Life Science Informatics Publications

Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences

Journal Home page http://www.rjlbpcs.com/

RJLBPCS
ISSN 2454-6348

Original Research Article DOI: 10.26479/2019.0503.36

PERIODS OF WEED INTERFERENCE ON BEAN CROP WITH CULTIVARS PLANTS DIFFERENT ARCHITECTURE TYPES

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ABSTRACT: Bean plants with growth types and plant architecture that facilitate cultural practices and high productivity, have been an important requirement for farmers. However, overcoming competition with weeds becomes a limiting factor. This research was conducted to determine the period prior to interference (PPI) on bean cultivars of different types plant growth with an arbitrary level of 2.5%, 5% and 10% productivity loss. The experimental treatments consisted of eight coexistence periods of the crop and weeds: 0-10, 0-20, 0-30, 0-40, 0-50, 0-60, 0-70, 0-harvest days after emergence and a control plot that was kept weed-free throughout the study period. The experimental design was a random block design with four replications. The periods prior to interference were 21, 30 and 35 days for the BRS Pontal bean cultivar and 0, 5 and 12 days for the IPR Juriti cultivar, with the arbitrary levels of reduction of productivity of 2,5%, 5% and 10%, respectively, living with the infesting community composed predominantly of the species *Digitaria* sp., *Portulaca oleraceae*, and *Eleusine indica*. The architecture of the bean plant is of paramount importance in the choice of the farmer. However, 35 DAE of the bean plants, weed control must be done.

KEYWORDS: *Phaseolus vulgaris* L., Plant morphology, Competition, Weed Community.

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1.INTRODUCTION

Weeds are a real problem in bean cultivation. Because the bean plant has a short development cycle, it is affected by competition with weeds, especially at the beginning of its development; however, if the weed community is present throughout the crop cycle, the reduction in productivity can reach extreme limits up to 90% [1, 2]. Another important characteristic is the cost to control these plants, which can vary from 20 to 30% of the total cost of production [3], resulting in large monetary contributions to the farmer [4]. To correct weed management, it is necessary to cognize the periods of interference, so that management can be carried out at the appropriate time, thus allowing the culture to express its productive potential [5, 6]. For Silva et al [7] in weed management, the period prior to interference (PPI) becomes one of the most important periods of the crop cycle, from which productivity is significantly affected. PPI is conceptualized as the period from emergence or planting, where the crop can live with weeds before its productivity or other characteristics are adversely affected. The selection of the cultivar is also a simple strategy that should be included for the efficient management of weeds in the bean crop [8]. The different types of growth habits of bean cultivars may alter the competition between the crop and the weed community [9]. The cultivars of habit of growth type I and II have more erect architecture and few lateral branches slowly covering the soil, favoring weeds. However, in the cultivars of type III, soil cover occurs rapidly, and may be a competitive advantage for the crop, and may attenuate the interference [10, 11]. Through the above, the main objective of this work was to determine the period prior to interference (PPI) in beans of two types of indeterminate growth habits.

2. MATERIALS AND METHODS

2.1. Site, plant material and sowing

Two experiments were carried out under field conditions, in Jaboticabal city, which is at latitude 21°15'22", longitude 48°18'58" and altitude of 595m, São Paulo state (Brazil). For this, it was used bean cultivars of the carioca group: BRS Pontal and IPR Juriti Claro. The descriptions of these cultivars:

•BRS Pontal - is a cultivar with high productive potential, an indeterminate growth habit type III and prostrate plant architecture. It exhibits resistance to common mosaic and anthracnose; intermediate resistance to bacterial blight, fusarium and rust [12].

•IPR 139 (Juriti Claro) - has an indeterminate growth habit type II, vertical, adapted to mechanical harvesting, high productive potential, moderately tolerant to common bacterial blight, susceptible to anthracnose and resistant to common mosaic, powdery mildew and rust [13].

The soil of the experimental area was classified as a Dark Red Latosol, of clay texture, whose result of the chemical analysis is in Table 1. The soil preparation was carried out in the conventional system.

Table 1. Chemical soil analysis of the experimental site.

Chemical analysis									
pH	M.O.	P Resina	K	Ca	Mg	H+Al	SB	T	V
$CaCl_2$	g/dm³	mg/dm³			mmol$_c$/dm³				%
5,1	19	20	3,1	16	12	28	31,1	59,1	53

The sowing was performed by means of the conventional sowing planter of five rows, with spacing of 0.5 m between rows, with 12 seeds per meter density, totaling 37.1 kg ha^{-1} performed on April 1, 2014, being classified as winter planting, and when there was no rain, a supplementary irrigation system was used for conventional spraying. During the experimental period, preventive applications of insecticides and fungicides were carried out in a total area, aiming at the health of the crop.

2.2. Treatments application

The treatments consisted of the coexistence of the crop with weeds from emergence to different phenological stages: 0-10, 0-20, 0-30, 0-40, 0-50, 0-60 and 0-70 days after emergence (DAE) and another witness without weed contact. After each of these initial coexistence intervals, the plots were maintained without weeds until the end of the bean life cycle, in both experiments. The experiments were conducted in an area whose history included weed homogeneous infestation of different species, eight treatments with four replications were applied within this area, totaling 32 plots.

2.3. Experimental design

A randomized complete block design with four replications was used. The experiment was conducted using a conventional sprinkler supplementary irrigation system in the absence of rainfall. Data on rainfall, relative humidity and minimum, maximum and average temperatures during the experimental period are presented in figure 1.

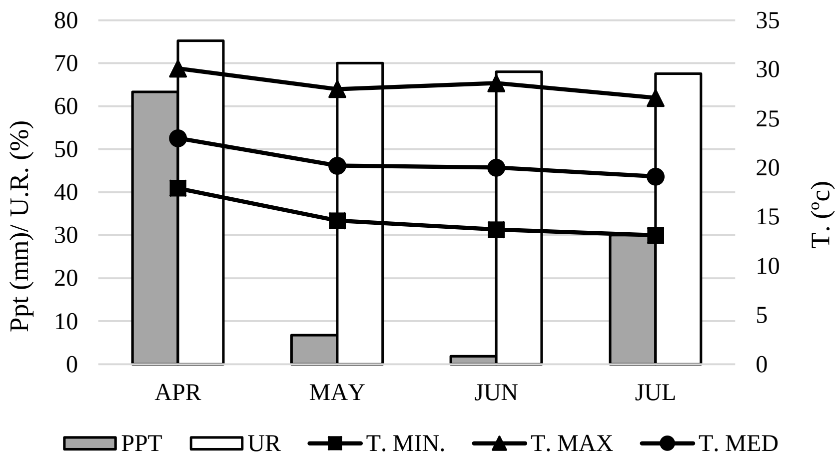

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Figure 1. Precipitation, maximum, media and minimum temperatures during the trial period

The evaluation of the weed community was performed at the end of each period of coexistence of each plot. The weeds present in two sample areas of 0.25 m^2 randomly collected in the experimental plots were removed, identified, separated by species, counted and dried in an oven with forced air circulation at 70° C for 96 h to determine dry mass, performed with the aid of a scale with an accuracy of 0.01 g. The experimental plots, after the end of their respective coexistence periods, were then maintained without weeds until harvest, by removal periodic weeds. With the weed community data the relative importance of the weed community was calculated, which consists of an index that involves three factors: relative frequency; relative density and relative dominance, following the formulas proposed by Mueller-Dombois & Ellemberg [14]. Harvesting started on days 109 DAE, manually, with moisture grains around 13%. The pods were mechanically trod and the harvested beans were weighed in a precision scale of 0.01 g.

2.4. Statistical analysis

The analysis of the yield data was performed individually for each cultivar and the results were submitted to regression analysis by Boltzman's sigmoidal model [15]:

$$y = \frac{(P1 - P2)}{1 + e^{(X - X_0)/dx}} + P2$$

Legend: y = grain yield of the bean in function of the coexistence periods.

P1 = maximum yield obtained in the plants kept weeding during the whole cycle.

P2 = minimum yield obtained in plants living with weeds during the maximum period (109 days).

(P1 - P2) = production losses.

X = upper limit of the coexistence period.

X0 = upper limit of the coexistence period, which corresponds to the intermediate value between the maximum and minimum production.

dx = parameter that indicates the speed of loss of production as a function of the coexistence time.

Based on the regression equation, the previous period of weed interference was determined for the arbitrary tolerance levels of 2.5%; 5% and 10% reduction in bean crop productivity, in relation to the treatment maintained in the absence of weeds. Based on the regression equations, the regression analysis was performed using the Origin® program.

3. RESULTS AND DISCUSSION

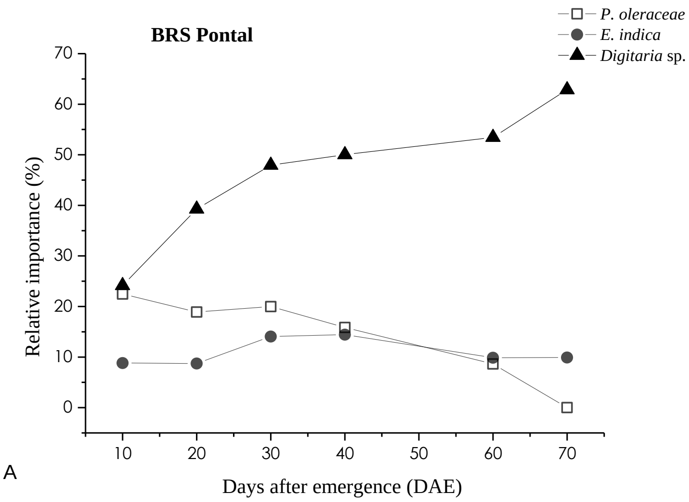
3.1. Weed community

During the experimental period, it was verified that the weed community was composed of 19 weed species (Table 2). Of this total, ten species (52%) are dicotyledonous and nine species are monocotylated (47%). In the group of monocotyledons, the family that stood out the most was the Poaceae with five species. In the eudicotiledonias group, the Asteraceae families are presented with three species each. The families Poaceae and Asteraceae were also the most found in researches with common bean in the interior of São Paulo [16-18, 11] and irrigated bean plants under central pivot in the interior of Goiás in Brazil [19].

Table 2. Weed community of the experimental area

Famíly	Scientific name	International code	
Amaranthaceae	*Alternanthera tenella* Colla	ALRTE	Dicots
Amaranthaceae	*Amaranthus defluxus* L.	AMADE	Dicots
Asteraceae	*Acanthopermum hispidum* DC.	ACHI	Dicots
Asteraceae	*Emilia sonchifolia (L.) DC.*	EMISO	Dicots
Asteraceae	*Parthenium hysterphorus* L.	PTNHY	Dicots
Brassicaceae	*Raphanus raphanistrum* L.	RAPRA	Dicots
Commelinaceae	*Commelina benghalensis* L.	COMBRE	Monocots
Convolvulaceae	*Ipomoea grandifolia* (Dammer) O'Donell	IPOGR	Dicots
Cyperaceae	*Cyperus rotundus* L.	CYPRO	Monocots
Fabaceae	*Indigofera hirsuta L.*	INDHI	Monocots
Fabaceae	*Senna obtusifolia*(L.) H. S. Irwin &Barneby	CASOB	Monocots
Poaceae	*Cenchrus echinatus L.*	CCHEC	Monocots
Poaceae	*Cynodon dactylon* (L.) Pers.	SYNDA	Monocots
Poaceae	*Digitaria* sp.	DIGHO	Monocots
Poaceae	*Eleusine indica* (L.) Gaerth	ELEIN	Monocots
Poaceae	*Panicum maximum* Jacq.	PANMA	Monocots
Rubiaceae	*Richardia brasiliensis Gomes*	RCHBR	Dicots
Portulacaceae	*Portulaca oleraceae* L.	POROL	Dicots
Solanaceae	*Solanum americanum* Mill.	SOLAM	Dicots

The most important weeds found in the experimental areas were species such as *Digitaria* sp., *Portulaca oleraceae* and *Eleusine indica*, in the two cultivars, however differences occurred between seasons and species evaluated (Figures 2, 3 and 4). The species *Digitaria* sp., obtained high relative importance (RI) values, being always superior to the others, in all evaluated time, in the two cultivars. At the beginning of the experimental period (20 DAE) the relative importance of this species was above 20% linearly up to 70 DAE, in which BRS Pontal and 69% in the area with IPR Juriti (Figure 2). This is based on the large number of individuals found in the area and dry mass that this species possessed throughout the experiment (Figure 3, 4). At 40 DAE the individuals density was maximal, in which it exceeded 250 individuals per square meter at the place where the cultivar BRS Pontal was present and exceeded 500 individuals per square meter in the area with the IPR Juriti cultivar (Figure 3). The dry mass was maximum at 70 DAE in its areas, reaching in the cultivar BRS Pontal 316.08 g m^{-2} and in the place with IPR Juriti beans, the value was extremely high surpassing 757 g m^{-2} (Figure 4). Similar results were obtained by Tavares *et al*. [19], in which the species *Digitaria horizontalis* was expressive in bean cultivated in three planting seasons, being higher than 30% in the summer-fall season. Borchardt *et al.* [20] verified losses of 35% in the bean crop when *D. horizontalis* was present in the weed community. Parreira *et al*. [11] when working with bean growers of different growth habits, verified that the relative importance of this species varied from 24 to 51%, depending on the season and evaluated cultivar.



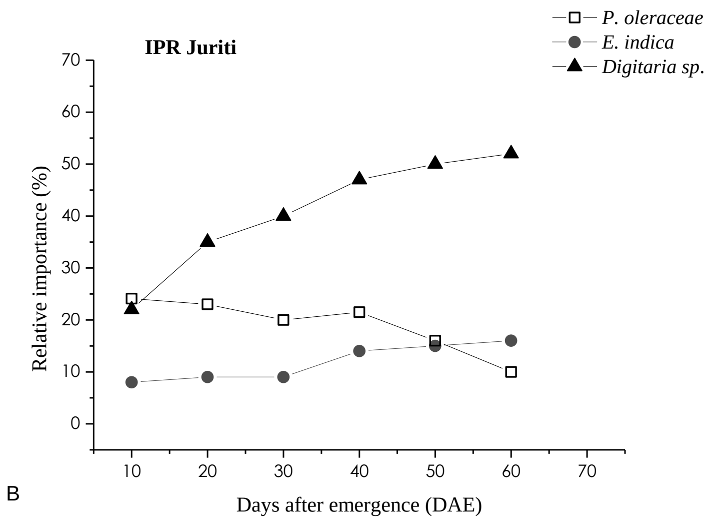
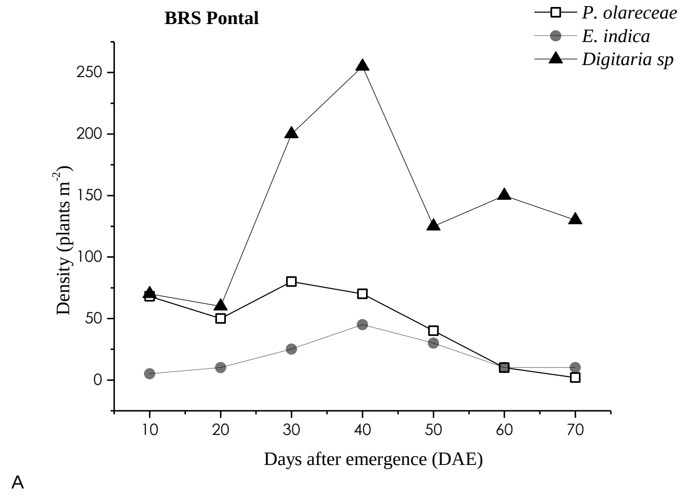


Figure 2: Relative importance (%) of the most relevant weeds present in the bean crop of the cultivars BRS Pontal (A) and IPR Juriti (B).

The specie *Portulaca oleraceae* was the second most important, with significant values at the beginning of the experimental period, higher than 20% RI, however during the experiment the values were drastically reduced in both cultivars (Figure 2). In the two areas, in the last evaluation (70 DAE), the RI reached zero due to the absence of plants found in this evaluation. The highest densities were obtained at 30 DAE, with 88 plants m^{-2}, in the present area the cultivar BRS Pontal and 175 plants m^{-2} at the site with IPR Juriti (Figure 3). The dry mass accumulated up to 50 DAE, surpassing 50 g m^{-2} in the area where BRS Pontal was present and with the cultivar IPR Juriti present, *P. oeracea* plants exceeded 100 g m^{-2} (Figure 4). The specie *P. oleracea* performs the process of photosynthesis through the C_4 cycle, has a very short cycle, is present in tropical and cold regions, adapting well to poor soils, however the vegetative development is lower [21].



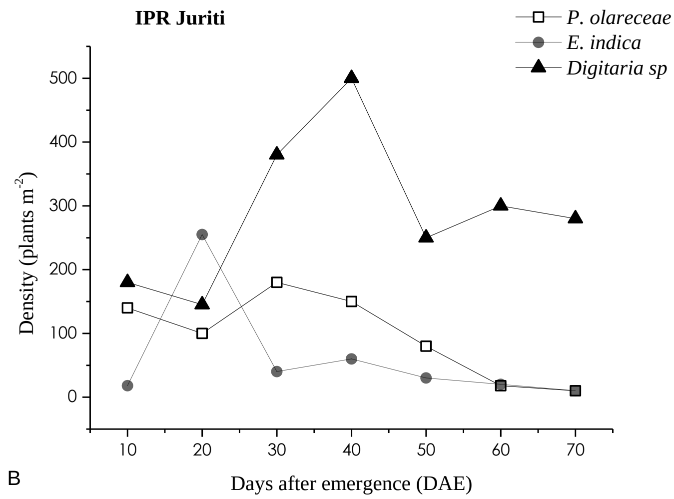


Figure 3: **Density (plants m^{-2}) of the most relevant weeds present in the bean crop of cultivars BRS Pontal (A) and IPR Juriti (B).**

At the sites of the two cultivars studied the *Eleusine* species indicates the relative importance did not have high variation during the evaluated periods, ranging from 9 to 15% (Figure 2). In the cultivar area BRS Pontal kept RI around 9% up to 30 DAE, increasing to 15% in the period from 40 to 60 DAE and decreasing again to 9% at the end of the 70 DAE evaluation period. In the present area the cultivar with IPR Juriti, during the whole experiment, this species kept IR around 10%, presenting its peak of importance relative to 50 DAE, when it reached 14.47%. The densities of this weed had different behaviors at both sites, however the highest density was obtained at 40 DAE in the area with the BRS Pontal cultivar with 40 plants per m^{-2}, and in the area with the IPR Juriti cultivar the highest density was acquired at the beginning of the experimental period (20 DAE) with density 268 m^{-2} plants (Figure 3). The plants of this species accumulated dry mass more slowly, reaching the maximum of dry mass at 50 DAE (60.69 g m^{-2}) at the site with the cultivar BRS Pontal, after which they decreased to 24,38 g m^{-2} at 70 DAE (Figure 4). In the area with the IPR Juriti beans, at 50 DAE, *E. indica* plants reached 121.38 g m^{-2}, decreasing to 48.75 g m^{-2} at 70 DAE. Species plants *Eleusine* produce a high amount of seeds, which are disseminated by the wind, have a competitive advantage over the other species when it is established in compacted soils and high acidity [22, 23].

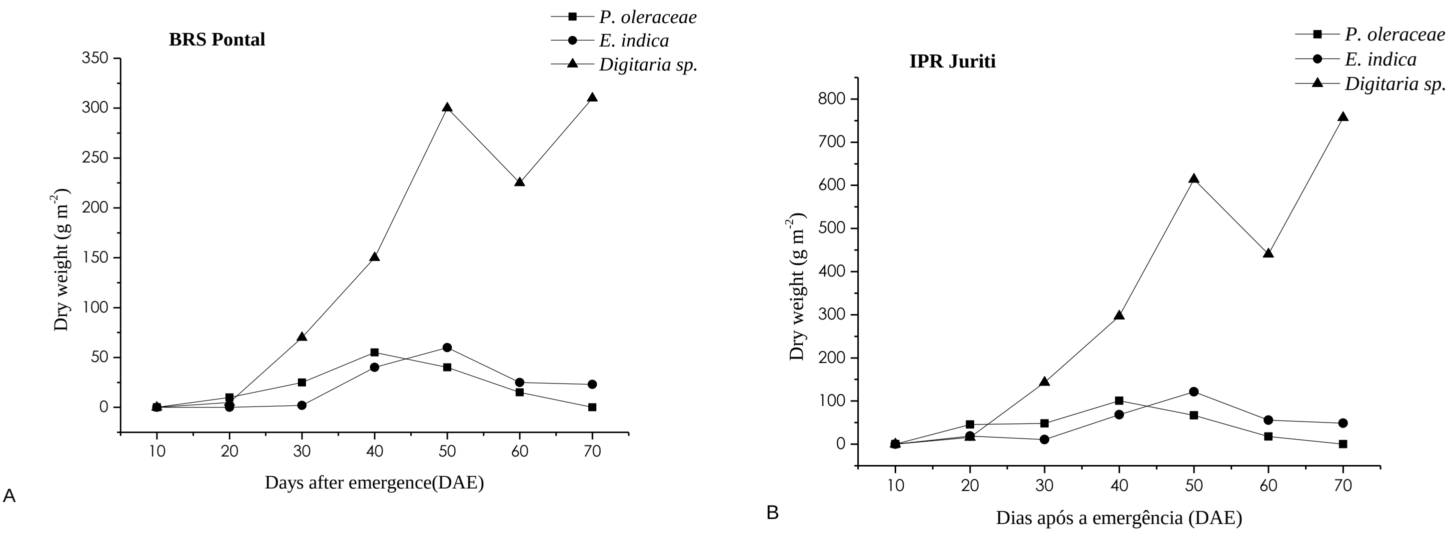


Figure 4: **Dry weight (g m^{-2}) of the weeds most relevant present in the bean crop of cultivars BRS Pontal (A) and IPR Juriti (B).**

3.2. Bean crop productivity

There was a 77.8% and 57.9% reduction in bean productivity because of living with weeds throughout the cycle for BRS Pontal and IPR Juriti cultivars, respectively (Table 2). Parreira *et al.* [11] found similar results when searching for cultivars with different growth habits. Type III growth habit (BRS Pontal) was more affected by competition with weeds during the whole crop cycle (up to 76%) and bean growers with type II growth habit (IPR Juriti) obtained a reduction in production, around 69%, but extremely significant. For example, in studies in the Amazon region, bean cultivars, of indeterminate growth habit type IV, obtained losses that varied from one cultivar to the other. from 60 to 90%, depending on the cultivar analyzed [24]. In the northeast Brazil, Freitas et al. [25] found a reduction of 90% in their grain yield using cultivar BR 16. Meanwhile Correia *et al*. [26] in Maranhão state, showed 46% losses in the yield of beans with the same growth habit (type IV). When using the cultivar Manata, with an indeterminate growth habit type I (with more erect architecture), in Portugal, with the crop under full development conditions, the reduction in productivity was over 65%, under water stress the increased loss to 76% [27]. In the United States, Sbatella *et al*. [28] working with Great Northern 'Orion, verified losses of 1.2 to 1.8% in production every 100 days of delay in control when volunteer maize was present in the crop. In Italy, Stagnari & Pisante [29] found that weeds reduced the production of lowland bean (*Phaseolus vulgaris*) by 60%. According to the Boltzman equation, the highest production in the absence of weeds was obtained by the cultivar IPR Juriti, surpassing 3.323 kg ha^{-1}, which has an indeterminate growth habit (type II) and cultivar BRS Pontal, with the habit of indeterminate growth (type III) with lower production, reaching 2.396,4 kg ha^{-1} (Table 3). The cultivar that presented higher productivity in the weeds presence was also IPR Juriti (1.398,81 kg ha^{-1}) (Table 3). The cultivar BRS Pontal presented the lowest yield in the presence of weeds (531,48 kg ha^{-1}), however the bean plants of this cultivar were more effective in competition with weeds, presenting lower reduction loss velocity (dx = 8, 8) than the cultivar IPR Juriti (dx = 14.9), thus the loss in production was slower, achieving productivity of more than 1.300 kg ha^{-1} with weed interactions throughout the crop cycle. However, it should be noted that this cultivar did not obtain high yield in the absence of weeds.

Table 3. Parameters determined for the Boltzman sigmoidal equations adjusted to the grain yield data according to the weed coexistence periods for the cultivars BRS Pontal and IPR Juriti.

Parameters	Cultivars	
	BRS Pontal	IPR Juriti
P1	2.396,4	3.323,83
P2	531,48	1.398,81
X0	52,11	36,83
dx	8,83	14,9
R^2	0,96	0,97
Production loss	77,80%	57,90%

3.3. Periods of interference

Considering the arbitrary value of 5% loss in productivity, BRS Pontal, which has indeterminate growth type III, very prostrate, consequently shading between the lines quickly, the PPI was 30 days after emergence (DAE) (Figure 5). On the other hand, the cultivar IPR Juriti with indeterminate growth type II, of more erect architecture, was consequently more sensitive to the interference of the weed community at the beginning of the vegetative period, resulting in an PPI of 5 DAE. Parreira *et al.* [7] also obtained extremely low PPI values when analyzing beans with indeterminate growth type II of only 3 days, tolerating a 5% loss in productivity.

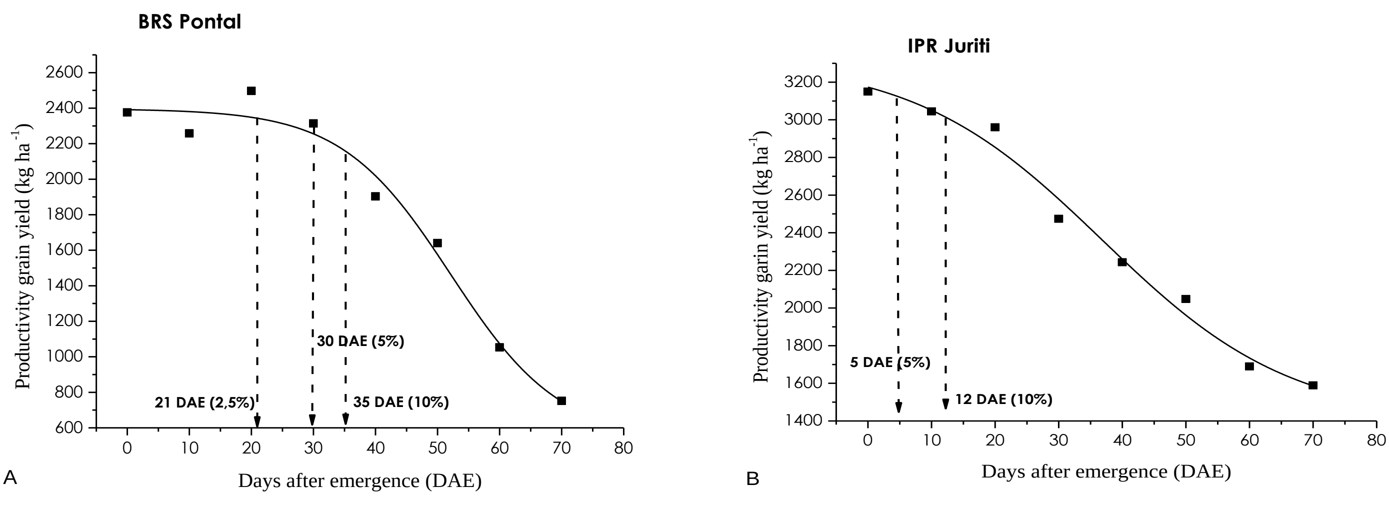


Figure 5. Productivity grain yield of BRS Pontal beans and IPR Juriti, in response to periods of coexistence with weeds, considering the loss of productivity arbitrary of 2.5%, 5% and 10% in productivity

With cultivars of habit indeterminate growth type III, cultivar Rubi, Scholten *et al*. [18] and Bressanin *et al.* [30] obtained results like the BRS Pontal cultivar, with PAI ranging from 19 to 23 DAE. Parreira *et al.* [31, 11] found the PAI 20 days in common bean growers (type III). By decreasing this arbitrary value to 2.5% reduction in productivity, the PPI value decreases by 9 days for the cultivar BRS Pontal (21 days) and for the IPR Juriti cultivar the PPI value is so small that any time of competition of plants of this cultivar with weeds, already cause significant decreases in productivity (Table 4). By increasing the percentage of yield loss to 10%, the PPI increases to 35 days in the BRS Pontal cultivar and 12 days to the IPR Juriti cultivar. The IPR Juriti cultivar, although presenting the highest productivity, was not efficient in competition with weeds, presenting extremely low values of PPI, regardless of loss in productivity, cannot reach 15 days of weed contact (Table 4).

Table 4. Periods prior to interference (PPI) considering the 2.5%, 5% and 10% reduction in productivity for bean cultivars BRS Pontal and IPR Juriti.

	Productivity Grain		
Cultivars	2,50%	5%	10%
	Days After Emergence (DAE)		
BRS Pontal	21	30	35
IPR Juriti	-	5	12

The choice of the producer among these cultivars will depend on when the weed management in the area will occur, regardless of the weed community existing in the area. If this management is done late, the cultivar BRS Pontal is a proper option, remembering that the productive potential of this cultivar is lower. If the choice is made by IPR Juriti, the weed management must be carried out from the sowing so that the yield return is satisfactory.

4. CONCLUSION

The periods prior to interference were 21, 30 and 35 days for the BRS Pontal bean cultivar and 0, 5 and 12 days for the IPR Juriti cultivar, with the arbitrary levels of reduction of productivity of 2,5%, 5% and 10%, respectively, living with the infesting community composed predominantly of the species *Digitaria* sp., *Portulaca oleraceae*, and *Eleusine indica*.

ACKNOWLEDGEMENT

The authors thank to the FCAV-UNESP for financial supports and research facilities

CONFLICT OF INTEREST

Authors have no conflict of interest.

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