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Effect of Plant Senescence Inducers on Landraces and Commercial Cultivars of Common Beans

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Abstract: The aim of this study was to analyze the influence of plant senescence inducers and their effects on plant senescence intensity and grain yield of common bean differing in tegument color (black or carioca) and among commercial cultivars or landraces. Four commercial cultivars and four landrace genotypes of common bean which were studied using senescence inducers (ethephon, paraquat, flumioxazin and prohexadione-Ca) and control (without senescence inducers). The ethephon, flumioxazin and paraquat promoted plant senescence in about ten days after the application, but among the four senescence inducers paraquat is the most consistent desiccant. The SCS Guará, carioca grain show senescence faster than other genotypes. In conclusion, the genotypes grouped in black or carioca tegument showed similar senescence after paraquat treatment. However, paraquat leads to 30% higher senescence intensity on commercial cultivars than landraces without affecting negatively its grain yield.

Key words: *Phaseolus vulgaris* · Grain yield · Pre-harvest · Ripening

INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) is an economic and nutritious important food in many parts of the world, particularly to country, such as Myanmar, India and Brazil, with 3.80, 3.63 and 2.94 millions of tonnes, respectively, produced at 2013 harvest [1]. In Brazil the growing of common bean takes place in practically all the national territory. The evolution of natural practices allied to the development of new cultivars and the adoption of technologies by Brazilian growers allowed significant gain in the grain yield going up to levels from 500 kg ha^{-1} of national average in the end of the 70's up to 1.000 kg ha^{-1} in the last harvests. The average yield is different according to the region where the bean is grown corresponding to 1730, 1580, 1530, 768 and 428 kg.ha^{-1} in Mid-western, Southeast, South, Northeast and North regions in the country, respectively [2].

Besides the yield performance of bean crop, other factor involved in the commercialization of grains is its quality which is influenced by biotic and abiotic factors in particular the hydric excess that is directly associated for grain qualitative and quantitative losses which are observed at the harvest time of this crop [3]. Such losses highly influenced the uneven maturation of grains that are observed inside a same plant and also among plants in the crop. According to Andrade and Vieira [4], the harvest is the most risked activity regarding to the product quality and which demands more workmanship and resources from the grower making essential the identification of the correct time for its beginning. As the same authors, if the harvest is done earlier there will be a yield decrease, if the harvest is done later, the main problems would be related to natural threshing of the crop, grain cracks and losses by deterioration.

Among the cultural practices, the usage of desiccant herbicides has been remarked as an alternative to accelerate and mainly to homogenize the drying of plants allowing an earlier harvest because it reduces the period of crop remaining in the field with a consequently lower exposure of these grains to the biological agents which decrease the grain quality and yield of this crop [5, 6]. The herbicides of the bipyridinium group, paraquat(Gramoxone®) and diquat (Reglone®) are much employed in several crops being of proven efficiency in the soybean crop [7]. Paraquat has served as model to

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explain the mode of action of bipyridinium whose action reaches its peak a membrane degradation, cell plasma leakage and the tissue death resulting in a desiccation of plants within a short time [8,9].

The optimum time for application of senescence inducer substances (desiccants) must have as a referential the growth stage named physiological maturity where the grain acquires the maximum dry matter weight and the deterioration indexes are minimum, such characteristics are very important to preserve the grain quality [10]. Otherwise, earlier desiccant application led to a significant decrease in the grain yield [11-13]. Otherwise, later applications near the crop harvest maturation make possible to the grains remain for long time in the field subjected to adverse conditions and the presence of pathogens causing them serious damages to the grain quality [10].

Considering the hypothesis that: i) distinct common bean cultivars (commercial and landrace ones or those of black or carioca tegument colors) which show senescence naturally and homogeneously under the climatic conditions of Santa Catarina Plateau show deterioration signals and grain yield losses; ii) the chemical inducers desiccation makes possible to antecipate the harvest in comparison to the natural maturity of common bean plants; iii) there is a cultivar differential reaction to plant senescence inducer chemicals, likewise the aim of this work was to verify the influence of plant senescence inducers on different bean plant genotypes, distinct regarding totegument color (black and carioca) and, grown on Catarinense Plateau and their respective effects on the grain yield.

MATERIALS AND METHODS

The experiment was carried out during 2010/2011 and 2011/2012 growing seasons in the Municipality of Lages-SC. The Municipality of Lages is located in South Plateau of Santa Catarina with an average altitude of 930 m, south 27°48’58” S latitude and west 50°19’34” W longitude, with an average temperature of 15°C and an annual rainfall of 1.500 mm [14].

The experiments were installed on the days 29 of October, 2010 and 15 of December, 2011. Eight genotypes of common bean being four landraces and four commercial cultivars were used in the first year; while three and five ones were used in the second year, respectively. The landrace genotypes are felled from the collection of (BAF) Active Germoplasm Bank of Common Bean of (UDESC) Santa Catarina State University in Lages, SC. The genotypes used were: BAF13, BAF55, IPR88-Uirapuru, BRSCampeiro of the black commercial group and BAF50, BAF84; BRS-Pérola; SCS-Guará and IPR Tangará of the carioca commercial group which are described in the Table 1. The choice of these genotypes was based on previous studies which have been done constantly since 2005, thereby they have been evaluated regarding to technological, morphological and agronomical characters of grains and seeds [15-18]. The commercial genotype seeds were acquired at Copercampos Cooperative in Campos Novos-SC being selected among the recommended genotypes for cropping according to CTSBF [19] (*South Brazilian Technical Commission for Bean).

The experimental was laid out in randomized complete block design with three replications in plots of four rows of four meters long, spaced 0.5 m between rows with 15 seeds sown a linear meter being the external rows considered as borders and the useful area was made up by two internal rows excluding 0.5m from the extremities. This kind of conduction was selected based on the Brazilian Value for Cultivation and Use for Bean (Bean – EVCU).

The soil tillage in the two years was that conventional with one plowing and two harrowings. The liming and fertilization followed the recommendations for growing beans, being done according to the soil analysis and the recommendations described by the Commission for Soil Chemistry and Fertility of RS and SC [20] for a potential grain yield of 2.5 t ha^{-1}. The top-dressing was applied twice, the first when the plants presented three trifoliate leaves and the second, at the beginning of the flowering corresponding to the growth stage (GS) V4 and R5, respectively according to the common bean phenological scale [21], employing 30 kg ha^{-1} of N (urea) at each application. The control of weeds, diseases and pests was done according to the needs, using the chemicals recommended for the crop [19].

The plants were treated with flumioxazin (30 g i.a. ha^{-1}; Flumyzin 500®), paraquat (400 g i.a. ha^{-1}; Gramoxone 200®), ethephon (120 g i.a. ha^{-1}; Ethrel 720®) and prohexadione-Ca (55 g i.a. ha^{-1}; Viviful®). The application was performed with a backpack CO_2 pressurized sprayer with a constantly pressure to make possible a spraying equivalent to 200 L ha^{-1} of mixture. The phenological stage of the plants for spraying was the beginning of the physiological maturity (transition between the GS R8 and R9), taking in account when 50%

Table 1: Genotype characteristics of common beans (landrace and commercial cultivars) recommended for Brazil Southern states and used in the experiments. Lages-SC, 2010/2011 and 2011/2012 growing seasons

Landraces [1]/	Maintainer	Commercial Group	Characteristics
BAF13	UDESC-BAF	Black	It presents indeterminate growth with flat, long and kidney shape seeds. It is usually named Taquara, its origin is from Caxambu do Sul/SC.
BAF50	UDESC-BAF	Carioca	It presents indeterminate growth; it is named Carioca Brilhante, its origin is from Lebon Regis/SC, its seed is like carioca with a flat and spherical shape.
BAF55	UDESC-BAF	Black	It presents indeterminate shrub growth, named Preto Cunha Porã, its origin is from: Cunha Porã/SC, its seed has a flat and spherical shape.
BAF84	UDESC-BAF	Carioca	It presents indeterminate shrub growth, black strip rosy coloring seed its origin is from Pinheiro Machado/RS; its seed is spherical and semi-full.
Cultivars [2]/	Maintainer	Commercial Group	Characteristics
BRS-Pérola	EMBRAPA	Carioca	It presents a vigorous growth and intermediate cycle, semi-upright size, from carioca commercial grouping, it is the most grown in the country being its cropping recommended in 17 states.
BRS-Campeiro	EMBRAPA	Black	Suitable for rainy and dry growing seasons, it presents upright size, semi-early cycle (75-85 days).
IPR- Tangará	IAPAR	Carioca	Medium cycle of 87 days, an intermediate tolerance to dry growing seasons and high temperatures, it presents a high potential yield.
IPR88-Uirapuru	IAPAR	Black	It presents upright size, medium cycle of 86 days, tolerance to hydric deficit and to high temperature during the reproductive phase suitable for rainy and dry growing seasons.
SCS-Guará	EPAGRI	Carioca	It has a high potential yield, it presents a light-bege back ground coloring and uniformity regarding to grain size and semi-upright and intermediate cycle.

[1/]Source: Coelho *et al*. [17].[2/] CTSBF (*Comissão Técnica Sul- Brasileira de Feijão) [19].

of pods showed off a straw-yellow color, parameter used in field to determine the physiological maturity [21]. The plants were evaluated at the 03; 06; 08 and 10 days after the chemical application (DAA) where attributed percentage values to plant senescence being 0% (without effect) to plants with the presence of green leaves and 100% (with desiccant effect) to plants with all the leaves dried. This characterization of plant senescence intensity was performed based on the view of phytotoxicity symptoms showed and the outcomes for statistics were taken in account only those of the tenth day.

The harvest was performed at the 10 DAA consisting of the handheld uprooting of plants and mechanized trail. The grain yield was determined based on the production of the useful plot, correcting the water content to 14% moister content and it was expressed in kg ha^{-1}. Immediately after the trail was taken one sample of 10g of grains from each experimental plot and was proceeded the determination of the water content in a hot house at 105 °C for 24 hours according to the method 44-15 of American Association of Cereal Chemists [22]. The grains harvested were packaged in paper bags and stored in cold chamber (8±2 °C) and under an air relative humidity lower than 40%. Onwards, the processing of grains was performed handheld with the removal of impurities and strange materials (stones, land, clods and plant rests: stalks and leaves).

For the determination of 100 seeds weight was followed the methodology described in the technical regulation of bean grain classification prescribed in the normative instructions IN12/2008 and IN56/2009 released by Ministério da Agricultura e Reforma Agrária named Ministry of Agriculture and Agrarian Reform [23], such procedure was done so that each treatment would form only one sample which was quartered then reduced until the working sample be obtained and then this was subdivided into four sub-samples of 100 seeds, proceeded the individually counts and subsequent weighting of these sub-samples and further conversion to the value of 100 seeds weight.

The results of all variables were submitted to analysis of univariate variance to realize the existence of difference among the treatments, at 5% of probability through F Test. The percentage and counting values were transformed for performing the analysis of variance through the arc sine $(x/100)^{0,5}$ function. For comparing the averages among the genotypes inside each growing season was applied the Duncan Test and for comparing the different groups: (i) tegument colors and (ii) commercial cultivars of the landrace genotypes was applied the Scheffé Test. The comparison (in each genotype) among the senescence inducer chemicals to the witness was made through Dunnett Test. Was taken an account the minimal significance of 5%. The analyses were performed through the aid of SAS® software [24].

RESULTS AND DISCUSSION

In the evaluation of the bean plant senescence submitted to the application of senescence inducer substances, was observed the interaction among the variables of chemical inducers and cultivars. The genotypes that senesced faster after the application of plant inducer substances were: SCS-Guará (due to flumioxazin and paraquat application); BRS Campeiro (paraquat) BRS-Pérola (paraquat) and BAF84 (paraquat) (Table 2). On the general average for the plant senescence inducer substances the most efficient chemical in the desiccation was the paraquat followed by the flumioxazin, respectively. The cultivar that senesced faster was the SCS-Guará.

Regarding to the tegument color, occurred a chemical interaction because of the tegument coloring, being the black color genotypes without the application of substances (witness) senesced faster. However, when they were submitted to prohexadione-Ca application, the black tegument genotypes showed just 30% of senescence in comparison to 37% of senescence in carioca tegument genotypes (Table 2).Considering the comparison between commercial cultivars to landrace varieties, was verified that the commercial genotypes under influence of paraquat desiccation showed a higher senescence intensity, being 77% of senescence in the plants of commercial cultivars and 47% in landrace varieties then a difference of 30%. However, when they were only compared to the grouping of black or carioca genotypes, this comparison pointed out that the paraquat was the most effective and consistent chemical to induce the senescence; with 61% of senescence in the black tegument genotypes and 64% in carioca tegument genotypes (Table 2).

In the literature, in carioca bean with the application of desiccants was observed a greater defoliant effect for the application of diquat, glufosinate ammonium + ethephon and glufosinate ammonium at 300 g i.a. ha^{-1} [25]. They also indicated that, the treatment with glufosinate + ethephon + sodium lauryl ether sulphate showed a lower efficacy than the treatments previously mentioned. However, in another research with “cranberry” striped tegument bean, carried out for three growing seasons (2010, 2011 and 2012) the desiccants diquat, glufosinate ammonium and carfentrazone-ethyl showed very close defoliant effects being 88, 85 and 79%, respectively [6]. There is, however a lack of information from research which investigate the relationship between the tegument coloring and desiccation efficacy.

Table 2: Senescence intensity of bean genotypes because of the application of plant senescence inducer substances, Lages-SC

Genotypes	Controls	Flumioxazin	Ethephon	Paraquat	Prohexadiona-Ca	Mean
Senescence intensity at 10° day (%)						
Season 2010 / 2011						
BRS Campeiro	41	25	17	* 75	12	34 B
BAF 50	NS 31	25	33	37	25	30 B
IPR Uirapuru	62	50	* 0	75	* 0	37 B
BRS Pérola	25	0	32	* 75	34	33 B
BAF 13	NS 37	50	0	50	33	34 B
SCS Guará	17	* 87	50	* 83	50	57 A
BAF 55	NS 44	25	44	43	17	34 B
BAF 84	25	24	25	* 58	37	34 B
Mean	35	36	24	*62	25	
MSD	90	96	91	83	62	22
CV (%)	28	42	36	37	34	27
Tegument collor						
Black	46 a	37 NS	15 NS	* 61 NS	15 b	35 NS
Carioca	24 b	34	36	* 64	37 a	39
Landraces x commercial cultivars						
Landraces	34 NS	31 NS	25 NS	* 47 b	28 NS	33 NS
Commercial	36	40	22	* 77 a	21	41

Distinct uppercase letters in the columns indicate significant differences, among genotypes, according to Duncan’s test ($P \leq 0.05$). Distinct lowercase letters in the columns indicate significant differences (between tegument collor or between landraces x commercial) according to Scheffé’s test ($P \leq 0.05$).

*, indicate significant differences from control to inducer, by genotype, according to Dunnett’s test ($P \leq 0.05$)

NS, not significant (P>0,05); MSD = minimum significant difference.

Table 3: Bean genotype seed yield submitted to pre-harvest treatment with plant senescence inducer substances in Lages/SC

Genotypes		Controls			Flumioxazin			Ehephon			Paraquat			Prohexadione-Ca		Mean	
---------- Seed yield (kg ha^{-1}) ----------																	
Season 2010 / 2011																	
BRS Campeiro		1151	AB		1406	A		1800	AB	*	2217	A		881	AB	1491	A
BAF50	NS	486	CD		683	B		323	D		395	C		566	B	491	D
IPR88-Uirapuru	NS	913	BC		1447	A		1108	C		1376	B		1375	A	1244	AB
BRS Pérola		853	BC	*	1602	A		890	CD		1126	B		1033	AB	1101	BC
BAF13	NS	1595	A		1175	AB		1433	BC		1378	B		993	AB	1315	AB
SCS Guará	NS	1112	AB		760	B		854	CD		724	BC		590	B	808	C
BAF55	NS	968	BC		1136	AB		1529	BC		712	BC		770	B	1023	BC
BAF84		143	D		619	B	*	2236	A	*	1336	B		1153	AB	1097	BC
Mean		903			1104		*	1272			1158			920			
DMS		544			679			699			689			613		347	
CV		24,9			24,5			22,7			24,6			27,5		24,9	
Season 2011 / 2012																	
BRS Campeiro		3074	A		2944	A		2428	BC	*	3311	A		2878	AB	2727	B
BAF50		1164	C	*	1816	BC		1050	D		1401	C	*	1809	BCD	1448	E
IPR88-Uirapuru	NS	3278	A		2296	AB		4289	A		3416	A		3182	A	3292	A
BRS Pérola	NS	2157	B		1767	BC		2137	BC		2021	BC		1737	CD	1964	D
BAF13	NS	2260	B		2403	AB		2080	BC		2093	BC		2178	ABCD	2203	CD
SCS Guará		2682	AB		2405	AB		2571	BC	*	2167	BC		2731	ABC	2511	B C
BAF55	NS	1281	C		1494	C		1467	CD		1407	C		1322	D	1394	E
IPR Tangará	NS	2771	AB		2828	A		2612	BC		2498	B		2882	AB	2718	B
Mean	NS	2333			2244			2329			2164			2340			
MSD		790			747			1104			934			1143		390	
CV		14,0			13,8			19,6			17,8			20,2		14,0	
Tegument collor																	
Black	NS	1815	NS		1788	NS		2017	NS		1864	NS		1697	NS	1836	NS
Carioca	NS	1421			1560			1584			1458			1563		1517	
Landraces x commercial cultivars																	
Landraces	NS	1128	b		1332	b		1445	B		1246	B		1256	b	1282	b
Commercial	NS	1999	a		1940	a		2077	A		1984	A		1921	a	1984	a

Distinct uppercase letters in the columns indicate significant differences, among genotypes, according to Duncan's test ($P \leq 0.05$). Distinct lowercase letters in the columns indicate significant differences (between tegument collor or between landraces x commercial) according to Scheffé's test ($P \leq 0.05$).

*, indicate significant differences from control to inducer, by genotype, according to Dunnett's test ($P \leq 0.05$)

^{NS}, not significant (P>0,05); MSD = minimum significant difference.

Seed yield was observed a genotype simple effect; there was also an interaction between the genotype and senescence inducer substance (Table 3). In 2010/2011 growing season, the application of different senescence inducer substances did not alter the seed yield of the genotypes BAF50, IPR88-Uirapuru, BAF13, SCS 202-Guará and BAF55, however for the genotypes BRS Campeiro (paraquat application), BRS-Pérola (flumioxazin) and BAF84 (ethephon and paraquat) resulted in a higher seed yield in comparison of these to the witness. In 2011/2012 growing season, the application of different senescence inducer substances did not change the seed yield of the genotypes IPR-88Uirapuru, BRS-Pérola, BAF13, BAF55 and IPR Tangará. However, for the genotypes BRS Campeiro (paraquat application), BAF50 (flumioxazin and prohexadione-Ca) BRS-Pérola resulted in a higher seed yield in comparison to their respective witnesses and, only for SCS-Guará the paraquat application led to a lower seed yield in comparison to its respective witness.

It is remarkable that in general, the application of senescence inducer substances in pre-harvest of bean plant cropping did not affect negatively the seed yield, because at the time of the applications, the quantity of pods, seeds per pod and the final population of plants were already defined. Kappes *et al*. [26] verified that bean seed yield was not affected because of the application time, on this case after the plant physiological maturity defined as GS R9.

The herbicides used in pre-harvest allow to uniformness the maturity then provide an even drying of pods and seeds, advance the harvest and do not harm the seed yield because they do not induce the dehiscence of pods, do not affect the germination neither the seed vigor, reduce the grain water content and control the eventual weeds [27]. These data can be explained due to the fact of the pre-harvest desiccation uniformness the maturity and provide conditions to a fast seed moister loss, making problems such as green seeds be reduced at the harvest time, factors which interfere with the grain quality and favor the appearance of pathogens during the storage causing losses to the growers. However, negative results of the seed yield due to the senescence chemical induction are pointed out when the chemical application is performed earlier, i.e. before the physiological maturity stage [10, 11, 12, 28].

In 2011/2012 growing season in general, the seed yield was higher for all the cultivars in comparison to the 2nd season (Table 3). This difference may be attributed to the unique climatic conditions which occur at each season grown [29]. According to Nobrega *et al.* [30] the hydric deficit in the bean cropping affects the seed development and yield when it happens in the stages of flowering and filling of pods, because occur the abortion and fall of flowers decreasing the number of pods per plant. However, if the hydric deficiency happens in vegetative stages, occurred a decrease of the foliar area and this does influence indirectly the final seed yield [30].

Table 4: 100 seeds weight of bean genotypes grown in Catarinense Plateau submitted to the treatment with plant senescence inducer substances in the two growing seasons

Genotypes		Controls			Flumioxazin			Ethphon			Paraquat		Prohexadione-Ca		Mean	
---------- 100 seeds weight (g) ----------																
Season 2010 / 2011																
BRS Campeiro	NS	23.8	A		24.1	A		23.4	AB		24.6	A	23.5	A	23.9	A B
BAF 50	NS	24.0	A		24.0	A		24.1	AB		24.7	A	24.0	A	24.2	A
IPR Uirapuru	NS	23.7	A		23.6	A		25.3	A		24.6	A	25.1	A	24.5	A
BRS Pérola	NS	25.5	A		25.5	A		25.0	A		24.1	A	22.8	A	24.6	A
BAF 13	NS	22.6	A		23.5	A		23.3	AB		22.5	AB	23.4	A	23.1	B
SCS Guará		25.3	A	*	23.8	A		26.7	A	*	22.7	AB	25.3	A	24.8	A
BAF 55	NS	19.1	B		20.4	B		20.6	B		20.8	B	18.9	B	20.0	C
BAF 84	NS	18.2	B		17.3	C		-			-		18.4	B	18.0	D
Mean		22.8			22.8		*	24.1			23.4		22.7			
DMS		3.1			2.7			3.6			2.9		3.8		1.1	
CV		5.7			4.9			6.2			5.1		6.9		5.9	
Season 2011 / 2012																
BRS Campeiro		24.4	C	*	23.1	D	*	22.0	C		23.7	C	23.5	C	23.3	D
BAF 50		24.0	C	*	26.0	B		24.9	B		24.4	C	24.1	BC	24.7	C
IPR Uirapuru		25.3	B		24.4	C		24.5	B	*	23.8	C	24.9	B	24.6	C
BRS Pérola	NS	27.7	A		28.3	A		27.3	A		26.4	B	27.0	A	27.3	B
BAF 13		22.1	D		21.7	E	*	20.8	D	*	20.6	D	21.6	D	21.4	E
SCS Guará		25.4	B	*	24.5	C	*	24.3	B	*	21.9	D	24.8	B	24.2	C
BAF 55		17.3	E	*	18.0	F		17.5	E		17.4	E	17.4	E	17.5	F
Tangará	NS	27.9	A		28.7	A		28.2	A		27.9	A	27.5	A	28.0	A
Mean		24.3			24.3		*	23.7		*	23.3		23.9			
MSD		0.9			0.9			1.3			1.6		1.5		0.6	
CV (%)		1.5			1.6			2.2			2.8		2.0		3.1	
Tegument collor																
Brack	NS	22.3	NS		22.4	NS		22.2	B		22.2	NS	22.3	NS	22.3	NS
Carioca	NS	24.8			24.8			25.8	A		24.6		24.2		24.5	NS
Landraces x Commercial cultivars																
Landraces	NS	21.1	b		21.6	B		21.9	B		21.7	b	21.1	b	21.2	b
Commercial	NS	25.5	a		25.1	A		25.2	A		24.4	a	25.0	a	25.0	a

Distinct uppercase letters in the columns indicate significant differences, among genotypes, according to Duncan's test ($P \leq 0.05$). Distinct lowercase letters in the columns indicate significant differences (between tegument collor orbetween landraces x commercial) according to Scheffé's test ($P \leq 0.05$).

* = indicate significant differences from control to inducer, by genotype, according to Dunnett's test ($P \leq 0.05$)

NS = not significant (P>0,05);MSD = minimum significant difference.

However, in the cycle final stages, in particular the hydric excess leads to plant senescence delay and therefore it increases the retention of green pods and leaves, indeed this was observed in the first season, because on the final 10 days of the cycle occurred 7 rainfall days, adding 98 mm, otherwise in 2012 season did just 2 days and 25 mm rainfall. This water excess in soil at common bean maturation (GS R9) prolongs the natural cycle and delays the harvest operations [31]. On this situation, the plant senescence chemical induction is a potentially beneficial management practice.

In the analysis of 100 seeds weight was verified a genotype simple effect, as well as a desiccant simple effect within each season. There was an interaction between genotype and plant senescence inducer substance between both seasons (Table 4). Considering each genotype, in 2010/2011 season, the 100 seeds weight was not altered by the application of different plant senescence inducer substances for the genotypes BRS Campeiro, BAF50, IPR88-Uirapuru, BRS-Pérola, BAF13, BAF55 and BAF84, however for the genotype SCS 202-Guará (paraquat and flumioxazin) resulted in lower 100 seeds weights.

For 2011/2012 season, the application of different senescence inducers did not alter the 100 seeds weight of the genotypes BRS-Pérola and IPR Tangará. However, for the landrace varieties BAF50 and BAF55 under the effect of flumioxazin application were verified higher weights in comparison to the witness. A contrary reaction was verified among the genotypes BRS Campeiro (flumioxazin and ethephon), IPR88-Uirapuru (paraquat), BAF13 (paraquat and ethephon), SCS 202-Guará (flumioxazin, ethephon and paraquat) in which resulted in lower weights comparing them to their respective witnesses. Similar results were observed by Forbes and Pratley [32] on bean, alfafa Moyer *et al*. [33] and soybean Gubbels *et al*. [34]. Likewise, the common bean desiccation performed with paraquat or a paraquat + diquat mixture on the bean plant verified that the seed weight was not affected [35].

These divergences on results, be under these experimental conditions or under those found in the literature due to the senescence chemical induction, biologically can be explained for the cases of reduction of 100 seeds weight, because they may occur when the proportion of green and mature pods has not reached a value higher than 50% of mature pods, thus in the pods still green, the grains did not reach yet their maximum dry mass which results in a lower value of 100 seeds weight. Among different bean genotypes occur differences in the lengths of the GS R5 and R6 [36], as a consequence of occurring more than one flowering on a same bean plant leading to an anachronism in the flowering, pod formation and seed filling [21] with a consequent difficulty on the determination of the physiological maturity moment [36]. However, lower values of 100 grain weight observed in the witness in comparison to the senescence chemical induction, biologically still needs scientific investigations, unless existing a greater natural intrinsic variation (heterogeneity) of seed weight of a greater frequency in landrace varieties [14, 36].

CONCLUSION

Among the substances used in common bean pre-harvest, the most efficient for the plant chemical senescence induction is the paraquat. Besides the paraquat, the ethephon and flumioxazin chemicals also promote the acceleration in the plant senescence.

The bean cultivars senesce than the landrace varieties and, differently after the application of plant senescence inducer substances, among the cultivars used, the SCS-Guará of carioca commercial group senesces faster.

The senescence inducer substances show more positive effects than negative on seed yield of common bean, however dependently on the genotype; paraquat (BRS-Campeiro, first and second season) paraquat (BAF84, first season), ethephon (BAF84; first season) and flumioxazin (BRS-Pérola, first season; BAF50 second season) showed positive effects, respectively or negative effects (SCS-Guará, only on the second season, for paraquat application).

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