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Soybean seeds quality under different levels of vigor and fertilizing supplying

Qualidade de sementes de soja sob diferentes níveis de vigor e fornecimento de fertilizantes

Calidad de las semillas de soja bajo diferentes niveles de vigor y suministro de fertilizantes

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Abstract

The aims to evaluate the soybean seeds quality in response to the vigor level of seeds and the fertilizing distribution system in the sowing row. The experimental design was random blocks organized in factorial scheme, being two growing environments (Passo Fundo – RS and

Ernestina – RS) x three vigor levels classified as high, medium and low (90%, 70% and 60% vigor, respectively) x three fertilizing distribution systems (no distribution, conventional and overflow), and the treats disposed in four replicates. The measured characters were thousand seeds mass, germination, accelerated aging, electric conductivity, viability and vigor, shoot and root length, shoot and root dry matter and field emergency. Vigor and physiologic quality of produced seeds are intimately related to characteristic of environment of production and vigor level of used seeds. Elevated physiologic potential are obtained in seeds produced in specifically using seeds with high vigor independent of the fertilizer distribution system.
Keywords: *Glycine max* L.; Production seed; Management of fertilization.

Resumo

Objetiva-se avaliar a qualidade das sementes de soja em função do nível de vigor das sementes e do sistema de distribuição da adubação na linha de semeadura. O delineamento experimental foi em blocos ao acaso, organizados em esquema fatorial, sendo dois ambientes de cultivo (Passo Fundo - RS e Ernestina - RS) x três níveis de vigor classificados em alto, médio e baixo (90%, 70% e 60% vigor, respectivamente) x três sistemas de distribuição de fertilizantes (sem distribuição, convencional e transbordamento), e as guloseimas dispostas em quatro repetições. Os caracteres medidos foram massa de mil sementes, germinação, envelhecimento acelerado, condutividade elétrica, viabilidade e vigor, comprimento de parte aérea e raiz, matéria seca de parte aérea e raiz e emergência de campo. O vigor e a qualidade fisiológica das sementes produzidas estão intimamente relacionadas às características do ambiente de produção e ao nível de vigor das sementes utilizadas. Potenciais fisiológicos elevados são obtidos em sementes produzidas especificamente com sementes de alto vigor independente do sistema de distribuição de fertilizantes.
Palavras-chave: Glycine max L.; Produção de sementes; Manejo da fertilização.

Resumen

El objetivo es evaluar la calidad de las semillas de soja en respuesta al nivel de vigor de las semillas y al sistema de distribución de fertilizantes en la fila de siembra. El diseño experimental fue de bloques al azar organizados en esquema factorial, siendo dos ambientes de cultivo (Passo Fundo - RS y Ernestina - RS) x tres niveles de vigor clasificados en alto, medio y bajo (90%, 70% y 60% de vigor, respectivamente) x tres sistemas de distribución de fertilizantes (sin distribución, convencional y rebosadero), y las golosinas se disponen en cuatro repeticiones. Los caracteres medidos fueron masa de mil semillas, germinación,

envejecimiento acelerado, conductividad eléctrica, viabilidad y vigor, longitud de brotes y raíces, materia seca de brotes y raíces y emergencia de campo. El vigor y la calidad fisiológica de las semillas producidas están íntimamente relacionados con las características del entorno de producción y el nivel de vigor de las semillas usadas. Se obtiene un potencial fisiológico elevado en semillas producidas específicamente utilizando semillas con alto vigor independientemente del sistema de distribución de fertilizantes.
Palabras clave: Glycine max L.; Producción de semillas; Manejo de la fertilización.

1. Introduction

Originated from China, the soybean (*Glycine max* (L.) Merril) is the more economically expressed fabaceae worldwide, and Brazil is its highest producer. A data collection realized by the National Supply Company (CONAB) demonstrates how relevant the soybean production is, with area of 35,2 million hectares and production of 118,88 million tons of grains (CONAB, 2018).

The population growth, with the food demand, is increasing the soybean productive scenario with the necessity of higher seeds productivities and quality (Marcos–Filho, 2015). The first factor to be considered in the searching for high grain yields is using seeds with high genetic, physic, sanitary and physiologic quality, that reveal elevated vigor and physiologic potential. These conditions can proportionate to plants, the possibility to stand out on the likely stress conditions (Peske et al., 2012; Szareski et al., 2018). Although, it is fundamental that after the seedlings emergence, they receive conditions to nourish themself with water and minerals, so they can originate high performance seeds in relation to the seeds or grains production (Aumonde et al., 2017).

In Brazil, the fertilizing system of application is the conventional, where it is used a homogenous representative condition of the soil fertility in the area. The soil is variable, by nature, in its physical and chemicals attributes (Bonotto, 2012). The search for uniform growing fields and differential crop performances is inwardly related to the use of seeds with high physiologic potential, being uniformly disposed in the sowing row.

In sight of the lack of the researches combining the seeds vigor and the fertilizers distributions, as well its effects in the seeds produced from the soybean crops, this work aims to evaluate the soybean seeds quality in response to the vigor level of seeds and the fertilizing distribution system in the sowing row.

2. Materials and Methods

The experiment was arranged in two growing environments in the state of Rio Grande do Sul. Both experiments were conducted in the growing season of 2016/17, being Enerstina-RS, located at the latitude 28º29'56"S and longitude 52º34'24"W with altitude of 493 meters, and Passo Fundo-RS in the coordinates of latitude 28º15'46"S and longitude 52º24'24"W, with altitude of 687 meters. Either soils are classified as Haplortox soil(STRECK et al., 2008), and the climate was classified by Köppenn as humid subtropical type Cfa.

The experimental design was random blocks organized in factorial scheme, being two growing environments (Passo Fundo – RS and Ernestina – RS) x three vigor levels classified as high, medium and low (90%, 70% and 60% vigor, respectively) x three fertilizing distribution systems (no distribution, conventional and overflow), and the treats disposed in four replicates. For this study, it was used the cultivar DM 5958RSF IPRO®, with maturation group of 5.8 and undetermined growth habit.

Before the seedling, the seeds were stratified in batches with different vigor levels, for the proceeding it was used the accelerated aging method (AOSA, 1983). For such, the seeds were distributed in unique layers of approximately 250 grams and disposed on an aluminum grid fixed on the interior of a plastic recipient. In each recipient were added 240 ml of distilled water and allocated in aging chamber adjusted for 41ºC. After 48, 84 and 96 hours of exposition, the seeds were submitted to germination test (Brasil, 2009), being the criteria established to define vigor levels at 90% (high), 70% (medium) and 60% (low).

The soil fertility and acidity correction was realized based on the previous analysis following the instructions of the fertilizing and liming manual (CQFS, 2016). It was used 300 kg ha^{-1} of N.P.K. fertilizer in the formulation 02-20-20, homogenized for all treats, except to the one with no fertilizing.

Three fertilizer distribution systems were used in the sowing machine, such as the absence of fertilizing, conventional dispenser composed by worm thread with inferior escape by gravity, using a conducting tube reaching the groove in the soil. The last, is the overflow system (non-conventional), composed by worm thread with escape by overflow where the fertilizer is triggered by booster and conducted to the damming chamber. After the overflow occurs in homogenous and uniform volumetric amounts thru the level regulator to the flush nozzle directed to the soil.

The seeding was realized in the first fortnight of November 2016. The sowing density was standardized for both environments, being 30 seeds m^{-2}. The experimental units were composed by five sowing lines and five meters length, spaced by 0,45 meters, totalizing 11,25 m^2. The weeds, pests and diseases were controlled in order to minimize the biotic effects in the experiment results.

In order to evaluate the characters, it was harvested 3,96 m^2 corresponding to the utile area of each experimental unit. The seeds were harvested with 18% humidity anddried to 12% in kiln with forced air circulation. The characters were measured thru the homogenization of seeds originated from plants of the utile area of each experimental unit, being:

Thousand seeds mass (TSM): determined by the mass of eight replicates with 100 seeds of each experimental unit, expressed in grams (Brasil, 2009).

Germination (G): based in four replicates of 50 seeds from each experimental unit, sowed in germitest paper, previously wet with water amount equivalent of 2,5 times the substrate mass, and allocated in 25ºC temperature. The evaluations were realized at the eight day after the tests installation, and were stated in percentage of normal seedlings (Brasil, 2009).

Accelerated aging (AA): based in the AOSA (1983) and Marcos Filho (1999) methodology, 200 seeds per experimental unit were used and distributed in one layer on an aluminum grid fixed in the recipient. Afterwards, it was added 40 ml of distilled water and putted under temperature of 41ºC for 48 hours.

Electric Conductivity (EC): four replicates were used, with 50 seeds soaked in 75 ml of deionized water, during 24 hours, with 25ºC. After, it were realized readings with results in $\mu S\ cm^{-1}\ g^{-1}$ of seeds (AOSA, 1983).

Viability (VI) and vigor (VG): hundred seeds from each experimental unit were separated in two replicates of 50 seeds AOSA (1983). The seeds were wrapped in two wet germination paper and maintained in this conditions for 16 hours on 25ºC. After this period, the seeds were allocated in recipients with tetrazolium solution at 0,075%, and then they were directed to germinator of 35ºC to 40ºC for approximately 180 minutes. When visualizing the ideal coloration, the seed were washed, cut and classified with the number of potentially germinable (França Neto et al., 1998).

Shoot (SL) and Root length (RL): the seeds were disposed lengthwise in the superior third of the wet paper, where twenty seeds germinated uniformly at the temperature of 25ºC. At the eight day after the beginning of the tests, the seedlings were evaluated, and the results were expressed in centimeters (Nakagawa, 1999).

Shoot (SDM) and Root dry matter (RDM): ten seedlings were allocated in paper bags on a kiln with 105ºC during 24 hours. After elapsed the time, the mass was measured in grams (Nakagawa, 1999).

Field emergency (FE): the seeds were sowed in raised planting beds with treats disposed in four replicates, were each experimental unite was composed of 50 seeds. The measurement occurred 14 days after sowing, expressed in percentage (Brasil, 2009).

The data was submitted to a diagnostic of normality and homogeneity of the residue variances. Afterward, it was proceeded the variance analysis at 5% probability with the aim to verify the presence of the interaction among growing environments x vigor levels x fertilizers distribution systems. When significant, the simple effect was simplified, although, when non-significant, it was simplified the sources of variation in main effects. All measured characters were submitted to analysis of genetic dissimilarity thru the *Mahalanobis*algorithm, where the observed values were pondered by the matrix of the residue variances. These estimates were applied in the construction of the main compounds analysis, where it was considered the abscess axis of "X" and "Y" as independent, and it was plotted the treat effects guided by the axis origin. The measured characters were identified in the Biplot way, and the statistical analysis were realized thru the Genes software (Cruz, 2013).

3. Results and Discussion

The variance analysis revealed significance of 5% probability to the interaction between growing environments x vigor levels x fertilizers distribution systems (Table 1), through the characters TSM, G, AA, SL, RL and FE. Significant interaction was evidenced between vigor levels x fertilizer distribution system for shoot dry mass (MSPA).

At Enerstina – RS, the thousand seed mass did not differ to the seeds obtained from plants originated of high vigor seeds, but medium vigor seeds tend to reduce the thousand seed mass in fertilizer absence. The conventional and overflow systems revealed superiority to the thousand seeds mass when originated from high vigor seeds (Table 2).

At Passo Fundo – RS, the TSM was superior when the soybean was cultivated using high vigor seeds and conventional distribution system. For the medium and low vigor, it was observed superiority in seeds coming from overflow system. In the absence of fertilizing, the superiority was verified for seeds originated from high vigor (Table 2).

Between growing environments and TSM, in the absence of fertilizing and at the conventional system, the seeds originated from high vigor were superior in the Passo Fundo –

RS environment. In the overflow system, the high vigor revealed superiority for Ernestina – RS. The medium vigor evidenced superiority to Passo Fundo – RS independently the fertilizer distribution system. According to Such et al. (2009), plants originated from seeds with physiologic potential cannot influence the thousand seeds mass.

In Ernestina – RS, the germination did not revealed variation between vigor levels and fertilizer distribution system. At Passo Fundo – RS, the germination demonstrated similar answer for high and medium vigor, but at low vigor there was an increase in the conventional fertilizer distribution system. As state by Mondo et al. (2012), there is a relation between soils chemical attributes and seeds physiologic potential, where the variability of soil nutrients did influence the magnitude of seeds germination.

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Table 1. Summary of variance analysis for 11 compounds related to soybean seeds quality prevenient of two growing environments, three vigor levels and three fertilizers distribution system.

SV	DF	Mean Square										
		TSM	G	AA	EC	Via	Vig	SDM	MSR	SL	RL	FE
Environment (A)	1	32,01*	126.61*	366.99*	1106.30*	1843.54*	7152.75*	0.08*	0.00*	132.78*	1.45	1035.84
Vigor (V)	2	9,6*	185.99*	123.16	192.97	97.01	200.19	0.02*	0,00	5.73	1.42	490.96
A X V	2	3,53*	161.04*	122.66	85.87	134.15	202.41	0.00	0,00	1.72	16.51*	1600.74*
System (S)	2	1,61*	248.82*	119.64	33.66	120.49	95.92	0.03*	0,00	5.09	2.21	187.67
A X S	2	0,11	156.93*	106.12	0.56	64.24	114.30	0.01	0,0*	11.96*	8.12	1626.90*
V X S	4	8,04*	10.76	115.34*	29.37	32.40	73.42	0.02*	0,00	4.76	1.75	3387.38*
A X V X S	4	6,76*	184.60*	240.31*	40.75	27.49	72.58	0.00	0,00	10.49*	14.21*	1707.06*
Block	7	0.04	16.32	74.53	0,00	0,00	0,00	0.00	0,00	0.26	0.66	279.24
Residue		0.33	43.92	47.84	72.85	68.79	111.64	0.00	0.00	2.61	3.23	481.91
CV%		3,64	7.02	7.60	18.69	9.73	16.06	8.29	21.53	13.49	11.47	38.00

*Significant with 5% of probability by test F.
SV- Source of Variation; **DF-** Degrees of Freedom; **TSM-**Thousand Seeds Mass; **G-** Germination; **AA-**Accelerated Aging; **EC-**Electric Conductivity; **Via-**Viability; **Vig-** Vigor; **SDM-** Shoot Dry Matter; **MSR-** Root Dry Matter; **SL-** Shoot Length; **RL-**Root Length;**FE-**Field Emergence.
Source: Authors.
.

In Ernestina – RS, the AA demonstrated that the medium vigor level increased the character throughout the conventional system. There was variability among the three vigor levels, being specific the answer of the conventional system to reduce this character through low seeds vigor (Table 2). In Passo Fundo – RS, there was no difference between vigor levels and fertilizers distribution system for medium vigor. A research of Rossi et al. (2018) defined that the accelerated aging did not indicate plain effects in the vigor of soybean seeds. It was observed difference among growing environments for the produced seeds vigor, where the low vigor level presented itself specific to the conventional system. In general, it was obtained vigor superiority through the accelerated aging for Passo Fundo – RS.

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Table 2. Thousand seeds mass (TSM), germination (G) and accelereated aging (AA) of soybean seeds, in relation to the vigor levels of seeds (high, medium and low), fertilizer distribution systems (fertilizer absence, conventional and overflow) and growing environments (Ernestina-RS and Passo Fundo-RS).

MMS	Growingenvironments					
System	Ernestina-RS			Passo Fundo-RS		
	Vigor Level			Vigor Level		
	High	Medium	Low	High	Medium	Low
Absence	[1]15,83 aAβ	15,02 bBβ	15,79 aAα	16,45 bAα	15,85 bBα	15,67 bBα
Conventional	16,03 aAβ	15,60 aBβ	15,40 bBβ	16,95 aAα	15,99 bBα	15,68 bCα
Overflow	16,00 aAα	15,57 aBβ	15,48 bBβ	15,50 cCβ	16,73aAα	16,17 aBα
CV%	3,64					
G	Growingenvironments					
System	Ernestina-RS			Passo Fundo-RS		
	Vigor Level			Vigor Level		
	High	Medium	Low	High	Medium	Low
Absence	98,0 aAα	97,0 aAα	97,0 aAα	96,0 aAα	95,0 aAα	91,0 aAβ
Conventional	97,0 aAα	93,0 aAα	90,0 bAα	96,0 aAα	94,0 aAα	95,0 aAα
Overflow	93,0 aBα	91,0 aBα	97,0 aAα	94,0 aAα	94,0 aAα	87,0 bBβ
CV%	7,02					
EA	Growingenvironments					
System	Ernestina-RS			Passo Fundo-RS		
	Vigor Level			Vigor Level		
	High	Medium	Low	High	Medium	Low
Absence	94,0 aAα	88,0 bBβ	93,0 aAα	93,0 aAα	94,0 aAα	89,0 aBα
Conventional	89,0 bBα	94,0 aAα	83,0 bCβ	93,0 aAα	94,0 aAα	92,0 aAα
Overflow	89,0 bAα	85,0 bAβ	90,0 aAα	89,0 aBα	94,0 aAα	89,0 aBα
CV%	7,60					

CV- Coefficient of variation.
[1]means followed by same letter, lowercase in column for fertilizer distribution system inside growing environments and vigor level, uppercase in line for vigor levels inside fertilizer distribution system in each environment and Greek letter in line for growing environments inside fertilizer distribution system in each vigor level, do not differ among themselves by Tukey test ($p < 0,05$).
Source: Authors.

The SL, for Ernestina – RS, did not varied due to the low and medium vigor levels in relation to the fertilizers distribution system (Table 3). In Passo Fundo – RS, the plants originated from seeds with medium vigor level, independent from the distribution system, presented similarities for the shoot length test. It was obtained superiority for this test when the seeds were produced in Passo Fundo – RS (Table 3). Researches from Henning et al. (2010) and Vanzolini et al. (2002), showed that high vigor seeds resulted in seedlings with higher length in relation to the low vigor level batches.

Table 3. Shoot length (SL), root length (RL) and field emergence (EC) of soybean seeds, in relation to the association of vigor levels (High, Medium e Low), fertilizer distribution systems (fertilizer absence, conventional and overflow) andgrowing environments (Ernestina-RS andPasso Fundo-RS).

SL	Growingenvironments					
Systema	Ernestina-RS			Passo Fundo-RS		
	Vigor Level			Vigor Level		
	High	Medium	Low	High	Medium	Low
Absence	[1]12,14 aAα	11,55 aAα	11,43 aAα	13,28 aAα	12,20 aAα	12,24 bAα
Conventional	12,14 aAα	10,79 aAβ	11,18 aAβ	11,40 bBα	13,11 aAα	13,89 aAα
Overflow	10,47 bAβ	9,86 aAβ	10,82 aAβ	13,76 aAα	12,30 aBα	12,63 bBα
CV%	13,49					
RL	**Growingenvironments**					
Systema	Ernestina-RS			Passo Fundo-RS		
	Vigor Level			Vigor Level		
	High	Medium	Low	High	Medium	Low
Absence	16,44 aABα	15,33 aBα	17,11 aAα	15,17 abABα	16,42 aAα	14,48 bBβ
Conventional	16,05 aAα	15,38 aAα	15,39 bAα	14,59 bBα	16,27 aAα	16,18 aAα
Overflow	14,51 bBβ	14,84 aBα	16,52 abAα	16,39 aAα	15,39 aAα	15,17 abAα
CV%	11,47					
EC	**Growingenvironments**					
Systema	Ernestina-RS			Passo Fundo-RS		
	Vigor Level			Vigor Level		
	High	Medium	Low	High	Medium	Low
Absence	50 bAα	58 abAα	55 aAβ	60 aABα	57 bBα	75 aAα
Conventional	68 aAα	51 bBα	61 aABα	63 aAα	52 abABα	48 bBα
Overflow	57 abAα	70 aAα	30 bBβ	44 aBα	74 aAα	64 abABα
CV%	38,00					

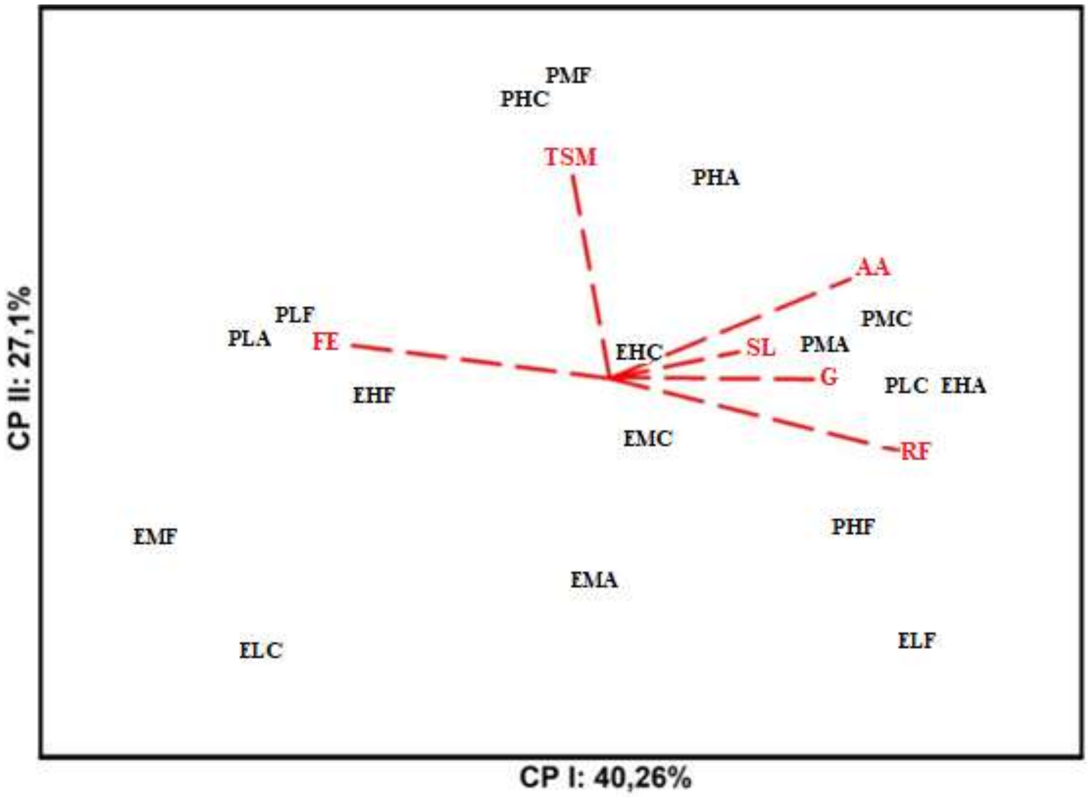
CV- Coefficientofvariation.
[1]means followed by same letter, lowercase in column for fertilizer distribution system inside growing environments and vigor level, uppercase in line for vigor levels inside fertilizer distribution system in each environment and Greek letter in line for growing environments inside fertilizer distribution system in each vigor level, do not differ among themselves by Tukey test ($p < 0,05$).
Source: Authors.

The RL, in Ernestina – RS, for the high vigor level demonstrated variation only for overflow fertilizer distribution, being this factor inferior to the conventional system. In the absence of fertilizer distribution there was no difference among low and medium vigor levels thru the vigor test. In Passo Fundo – RS, the RL did not differ to the medium vigor level, independent of the fertilizer distribution system. The absence of fertilizer in addition to the use of low vigor seeds culminate in the reduction of seedling root length (Table 3). Researches from Vanzolini and Carvalho (2002) demonstrate that vigorous seeds are those that showed higher primary root length, as well seedling length. Among the growing environments, the absence of fertilizer distribution and high and medium vigor levels did not revealed variability of root length of seedlings originated from seeds produced in Passo Fundo – RS.

In Ernestina – RS, the FE differed in fertilizer distribution system and vigor levels. At high and low vigor, the magnitude of seedlings emerged at field was superior in conventional system, although, the overflow system presented better answers in seeds with medium vigor (Table 3). At Passo Fundo – RS, the FE did not varied due to high vigor in relation to fertilizer distribution systems. Among growing environments, the FE demonstrated that the conventional system did not differed for the tested vigor levels. The overflow distribution system was similar to when low vigor seeds were use, being the seeds produced in Ernestina – RS considered lower vigor (Table 3). Tekrony et al. (1987) defined the existence of relation between the seedling field emergence with seeds vigor, what boost the plant growth and development, and initial development, as well results in effects in grains yield (Tekrony&Egli, 1991).

Multivariate performance (Figure 1) evidenced that AA, FE, TSM, SL, G and RL are intimately related to environment of seeds production and vigor level of seeds used to composed the production field. In this manner, the biometric approach by main compounds represents 67,36% of total variation of this study.

Figure 1. Plottingofmaincompounds scores, Thousand Seeds Mass (**TSM**), AccelerateAging (**AA**), Field Emergence (**FE**), ShootLength(**SL**), Germination (**G**), Root Length (**RF**), **PMF** (Passo Fundo, medium vigor, overflow), **PAC** (Passo Fundo, high vigor, conventional), **PHA** (Passo Fundo, high vigor, absence), **PLF** (Passo Fundo, low vigor, overflow), **PLA** (Passo Fundo, low vigor, absence), **PMC** (Passo Fundo, medium vigor, conventional), **PMA** (Passo Fundo, medium vigor, absence), **PLC** (Passo Fundo, low vigor, conventional), **PHF** (Passo Fundo, high vigor, overflow). **EHC** (Ernestina, high vigor, conventional), **EHF** (Ernestina, high vigor, overflow), **EMC** (Ernestina, medium vigor, conventional), **EMF**(Ernestina, medium vigor, overflow), **ELC** (Ernestina, low vigor, conventional) **EMA** (Ernestina, medium vigor, absence), **ELF** (Ernestina low vigor, overflow.



Source: Authors.

As follows, the field emergency presents affinity with Passo Fundo – RS in low vigor level and fertilizer absence (PLA), Passo Fundo – RS in low vigor level and overflow system (PLF), and with Ernestina – RS in high vigor level and overflow system (EHF). The TSM has affinity with Passo Fundo – RS in high vigor level and conventional fertilizer distribution system (PHC), and Passo Fundo – RS in medium vigor level and overflow system (PMF). The AA has affinity with Passo Fundo – RS in medium vigor level and conventional system (PMC). The SL has affinity with Passo Fundo – RS in medium vigor and absence of system (PMA). The germination has affinity with Passo Fundo – RS in low vigor and conventional system (PLC) and Ernestina – RS in high vigor and absence of system (EHA). The RL has affinity with Ernestina – RS in low vigor and absence of system (ELA) and Passo Fundo – RS in high vigor and overflow system (PHF). In these conditions, the selection of growing environment, fertilizer distribution system and seeds vigor level can specifically increase the physiologic attributes of soybean seeds production.

4. Conclusions

Vigor and physiologic quality of produced seeds are intimately related to characteristic of environment of production and vigor level of used seeds.

Elevated physiologic potential are obtained in seeds produced in specifically using seeds with high vigor independent of the fertilizer distribution system.

In view of the results of this work, it is necessary to carry out further studies, with more cultivars, in order to verify the real influence of biotic and abiotic factors on the vigor of the seeds, as well as the influence of the fertilizer distribution systems.

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