treatments

Soybean seeds of cultivar 5855 RSF IPRO (BMX ELITE) were classified in two sieve sizes (6.00 and 6.50 mm) and two vigor levels (high and low). The hybrid maize seeds used were of the Viptera Formula, classified into two sieve sizes (7.50 and 7.00 mm) and three vigor levels (high, medium and low).

Conduction of study

The following evaluations were carried out to characterize seed initial quality, followed by initial plant performance.

The germination test was carried out with four subsamples of 50 seeds, having as substrate three sheets of Germitest paper, moistened with distilled water in an amount equivalent to 2.5 times the mass of the dry paper. The seeds were kept in a germination chamber with a temperature of 25ºC. Seedlings considered normal were evaluated in a period of eight days after sowing for soybean and seven days for maize, according to the recommendations of the Rules for Seed Analysis (Brasil, 2009).

The first germination count was performed concomitantly with the germination test, by computing the percentage of normal seedlings present on the fifth day for soybean and on the fourth day after the installation of the maize test. This determination is based on the principle that the samples that present the highest percentage of normal seedlings, in the first count of the germination test, established by RSA (Brasil, 2009), are the most vigorous.

For the emergency test in the bed, 400 seeds were used, divided into four replicates of 100 seeds, sown in the alfisol soil, with a depth of 3 cm. The seedling counts were performed at 21 days after sowing.

In order to analyze the initial performance of plants, the seeds were distributed in PVC pipes with 100 mm diameter and with 0.20, 0.40 and 0.75 m of height, using as a substrate a mixture of sand and soil in the 2:1 proportion, seeded at 3 cm depth. Four replicates of 10 plants were collected for each replicate. For soybean plants, the samples were collected at 7, 11 and 14 days after sowing. For the maize plants, the samples were collected at 7, 14 and 21 days after sowing.

After the seedlings were removed from the tubes, they were carefully washed. With the aid of a ruler graduated in centimeters, the shoot, root and total 431 lengths of the seedlings were evaluated.

In order to evaluate the root volume, the methodology proposed by Basso (1999) was used. A graduated beaker was used, in which the water volumes were determined with roots and without roots and, by difference, the direct response of the root volume was obtained by the equivalence of units (1 mL = 1 cm^3). The roots were then transferred to the oven at 65°C for 72 h. After, the weighing was carried out in an analytical balance of 0.001 g precision, and the average results were expressed in milligrams per seedlings.

Experimental design

A completely randomized experimental design in a 3 x 2 bifactor scheme was used, corresponding to three vigor levels and two sieve sizes for corn seeds. For soybean seeds, a 2 x 2 bifactorial scheme was used, with 2 vigor levels and two seed sizes with four repetitions.

Statistical analysis

The data were submitted to the normality test. Subsequently, they were submitted to analysis of variance, followed by means comparisons through the Tukey test at 5% of probability, for each of the evaluated parameters.

Conclusion

The initial evaluation, as well as the length and the initial development of the seedlings, maintained the trend regarding the manifestation of vigor, where larger seeds with high vigor presented greater physiological potential for the tests performed.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

References

Aisenberg GR, Pedó T, Aumonde TZ, Villela FA (2014) Vigor e desempenho de crescimento inicial de plantas de soja: efeito da profundidade de semeadura. Enciclopédia Biosfera. 10 (18): 3081-3091.

Basso SMS (1999) Caracterização morfológica e fixação biológica de nitrogênio de espécies de Adesmia DC. e Lótus L. Porto Alegre: UFRGS, 1999. Tese. 268 f.

Brasil (2009) Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de sementes. Brasília: Mapa/ACS, 399p.

Carvalho NM, Nakagawa J (2012) Sementes: ciência, tecnologia e produção. 5.ed. FUNEP, 590p.

Conab - Companhia Nacional de Abastecimento (2019) Acompanhamento da safra brasileira de grãos. v. 6-Safra 2018/19 –Quarto levantamento, Brasília. 126p.

Dias MAN, Mondo VHV, Cícero SM (2010) Vigor de sementes de milho associado à mato-competição. Rev Bras Sementes. 32 (2): 93-101.

Facin F, Pedó T, Koch F, Martinazzo EG, Villela FA, Aumonde TZ (2014) Vigor de sementes e crescimento inicial de plantas de feijão sob efeito de baixas temperaturas. Ver Tecnol Cien Agropec. 8 (4): 35-40.

Fonseca NR (2007) Qualidade fisiológica e desempenho agronômico de soja em função do tamanho da semente. Faculdade de Ciências Agronômicas da UNESP - Campus de Botucatu, 2007, Tese, 68f.

Krzyzanowski FC, Vieira RD, França Neto JB (1999) Vigor de sementes: conceitos e teses. ABRATES, Londrina, 218p.

Lima AMMP, Carmona R (1999) Influência do tamanho da semente no desempenho produtivo da soja. Rev Bras Sementes. 21 (1):157-163.

Lopes NF, Lima MGS (2015) Interceptação e distribuição da energia radiante em comunidades terrestres. In: Lopes, N. F.; Lima, M.G. S. Fisiologia da produção. Viçosa, Ed. UFV, 117-144.

Machado RF (2015) Desempenho de aveia-branca (*Avena sativa* L.) em função do vigor de sementes e população de plantas. Pelotas – RS: UFPel, 2002. Dissertation. 46 f.

Marcos Filho J (2015). Fisiologia de sementes de plantas cultivadas. 2.ed. Londrina: ABRATES. 659p.

Mondo VHV, Cicero SM, Dourado-Neto D, Pupim TL, Dias MAN (2012) Vigor de sementes e desempenho de plantas de milho. Rev Bras Sementes. 34 (1):143 – 155.

Olsen D (2016) Variabilidade e desempenho em plantas de soja em função da qualidade fisiológica da semente. Pelotas -RS: UFPel, Tese, 65 f.

Pádua GP, França neto JB, Costa O, Zito RK, Krzyzanowski FC, Gazziero DLP (2007) Aplicação de glyphosate como dessecante em pré-colheita em semente de soja: efeito sobre a produtividade. In: Reunião de Pesquisa de soja da região central do Brasil, 29, Campo Grande, MS. Resumos... Londrina: Embrapa Soja. p.225-227. (Documentos, 287).

Pádua GP, Zito RK, Arantes NE, França Neto JB (2010) Influência do tamanho da semente na qualidade fisiológica e na produtividade da cultura da soja. Rev Bras Sementes. 32 (3):9-16.

Pedó T, Segalin SR, Silva TA, Martinazzo EG, Gazolla Neto A, Aumonde TZ, Villela FA (2014) Vigor de sementes e desempenho inicial de plântulas de feijoeiro em diferentes profundidades de semeadura. Rev Bras Ciênc Agrár. 9 (1): 59-64.

Radford PJ (1967). Growth analysis formulae: their use and abuse. Crop Sci. 7 (3): 171-175.

Schuch LOB, Peske ST (2008) Falhas e duplos na produtividade. Seeds News. 12 (6).

Trogello E, Modolo AJ, Portes ÁF, Brusamarello AP (2013) Tamanhos e formatos de sementes não influenciam a germinação, desenvolvimento e produtividade da cultura do milho. Pesq Agrop Gaúcha. 19 (1): 41-48.

Tunes LM, Pedroso DC, Badinelli PG, Tavares LC, Rufino CdeA, Barros ACSA, Muniz MFB (2011) Envelhecimento acelerado em sementes de azevém com e sem solução salina e saturada. Cienc Rural. 41 (1):33-37.

Vanzolini S, Carvalho NM (2002) Efeito do vigor de sementes de soja sobre o seu desempenho em campo. Rev Bras Sementes. 24 (1): 33-41.

Vazquez GH, Arf O, Sargi BA, Pessoa ACO (2012) Influência do tamanho e da forma da semente de milho sobre o desenvolvimento da planta e a produtividade de grãos. Biosci J. 28 (1): 16-24.

Zucareli C, Brzezinski CR, Guiscem JM, Henning FA, Nakagawa J (2014) Qualidade fisiológica de sementes de milho doce classificadas pela espessura e largura. Pesq Agropec Trop. 44 (1): 71-78.

Zucareli C, Brzezinski CR, Guiscem JM, Henning FA, Nakagawa J (2014) Qualidade fisiológica de sementes de milho doce classificadas pela espessura e largura. Pesq Agropec Trop. 44 (1): 71-78.