*IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*
*e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 12, Issue 6 Ser. I (June 2019), PP 37-46*
*www.iosrjournals.org*

# Productivity and Level of Weeding Level in Bean Cultivars in Response to Spacing between Rows

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***Abstract:*** *In Paraguay, the bean can become a good option for agricultural diversification, for commercial purposes and for this, changes must be made in the productive system of this item. Based on this, this work was developed, between September and October 2015, with the purpose of evaluating productivity and weeding level of cultivars of bean in response to the spacing between rows. The experimental design used was randomized complete blocks, with an arrangement of subdivided plots 2 x 4, the main plot being the cultivar(Negro and Carioca) and the secondary plot, the spacing between rows (30, 40, 50 and 60 cm ), with four repetitions. The number of pods per plant, total yield and weight of 1000 grains, fresh mass and dry weed mass per m2 were determined. The data obtained were subjected to analysis of variance and comparison of means by the Tukey test and regression analysis. The cultivar Carioca was superior to the Negro in the productive characters; the increase in spacing between rows induced lower values of the bean performance as well as the other productive components. There was an increase in the level of weeding by increasing the spacing between plants.*

***Keywords:*** *Phaseolus vulgaris, weeds, spacing, productivity*

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Date of Submission: 25-05-2019 Date of acceptance: 10-06-2019

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## I. Introduction

The production of bean in Paraguay in the period 2012/2013 was of 3.769.000 kg, with a sowed surface of 4.547 hectares and an average yield of 828.89 $kg.ha^{-1}$ and it is concentrated in the Departments of San Pedro, Concepción , Canindeyú and Amambay (DGEEC, 2015).

Its cultivation is approached at the level of small producers and is intended for family consumption (Schulz, 2006), but it can nevertheless become a good option for agricultural diversification, for marketing purposes.

For this, changes must be made in the productive system of this item, and within these, one of the aspects that can be modified refers to the spacing of the crop, since the distance of 0.60 m between rows and 0.25 m between plants recommended by the Ministry of Agriculture and Livestock (Schulz, 2006), results in a low plant density (66,667 $pl.ha^{-1}$) in relation to that used in other countries, mainly Brazil, where a density of 200,000 is recommended $pl.ha^{-1}$ (CTSBF, 2012).

With the increase of planting density it is expected that the productivity of the crop increases and this response reaches the maximum when the point of maximum technical efficiency is reached: the critical density that allows to reach the maximum productivity and above which the yields they are decreasing.

This density varies with the cultivar and the region, so for each case studies must be conducted in order to determine the exact relationship for each particular situation.

By varying the planting density, other aspects of production are also influenced, such as the level of weeding, which can directly influence production costs, since the quantity of hand weeded control or other operations for weed control can be modified.

Based on the presented approaches, this work was developed with the purpose of evaluating the effect of the spacing between rows on the productivity and the level of weeding of cultivars of bean, based on the following objectives: to determine the number of pods per plant, the total yield of the crop and the weight of 1000 grains of cultivars of bean in function to the spacing between rows. To evaluate the influence of the treatments on the number, fresh mass and dry mass of weeds in the cultivation of bean.

## II. Materials And Methods

**Location of the experiment**

The experiment was carried out in the period between September and December 2014 in a private farm located in the company Santa Lucía, Municipality of Belén, Department of Concepción, Paraguay, 19,5 km distant from the City of Concepción, on the V route General Bernardino Caballero, in the coordinates in the coordinates 23 ° 27 '58 "S, 57 ° 15' 43" W and altitude 79 msnm.

**Characteristics of the climate and soil of the place**

The average annual temperature in Belén is 23.5 °C; the average rainfall is 1346 mm per year. The driest month is August, with 48 mm. The month with the highest rainfall of the year is November with 161 mm. The hottest month of the year, with an average of 27.7 ° C, is January and the coldest month of the year is June with an average of 18.8 ° C (Directorate of Meteorology and Hydrology of the Directorate of Civil Aeronautics Paraguay 2015).

The soil is characterized by a sandy-frank texture, the content of organic matter in the superficial 20 cm is 0.75% (low), pH is slightly acidic, with values of 5.61, phosphorus level and low potassium according to the soil analysis carried out by the Soil Laboratory of Facultad de Ciencias Agrarias of the Universidad Nacional de Asunción (Table 1).

**Table 1.** Result of the soil analysis carried out by the Soil Laboratory of the Facultad de Ciencias Agrarias of the Universidad Nacional de Asunción.

| pH | O.M. | P | $Ca^{+2}$ | $Mg^{+2}$ | $K^{+}$ | $Na^{+}$ | $Al^{+3}$ | $Al^{+}$ | Texture | Color | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | ppm | | | $cmol.kg^{-1}$ | | | | | Munsell | Description |
| 5,68 | 0,75 | 2,2 | 2,61 | 0,35 | 0,08 | 0,03 | 0 | | Loam soil | 7,5 YR 4/4 | Brown |

**Experimental design used**

The experimental design that was carried out for the study was the Random Complete Blocks, with an arrangement of subdivided plots 2 x 4, being the main plot the cultivation and the secondary one, the spacing between rows (Table 1), totaling eight treatments and four repetitions; The experimental unit (UE) comprised plots of 14.4 $m^2$ (3.60 x 4.0 m) and the total experimental area was 460.80 $m^2$.

**Table 2.** Plots that have been used as treatments in the experiment. Concepción, Paraguay, 2016.

| Plots | Concept | Description | Símbols |
|---|---|---|---|
| Principal | Cultivar | Negro | $C_1$ |
| | | Carioca | $C_2$ |
| Secondary | Row spacement (cm) (1) | 30 | $D_1$ |
| | | 40 | $D_2$ |
| | | 50 | $D_3$ |
| | | 60 | $D_4$ |

(1) The spacing between plants was kept constant at 25 cm, so the following densities

$D_1$: 133.333 $pl.ha^{-1}$ $D_2$: 100.000 $pl.ha^{-1}$

$D_3$: 80.000 $pl.ha^{-1}$ $D_4$: 66.666 $pl.ha^{-1}$

**Process of experiment implementation and crop management**

Once the experimental area was selected, soil sampling was carried out, for which a soil sample was removed on 05/09/2015, which was sent to the Soil Laboratory of the Facultad de Ciencias Agrarias (UNA) for its characterization.

After 15 days the soil was prepared in a conventional way, by plowing and tracing, and the planting of the bean was carried out on 09/18/2015, at the spacing presented in Table 1.

Soil fertilization was carried out according to the recommendation of soil analysis were applied at the time of planting. Weed control was not carried out and cypermethrin was applied in a dose of 1 $lt.ha^{-1}$, on 2 occasions at 30 and 55 DDE, for the control of caterpillars.

During the experimental period, according to data recorded at the site of the experiment, there was only a 20 mm precipitation on 09/24/2015 and 40 mm on 10/18/2015, so the crop presented growth problems due to drought, which was reflected in the productivity obtained.

The harvest was made at 120 DDE, on 12/20/2015 when the plant dried completely. All the plants of each experimental unit were removed in a single time, later it is gathered in a bag for threshing in this way we proceed for each experimental unit.

**Determinations and evaluation procedures**
To study the effect of the treatments, the study was divided into two parts:

**Effect on the agronomic characters of the bean.**
**Number of pods per plant:** Of the two central rows of each experimental unit, discarding 0.50 m at each end, 6 plants were selected and from each of them were harvested and accounted for all the pods formed at the time of harvest , and the average represented the experimental unit. The results were expressed in podinas.pl$^{-1}$.

**Total yield of the crop:** All the plants of the experimental unit were harvested and the total mass of grains was determined on an electronic scale of 0.01 g of resolution and the value obtained was extrapolated for one hectare. The values were expressed in kg.ha$^{-1}$.

**Weight of 1000 grains:** From the total of harvested grains per experimental unit, a sample of 1000 grains was obtained and they were weighed on a balance of 0.01 g of resolution. The results were expressed in g.

**Effect on weed infestation**
To evaluate this phase, in each experimental unit was marked in the two central rows, discarding 0.50 m at each end, two areas or sampling units equivalent to 1.0 m$^2$ each and in them the following determinations were carried out. At 30 and 40 days after the emergency (DDE), using one unit for each date of determination:

**Number of weeds:** In each sampling unit we counted the number of weeds present for each identified species. The values were expressed in un.m$^{-2}$.

**Fresh mass of weeds:** Once the number of weeds was counted, the weeds were cut at the height of the neck with pruning shears and the fresh mass of the whole was determined on an electronic scale of 0.01 g of resolution. The values were expressed in g.m$^{-2}$.

**Dry mass of weeds:** Once the fresh mass was obtained in each sampling unit, the set of weeds was placed in a paper bag and placed in an oven at 65 ° C for 72 hours and then the dry mass was determined, an electronic balance of 0.01 g of resolution. The values were expressed in g.m$^{-2}$.

**Analysis of the data**
The recorded data were subjected to analysis of variance (ANAVA) by means of the 5% F Test and in case of a significant treatment effect, the means were compared by the Tukey Test at 5%. Regression analysis was also carried out for the spacing between rows in those determinations where significant effect was registered.

## III. Results

**Effect on the agronomic characters of the bean**
**Number of pods per plant**
Table 3 shows the means of the number of pods of the bean plant according to the factors individually; it can be verified that the factors cultivate and spacing between rows did not influence this character, either individually or in combination.

Thus, Carioca and Negro cultivars have a similar number of pods per plant, with an average of 4,52 podinas.pl$^{-1}$. Similarly, by varying the spacing between rows of 30 to 60 cm, there was no significant variation in this character, giving an average of 4,52 podinas.pl$^{-1}$.

**Table 3.** Number of pods per plant of bean in function to the cultivar and to the spacing between rows. Concepción, Paraguay, 2016.

| Plot | Description | Number of pods (pods.pl$^{-1}$) (1) | |
|---|---|---|---|
| Cultivar | Carioca | 4,62$^{ns}$ | |
| | Negro | 4,43 | |
| Row spacement (cm) | 30 | 5,00$^{ns}$ | |
| | 40 | 4,62 | |
| | 50 | 4,37 | |
| | 60 | 4,12 | |
| C. V. Cultivar (%) | 9,82 | DMS Tukey: | 0,50 % |
| C. V. Row spacement (%) | 15,44 | DMS Tukey: | 0,98 % |

(1) ns: Not significant. C.V: Coefficient of variation. LSD: least significant difference. MG: General mean.

**Total crop yield**

Table 4 contains the means of the total yield of the crop according to the factors in cultivated form and spacing between rows; It can be verified that the factors have a significant influence on this character, both individually and in combination.

**Table 4.** Total yield of the cultivar of bean (kg $ha^{-1}$) as a function of the cultivar and the spacing between rows. Concepción, Paraguay, 2016.

| Row spacement (cm) | Cultivar | | Individual Row spacement |
|---|---|---|---|
| | Negro | Carioca | |
| 30 | 204,45 A a | 213,45 A a | 208,95 A |
| 40 | 195,18 A a | 209,33 A a | 202,62 A |
| 50 | 143,68 B b | 192,23 A a | 167,95 B |
| 60 | 135,59 B a | 144,53 B a | 140,06 C |
| Individual Cultivar | 169,73 b | 189,89 a | |
| C. V. Cultivar (%) | | 7,10 | |
| C. V. Row Spacement (%) | | 5,90 | |

Means followed by the same capital letter for columns and lowercase for rows do not differ from each other by the Tukey Test at 5% error probability. C.V: Coefficient of variation. LSD: least significant difference.

Without considering the spacing between rows, the Carioca cultivar presented a higher yield with an average of 189,89 kg.$ha^{-1}$, statistically surpassing the Negro cultivar, which only reached 169,73 kg.$ha^{-1}$; the percentage difference in favor of the Carioca cultivar was 11,87%.

Regarding the effect of the spacing between rows for any of the cultivars, it is observed in Table 4 that the spacings of 30 and 40 cm between rows presented similar yields to each other, with an average of 205,78 kg.$ha^{-1}$, being higher than the other distances under study, which reached 167,95 kg.$ha^{-1}$ for the distance between rows of 50 cm and 140,06 kg.$ha^{-1}$ for 60 cm.

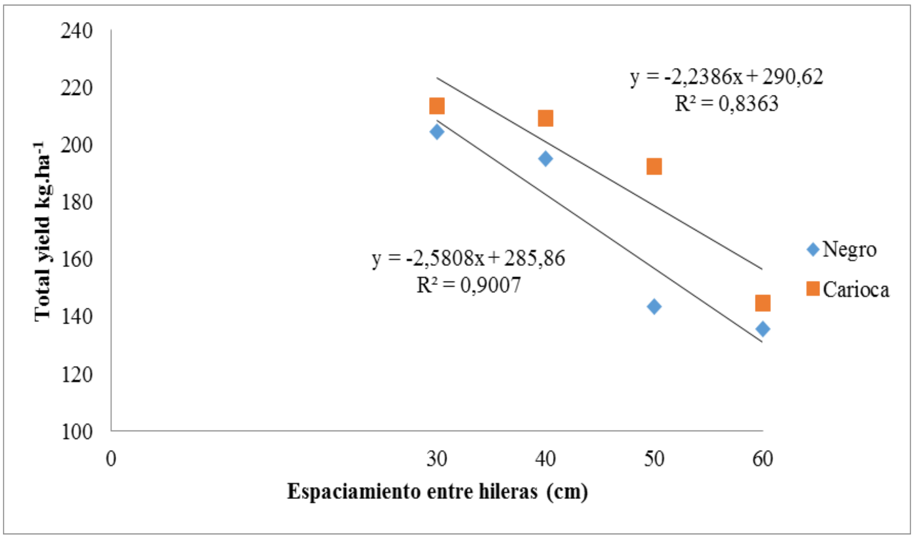


**Figure 1.** Adjusted curve between spacing between rows individually and the total yield of the bean culture. Concepción, Paraguay, 2016.

Figure 1 contains the adjusted curves between spacing between rows and the total yield of the cultivar of habilla for the cultivars Negro and Carioca. For both cultivars, the indicated ratio follows a decreasing linear model y = -ax + b, the corresponding equations being the following:

Y NEGRO = -2.5808X + 285.86 $R^2 = 0.9007$

Y CARIOCA = -2.2386X + 290.62 $R^2 = 0.8363$

where:

Y NEGRO, Y CARIOCA: Total yield of the cultivars Negro and Carioca, respectively (kg.$ha^{-1}$)

X: Inter-row spacing (cm)

$R^2$: Coefficient of determination

According to Figure 1, the Black cultivar undergoes a reduction of 2,58 kg.$ha^{-1}$ in its yield when the spacing between rows is increased by 1 cm, and the Carioca cultivar decreases by 2,23 kg.$ha^{-1}$ for each unit the spacing between rows is increased.

**Weight of 1000 grains**

The data presented in Table 5 correspond to the means of the weight of 1000 beans according to the factors individually; it can be verified that there is a significant effect of the factor cultivate on this character and not so of the spacing between rows or of the interaction of factors.

Thus, the cultivars presented a weight of 1000 grains statistically different from each other, with better values for the Carioca cultivar (215,68 g); in the Black cultivar only 196,81 g was reached. The percentage difference in favor of the first was 9,58%.

On the other hand, by varying the spacing between rows of 30 to 60 cm, there was no significant variation in the weight of 1000 grains, giving an average of 206,25 g.

**Table 5.** Weight of 1000 beans (g) as a function of the cultivar when spacing between rows. Concepción, Paraguay, 2016.

| Plot | Description | 1000 grains weight (g) | |
|---|---|---|---|
| Cultivar | Carioca | 215,68 A | |
| | Negro | 196,81 B | |
| Row spacement (cm) | 50 | 207,25 a | |
| | 40 | 207,00 a | |
| | 60 | 205,75 a | |
| | 30 | 205,00 a | |
| C. V. Cultivar (%) | 4,31 | DMS Tukey: | 8,29 % |
| C. V. Row spacement (%) | 6,35 | DMS Tukey: | 17,92 % |

Means followed by the same capital letter to cultivate and lowercase letters to space between rows do not differ from each other by the Tukey test at 5% probability of error. C.V: Coefficient of variation. LSD: least significant difference.

**Effect on weed infestation**

**Number of weeds**

Table 6 summarizes the means of the number of weeds per sampling unit ($1m^2$) at 30 and 40 days after the emergence of the bean (DDE); The analysis tables of the variance correspond to each of them.

In relation to the cultivar factor, the number of weeds recorded at 30 and 40 DDE was statistically similar in the plots of both cultivars (Negro and Carioca), with averages of 48,87 and 55,12 $un.m^{-2}$.

**Table 6.** Number of weeds, in un.m2, depending on the crop and the spacing between rows. Concepción, Paraguay, 2016.

| Plot | Description | Number of weeds ($un.m^{-2}$) 30 DDE | 40 DDE |
|---|---|---|---|
| Cultivar | Carioca | 52,00 A | 59,75 A |
| | Negro | 45,75 A | 50,50 A |
| Row spacement (cm) | 30 | 38,00 a | 48,50 a |
| | 40 | 45,00 ab | 53,50 ab |
| | 50 | 51,00 b | 56,50 bc |
| | 60 | 61,50 c | 62,00 c |
| C. V. Cultivar (%) | | 21,57 | 16,68 |
| C. V. Row spacement (%) | | 14,89 | 9,42 |
| DMS Tukey Cultivar: | | 11,86 | 10,34 |
| DMS Tukey Row spacement: | | 10,29 | 7,34 |

Means followed by the same capital letter to cultivate and lowercase letters for row spacing do not differ from each other by the Tukey test at 5% error probability. C.V: Coefficient of variation. LSD: least significant difference.

As for the spacing between rows, a smaller number of weeds was recorded per unit of sampling ($1 m^2$) with the spacing of 30 cm, reaching 38,00 $un.m^{-2}$ at 30 DDE and 48,50 $un.m^{-2}$ at 40 DDE. When the distance between rows was varied, the number of weeds increased, reaching 60 cm at values of 61,50 and 62,00 $un.m^{-2}$ for each moment of determination.

Figure 3 contains the adjusted curves between the spacing between rows and the number of weeds for the cultivars individually at 30 DDE and 40 DDE. For both evaluation moments, the indicated relationship follows a linear increasing model y = ax + b, the corresponding equations being the following:

$Y_{30DDE} = 0,765X + 14,45$ $R^2 = 0,9846$

$Y_{40 DDE} = 0,435X + 35,55$ $R^2 = 0,9888$

where:

Y 30DDE, Y 40DDE: Number of weeds at 30 and 40 DDE, respectively (un.m$^{-2}$)
X: Inter-row spacing (cm)
$R^2$: Coefficient of determination

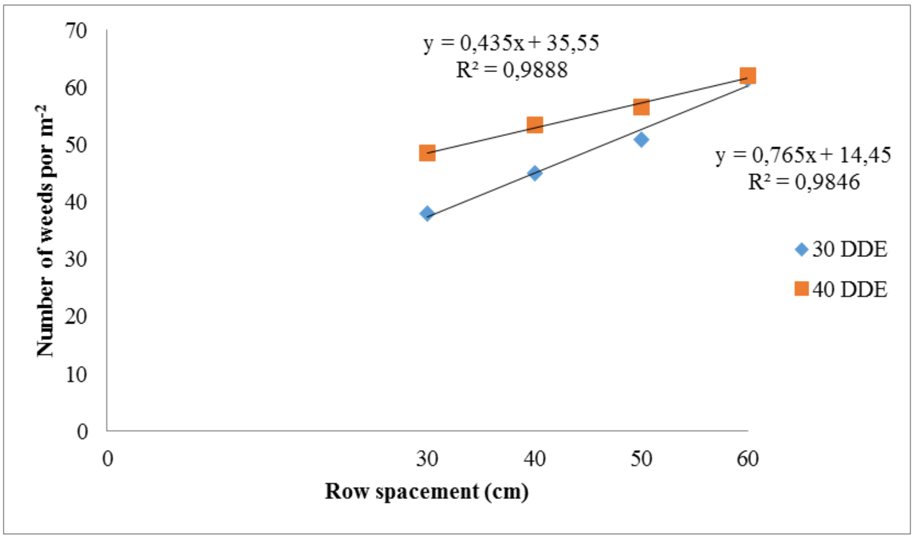


**Figure 2.** Adjusted curve between the row spacing and the number of weeds of the bean cultivation at 30 and 40 DDE. Concepción, Paraguay, 2016.

According to Figure 2, for the 30 DDE the number of weeds undergoes an increase of 0,75 un.m$^{-2}$ when the spacing between rows is increased by 1 cm, and for the 40 DDE, the increment is 0, 43 un.m$^{-2}$ for each unit that increases spacing between rows.

**Fresh weed mass**

The means of the fresh mass of weeds per sampling unit (1m$^2$) at 30 and 40 days after the emergence of the habitat (DDE), are presented in Table 7; the tables of analysis of variance corresponding to each of the moments of determination and they can verify that there is a significant effect of the factors cultivate and spacing between rows individually but not of the interaction of factors.

**Table 7.** Fresh mass of weeds depending on the cultivar and the spacing between rows. Concepción, Paraguay, 2016.

| Plot | Description | Fresh mass of weeds (g.m$^{-2}$) | |
|---|---|---|---|
| | | 30 DDE | 40 DDE |
| Cultivar | Negro | 75,37 A | 98,00 A |
| | Carioca | 193,50 B | 230,50 B |
| Row spacement (cm) | 30 | 113,37 a | 145,12 a |
| | 40 | 128,25 ab | 156,00 a |
| | 50 | 136,75 b | 166,87 ab |
| | 60 | 159,37 c | 189,00 b |
| C. V. Cultivar (%) | | 12,88 | 13,30 |
| C. V. Row spacement (%) | | 7,84 | 11,40 |
| DMS Tukey Cultivar: | | 95,09 | 116,97 |
| DMS Tukey Row spacement: | | 14,90 | 26,48 |

Means followed by the same capital letter to cultivate and lowercase letters for row spacing do not differ from each other by the Tukey test at 5% error probability. C.V: Coefficient of variation. LSD: least significant difference.

Considering the cultivar factor, the fresh mass of weeds at 30 and 40 DDE was statistically different in the plots of both cultivars (Negro and Carioca), with lower values for the Black cultivar with averages of 75,37 and 98,00 g.m$^{-2}$ two. In the plots of the Carioca cultivar, 193,50 and 230,50 g.m$^{-2}$ were recorded for each evaluation moment, respectively. With the Black cultivar a decrease of 156,73 and 135,20% was observed in the fresh mass of the weeds when compared with the plots cultivated with the Carioca cultivar.

Considering the effect of the spacing between rows on the fresh mass of the present weeds, it was observed that up to 30 DDE, in the 30 cm spacing, the lowest growth was registered with an average of 113,37 $g.m^{-2}$. When the spacing was increased to 60 cm, the fresh mass of weeds increased to 159,37 $g.m^{-2}$.

In the evaluation performed at 40 DDE, the spacings of 30 and 40 cm recorded fresh mass of weeds similar to each other, with an average of 150,56 $g.m^{-2}$, being statistically lower than those recorded in the other spacings. With 50 cm between rows, 166,87 $g.m^{-2}$ was obtained and with 60 cm, 189,00 $g.m^{-2}$.

Figure 3 contains the adjusted curves between row spacing and fresh weed mass for cultivars individually at 30 DDE and 40 DDE. For both evaluation moments, the indicated relationship follows a linear increasing model y = ax + b, the corresponding equations being the following:

Y 30DDE = 1,4650X + 68,51 $R^2$ = 0,9676
Y 40 DDE = 1,4251X + 100,12 $R^2$ = 0,9639
where:
Y 30DDE, Y 40DDE: Fresh weed mass at 30 and 40 DDE, respectively ($g.m^{-2}$)
X: Inter-row spacing (cm)
$R^2$: Coefficient of determination

According to Figure 3, for the 30 DDE the fresh weed mass undergoes an increase of 1,46 $g.m^{-2}$ when the row spacing is increased by 1 cm, and for the 40 DDE, the increase is 1,42 $g.m^{-2}$ for each unit that increases the spacing between rows.

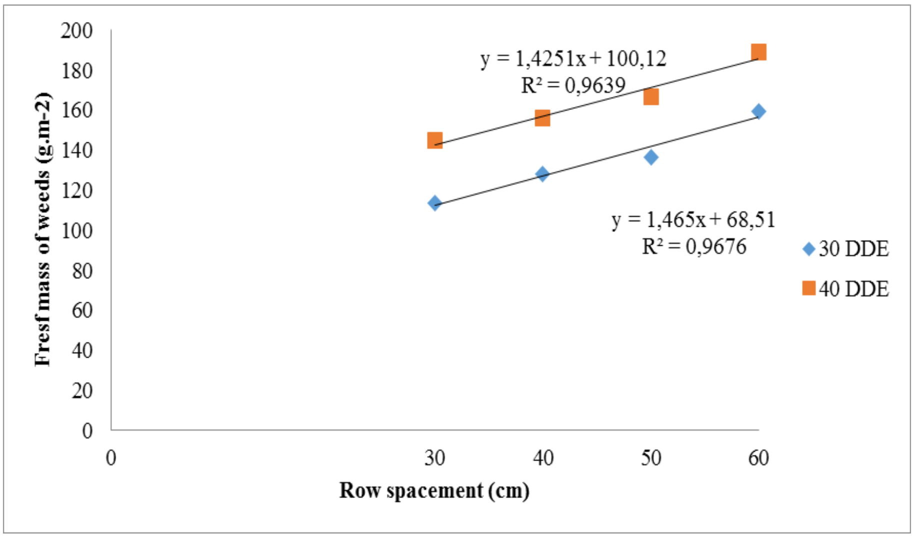


**Figure 3.** Adjusted curve between the spacing between rows and the fresh mass of weeds of the bean cultivation at 30 and 40 DDE. Concepción, Paraguay, 2016.

**Dry weed mass**

In Table 8 we can observe the means of dry mass of weeds per unit of sampling ($1m^2$) at 30 and 40 days after the emergence of the bean (DDE). According to the Fisher Test at 5%, there is a significant effect of the factors cultivating and spacing between rows individually but not of the interaction of factors.

The plots cultivated with the Black cultivar presented a dry weed mass of 44,75 $g.m^{-2}$ at 30 DDE, being significantly lower than that presented in the Carioca cultivar, where the weeds grew to reach 109,37 $g.m^{-2}$. At 40 DDE, the dry mass of weeds in the plots of the Black cultivar reached only 61,37 $g.m^{-2}$, while in the Carioca plots it reached 134,00 $g.m^{-2}$. With the Black cultivar a reduction of 144,40 and 118,34% was obtained in the dry mass growth of weeds at 30 and 40 DDE, respectively, in relation to the Carioca cultivar.

**Table 8.** Dry mass of weeds according to the cultivar and the spacing between rows. Concepción, Paraguay, 2016.

| Plot | Description | Weeds dryed mass ($g.m^{-2}$) | |
|---|---|---|---|
| | | 30 DDE | 40 DDE |
| Cultivar | Negro | 44,75 A | 61,37 A |
| | Carioca | 109,37 B | 134,00 B |
| Row spacement (cm) | 30 | 58,75 a | 74,50 a |

| | | |
|---|---|---|
| 40 | 78,75 b | 95,37 a |
| 50 | 81,37 b | 97,50 a |
| 60 | 89,37 b | 123,37 b |
| C. V. Cultivar (%) | 19,51 | |
| C. V. Row spacement (%) | 12,84 | |
| DMS Tukey Cultivar: | 25,58 | |
| DMS Tukey Row spacement: | 13,99 | |

Means followed by the same capital letter to cultivate and lowercase letters for row spacing do not differ from each other by the Tukey test at 5% error probability. C.V: Coefficient of variation. LSD: least significant difference.

Regarding the response of the dry weed mass to the variation of the spacing between rows, at 30 DDE in the plots of 30 cm between rows a dry weed mass of 58,75 $g.m^{-2}$ was observed, which is significantly lower than that recorded with the other spacings (40, 50 and 60 cm between rows) that reached an average of 83,16 $g.m^{-2}$.

At 40 DDE, the spacings between rows of 30, 40 and 50 cm were similar to each other in terms of the accumulation of dry weed mass, reaching an average of 89,12 $g.m^{-2}$. With 60 cm the weeds grew until reaching 123,37 $g.m^{-2}$, registering an increase of 38,43% in relation to the other spacings.

Figure 4 contains the adjusted curves between row spacing and dry weed mass for individual cultivars at 30 DDE and 40 DDE. For both evaluation moments, the indicated relationship follows a linear increasing model y = ax + b, the corresponding equations being the following:

Y 30DDE = 0,9448X + 34,5440 R2 = 0,8782
Y 40 DDE = 1,4874X + 30,7520 R2 = 0,9198
where:
Y 30DDE, Y 40DDE: Dry mass of weeds at 30 and 40 DDE, respectively ($g.m^{-2}$)
X: Inter-row spacing (cm)
$R^2$: Coefficient of determination

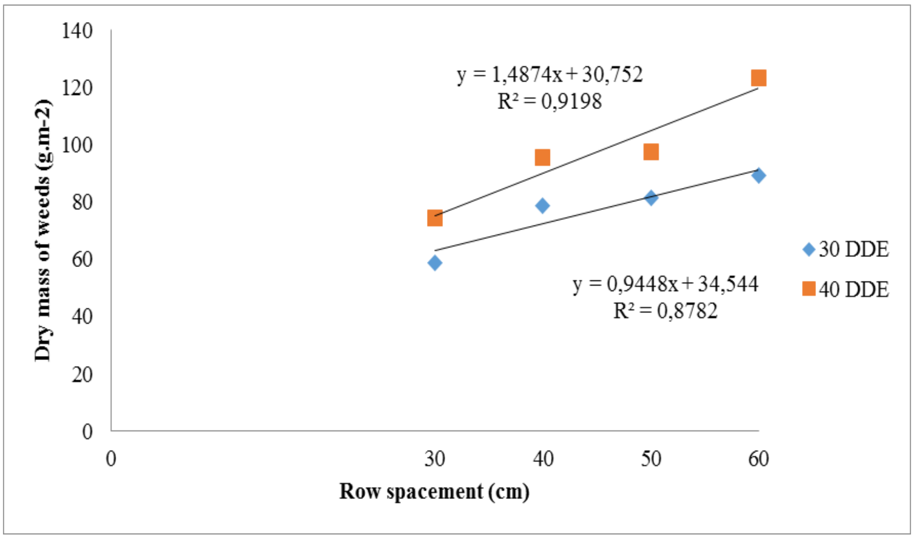


**Figure 4.** Adjusted curve between spacing between rows and the dry weed mass of the bean cultivation at 30 and 40 DDE. Concepción, Paraguay, 2016.

According to Figure 4, for the 30 DDE the dry mass weeds undergoes an increase of 0,94 $gm^{-2}$ when the spacing between rows is increased by 1 cm, and for the 40 DDE, the increase is 1,48 $gm^{-2}$ for each unit that increases the spacing between rows.

## IV. Discussion

The performance obtained during the experimental work was much lower than that recorded by the various researchers presented in the literature review. The same applies to the values corresponding to the other agronomic characters of the bean in this study.

The low productivity observed was entirely due to the lack of rainfall registered during the entire period of the crop, totaling only 60 mm, which does not cover the water needs of the crop, since according to the

Enciclopedia Práctica de la Agricultura y la Ganadería (1999) the Cultivation needs good water availability especially during flowering, with a total of 400 mm during the cycle.

However, it can be indicated that the trend observed in the results obtained is adjusted to the effects that the variation of the spacing induces in the crop: by increasing the spacing between plants and therefore by decreasing the density of the crop, the values of the productive characters decrease, confirming that the variation of spacing modifies the distribution of plants in an area, affects their vegetative and reproductive development and influences their agronomic characteristics (Conte e Castro, Boaretto & Kroll, 1999).

It also confirms that the variation of the populations affects the use of solar radiation by the leaves, influencing the photosynthetic capacity of the plant and therefore in the production, distribution and accumulation of photoassimilates (Evans, 1989, Marcelis, 1993; Marcelis, 1994).

Regarding the effect of the spacing on the weediness of the crop, it is observed that there is a tendency to increase the amount of weeds as well as the fresh and dry mass of the same with the increase in spacing.

This is explained due to the fact that, by decreasing the density of the crop, a greater free space is left for the growth of the weeds, which in turn was greatly benefited by the lack of rain, since the predominant species (*Cenchrus echinatus*) is a C4 metabolism plant, which gives it a great advantage in conditions of low water availability in relation to the bean, which is a C3 metabolism plant: the C4 plants are more efficient under stress conditions than the C4 (Taiz & Zeiger, 2006).

By increasing the spacing, weed interference increases, which accentuated the fall in the performance of the bush, as weed interferences cause reductions in the yields of agricultural crops, as indicated by Karam & Cruz (2004).

The results confirm that the productivity of the cultivar of bean can be reduced by the interference of the weeds from 15 to 97%, according to the density of the cultivated species (Lunkes, 1997, Scholten *et al*., 2011).

The low productivity was also a result of the interference of the weeds because the damages caused by the weeds depend on the species and the population density of the same (Carvalho, 1990, Mattos & Cardoso, 2005). This effect is due to the fact that weeds affect the growth and development of crops due to competition for water, light and especially nutrients (Radosevich *et al*., 1997) and, in turn, the spacing or separation distance of the cultivated plants can determine to a greater or lesser degree of interference, since the resources of the environment are limited (Casadei 2007, Marcolini *et al*., 2009).

The data referring to the amount of weeds and the dry mass of them is adjusted to the results of Parreira *et al*. (2013), considering diverse species of weeds, the density of weed plants in the cultivation of bean varies between 40 to 150 pl.m-2, with dry masses between 50 and 200 gm-2 in the period of 30 to 50 days of the crop.

## V. Conclusion

The cultivar Carioca was superior to the Negro in the productive characters; the increase in spacing between rows induced lower values of the performance of the bean as well as the other productive components. There was an increase in the level of weediness by increasing the spacing between plants.

The use of the Carioca cultivar is recommended with spacing between rows of 30 cm, equivalent to a density of 133,333 pl.ha$^{-1}$.

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Adolfo Leguizamón Resquin. " Productivity and Level of Weeding Level in Bean Cultivars in Response to Spacing between Rows. "IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) 12.6 (2019): PP- 37-46.