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# Phenological, morphological and yield component differences between a wild and domesticated form of common bean

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## Abstract

In 2014, two forms of common bean (*Phaseolus vulgaris* L.), one wild and the other domesticated, both of undetermined growth habit type IV, climber, were cultivated in the greenhouse. The culture was performed in hydroponics allowing the maximum expression of its genetic potential. The wild and domesticated form of *P. vulgaris* is an important reservoir of genes for plant breeding. The objective was to make a mutual comparison of phenological, morphological characters and yield components, as well as some physiological variables such as leaf area duration, net assimilation rate, pod filling index and harvest index. The wild form has a longer cultivation cycle than the domesticated one and a greater number of pods from the stage of filling the pod to the maturity of harvest and in the latter a greater number of seeds per plant, although the seeds of a smaller size and individual weight; likewise, the percentage of germination was similar in both forms without the need to scarify the seed. In the wild form, the total production of dry matter per plant and the duration of the leaf area are greater, this last characteristic due to the fact that its foliage remains functional longer compared to the domesticated one. The net assimilation rate is higher in the domesticated, which indicates its precocity. The traditional and modified harvest index (including and excluding the root in both cases) is higher in the domesticated form due to selection under domestication.

**Keywords:** *Phaseolus vulgaris* L., germplasm, indeterminate growth, seed weight per plant.

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# Introduction

The domestication of plants is related to the desire to satisfy the needs of man, which according to Hill (1952) are food, clothing, shelter, among others. The common bean, during a period of at least 7 000 to 8 000 years comprising the initial domestication phase and subsequent evolution under cultivation, has evolved from its wild form with a type of guide to one of bush, becoming the world, a domesticated legume very important for food. This evolution has been the result of mutation, selection, migration and genetic drift, acting on the raw material provided by *P. vulgaris* (Gepts and Debouck, 1991).

The centers of domestication that have been determined for the common bean are the Mesoamerican and the Andean, being a case of multiple and independent domestication (Kaplan and Lynch, 1999). The existence of a third center has been proposed, however, the current evidences do not allow to justify it (Hernandez *et al*., 2013). Mexico is part of the Mesoamerican domestication center, with a great diversity of *Phaseolus* ranging from wild, creole and improved (Peña *et al*., 2012). Strictly, it would be considered that *P. vulgaris* plants in their wild form would grow vigorously in undisturbed vegetation; however, in the future they could be found more frequently in secondary areas (Delgado *et al*., 1988).

In the archaeological remains of *P. vulgaris* only completely domesticated bean forms have been found, but there is no evidence of the domestication sequence (Gepts and Debouck, 1991). Deductions are made on the appearance of wild common bean based on what is currently observed; the archaeological remains show an increase in the size of the seed in the domesticated form (although also the size of the seed increases as it advances towards the south of the range of the distribution of the wild form, depending on the domestication center in which is found) (Toro *et al.*, 1990). The common bean is predominantly autogamous (Gepts, 1998).

The dehiscence in the pods of the wild form is key as the main characteristic (Schwanitz, 1966; Miranda, 1979; Delgado *et al.*, 1988; Toro *et al.*, 1990; Gepts and Debouck, 1991) and even Smartt (1988) considered explosive and Gentry (1969) when describing the dehiscence, points out that the seeds are violently projected. According to Gepts and Debouck (1991) dehiscence occurs in domesticated beans when it is destined for grain but not for green beans. The growth habit of wild bean in situ is commonly indeterminate climber (Miranda, 1979; Delgado *et al.*, 1988; Gepts and Debouck, 1991) and for domesticated can be indeterminate growth climber or also determined (Gepts and Debouck, 1991).

The leaves in the wild bean are small (Gepts and Debouck, 1991); the leaflets can measure from 3.2 to 9 cm in length and from 3 to 7 cm in width (Delgado *et al*., 1988), while in the domesticated they can be small to large (Gepts and Debouck, 1991). The inflorescences in the wild bean are almost always lateral and in the domesticated they can be lateral or terminal, depending on the habit of growth (Gepts and Debouck, 1991). The banner of flowers in the wild bean may be curved backwards and in the domesticated one it is usually erect (Gepts and Debouck, 1991). García-Hernández *et al*. (1999) recorded that the purple and purple color of the flower are the most frequent for wild beans; according to Gepts and Debouck (1991) they are rarely white, while in domesticated the white color is predominant.

The domesticated form of *P. vulgaris* L. shows greater values to the wild in length and width of pod (Lépiz *et al*., 2010), in the wild bean they are small measuring from 6 to 8 cm in length with 5 to 8 ovules, unlike domesticated which can measure from 4 to 30 cm and with 2 to 9 ovules (Gepts and Debouck, 1991); likewise, the length, width and thickness of the seed are greater in the domesticated (Vázquez and Cárdenas, 1992; Lépiz *et al*., 2010) and greater the weight of 100 seeds (Vázquez and Cardenas, 1992; Guzmán-Maldonado *et al*., 2003; Lépiz *et al*., 2010). In summary of the results of several authors (Bayuelo-Jiménez *et al*., 1995, 1996, 1997; Lepiz *et al*., 2010) it is had that the weight of the seed in the domesticated form is 9 times greater in relation to the wild one, similar to the limits indicated by Gepts and Debouck (1991), which are from 20 to 100 g/100 seeds in the domesticated form and from 6 to 14 g/100 seeds in the wild.

According to the results of Herrera and Acosta (2008) and García-Nava *et al*. (2014) who report the weight of 100 seeds for the case of wild beans “S13” and Fanjul *et al*. (1982) for the case of domesticated beans “Flor of Mayo X16441” (planted in the field, under irrigation conditions and at a density of 1 plant $m^{-2}$ in Chapingo, State of Mexico), which were the ones used in the present study, the weight of the seed of the bean “Flor of Mayo X16441” is 10 to 12 times higher than that of the wild bean “S13”.

Miranda (1979) points out that just as in the case of pods, for the seeds it is difficult to establish a single size limit for wild and domesticated beans, because the dimensions of these organs in the wild form overlap with the that presents the domesticated form. For the case of some materials of the wild form, values of the number of seeds per plant of 383 are reported (Bayuelo-Jiménez *et al.*, 1997). In the case of wild beans “S13” García-Nava *et al*. (2014) report 1 120 seeds per plant, grown in small pots (4.5 kg of substrate).

In the domesticated form of *P. vulgaris* there is still a wealth of genetic diversity that has not been used in breeding programs (Acosta-Gallegos *et al*., 2007). Also the wild form is a valuable resource, for example, Guzmán-Maldonado *et al*., 2003 found higher content of protein, calcium, iron and zinc in wild beans (G-22837) than in the domesticated Bayo Baranda; On the other hand, López *et al*. (2005) mention that traditional varieties are more heterogeneous and less productive, are well adapted to their local environment and have great genetic diversity, so it is important to conserve these plant genetic resources.

In the present work, the wild bean “S13” was chosen because it is a material with a high content of protein (28%) (Pérez and Acosta, 2002; Herrera and Acosta, 2008) and because it was used as parent of segregating populations, having resulted in a greater number of plants with significantly higher yield than the domesticated Black Tacana progenitor as reported by Herrera and Acosta (2008). On the other hand, the domesticated beans “Flor of Mayo X16441” were chosen for having the same habit of growth as the wild bean “S13” (indeterminate type IV climber). The objective of the present work was to establish the differences between both materials in terms of their phenology, morphology, performance components and some physiological estimators.

# Materials and methods

The study was carried out in a greenhouse in Montecillo, State of Mexico (19º 30’ north latitude and 98º 51’ west longitude and 2 250 meters above sea level). The wild form of *Phaseolus vulgaris* L. with registration number G23429 (S13) (CIAT, 2017) and a domesticated form X16441 of the Flor of Mayo (FM) type, both with undetermined growth type IV climber, was used. The S13 form was collected in Santa Isabel, Cholula, Puebla State, Mexico (18.97° north latitude and 98.38° west longitude, at 1430 meters above sea level) and was provided to us by Dr. Jorge A. Acosta Gallegos of INIFAP. The FM form is a registered variety with the number X-16441 in the germinal plasma bank of the Postgraduate School of the Ministry of Agriculture and Hydraulic Resources, in Chapingo, State of Mexico and collected by Efraím Hernandez Xolocotzi in Queréndaro, Michoacán, located at 1 800 meters above sea level, from a creole in Ixmiquilpan, Hidalgo, Mexico (Fanjul, 1978).

Planting was carried out on May 6, 2014 in polyurethane cups of 250 mL capacity with tezontle with a particle size less than or equal to one centimeter, as a substrate. At 20 days after sowing (dds) the plants with the first spread sheet corresponding to stage V2 according to Fernández *et al*. (1986) were transplanted into plastic pots (one plant per pot) with 18 kg of tezontle with the aforementioned granulometry. The first five days were watered with tap water and then with nutrient solution from Steiner (1984). At 42 dds trellises were installed using yarn to individually guide the plants.

A record of the phenological stages was kept (Fernández *et al*., 1986), the end of the crop cycle was considered as harvest maturity to which it was identified as $R9_F$. Three destructive samplings were carried out during the reproductive phase, corresponding to stage R6 (flowering), to stage R8 (pod filling) and to $R9_F$. In each destructive sampling were recorded: the number of pods per plant, the leaf area determined by an electronic area meter (Li-cor, LI-3100). The plants were dissected in roots, stems, petioles, petioles and rachis, were put to dry, together with the fallen organs, in a stove (Blue M) at 70 °C, until reaching constant weight. To determine the weight, a digital scale (Scout Pro) was used.

The leaf area length (DAF) was calculated using the leaf area index (LAI) according to Tanaka and Yamaguchi (2014), as well as the pod filling index (IV) according to the formula proposed by Kohashi (Escalante and Kohashi, 2015). In $R9_F$, the following were recorded for the seed: weight per plant, number per plant, weight of 100 seeds. The average number of seeds per pod was estimated based on a random sample of 20 normal pods per plant. The harvest index (CI) was calculated according to the formula of Wallace *et al*. (1972). Also, the modified harvest index (MCI) proposed by Kohashi *et al*. (1980). For the germination test, four repetitions of 25 seeds were used, according to the methodology called "between paper" (ISTA, 2014). The seed was not scarified in either of the two bean forms. Under this method of germination, the seedlings that developed normal structures were counted. The temperature was registered with a "data logger" (Extech® RTH10).

Experimental design and statistical analysis. A completely random design was used, with five repetitions for each sampling; the experimental unit consisted of one plant per pot. A comparison of means was made with the Mann-Whitney test for the variables: number of pods, number of seeds per plant and number of seeds per pod. In addition, Student's "t" test was used for the following variables: root weight and volume, stem weight, leaf area, seed yield, seed weight and seed germination, DAF, IV and IC. Also, when comparing some of the previous variables between stages, an analysis of variance was performed. The Infostat program (2016) and the SIGMA PLOT (2008) version 11 graphics were used for the statistical tests.

## Results and discussion

Temperature. The average weekly temperature throughout the crop cycle was maintained in the range of 20 to 25 °C, which according to Masaya and White (1991) is optimal for the growth of beans, since it promotes photosynthesis, respiration, germination of the seed, allocation of dry matter, root functioning and reproductive processes.

Phenology. For S13, in the present study, its cycle was 137 d (Table 1), which disagrees with that reported by García-Urióstegui (2015), who recorded a cycle of 94 d under the same culture conditions of the present work, but as his study was focused on the drying of the grain, the sampling was done before the plant reached harvest maturity. In the present study, the FM cycle was 118 dds (Table 1). Fanjul *et al*. (1982) reported a duration of 153 d after emergence (175 dds) for this same material sown in the field. Wild form S13 exhibited a longer cycle (19 d) than FM under greenhouse conditions. The duration of the crop cycle is multifactorial.

**Table 1. Days after sowing for each phenological stage in wild bean (S13) and domesticated (Flor of Mayo X16441).**

| Type of bean | V1 | V2 | V3 | V4 | R5 | R6 | R7 | R8 | R9 | $R9_F$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Wild | 8 | 14 | 21 | 30 | 63 | 67 | 71 | 83 | 119 | 137 |
| Domesticated | 6 | 9 | 20 | 29 | 51 | 57 | 60 | 71 | 102 | 118 |

V1= emergency; V2= primary leaves; V3= first composite sheet; V4= third compound sheet; R5= prefloration; R6= flowering; R7= pod formation; R8= filling of pods; R9= start of maturation and R9F= harvest maturity.

Fernández *et al*. (1986) mention that the duration of the different phenological stages is also affected by the habit of growth, by climate, soil and genotype. From the prefloration stage (R5) S13 was later than FM. Possibly a higher temperature in the greenhouse influenced to accelerate the phenological stages in FM with respect to field cultivation by Fanjul *et al*. (1982), who report an average temperature range between 14 and 20 °C. It can be assumed that with the S13 have also accelerated their phenological stages; however, since there is no record of the temperature of the crop in the field, this cannot be confirmed.

The beginning of the flowering stage (R6) in S13 was at 67 dds, while Garcia-Uriostegui (2015) reports 61 dds (under the same conditions); in FM in the present work was at 57 dds vs 86 d after the emergency (108 dds) reported by Fanjul *et al*. (1982). In S13, stage R8 was started 16 days after anthesis, contrasting with that reported by García-Uriostegui (2015) where it started approximately 9 days after anthesis; it was also observed that the duration between stages R6 and R8 are very similar between S13 and FM (Table 1).

## Morphological and physiological components

The presence of buttons in R8 and $R9_F$ indicates that the vegetative phase overlapped during the crop cycle with all the reproductive stages in both S13 and FM, which could be attributed to the type of climber indeterminate growth habit that both materials have. bean. No differences were observed in the number of pods per plant in the R6 stage between S13 and FM (Table 2), while in R8 and $R9_F$ (in the $R9_F$ vain pods were not counted) the number was notably greater in S13 (1014) that in FM (131), which for the case of S13 can be seen the similarity with that reported by García-Urióstegui (2015) by noting 817 pods per plant (slightly less because the objective of their investigation did not demand waiting for the harvest maturity), which represents an advantage for wild beans as it is a variable correlated with the number of seeds per plant (Bayuelo-Jiménez *et al*., 1999).

**Table 2. Number of pods per plant in three phenological stages of wild beans (S13) and domesticated ones (Flor of Mayo X16441).**

| Phenological stage | Type of bean | Number of pods | |
|---|---|---|---|
| R6 | Wild | $4^{\dagger}$ | a |
| | Domesticated | $6^{\dagger}$ | a |
| R8 | Wild | $45^{\dagger}$ | a |
| | Domesticated | $197^{\dagger}$ | b |
| $R9_F$ | Wild | $1014^{\dagger\dagger}$ | a |
| | Domesticated | $131^{\dagger\dagger}$ | b |

Averages with different letters are statistically different ($p<0.05$). The comparison is between type of beans for each stage. R6= beginning of the flowering stage; R8= start of the pod filling stage; R9F= harvest maturity; $^{\dagger}$= number of total pods (pods greater or less than 3 cm are included); $^{\dagger\dagger}$= number of normal pods that reached maturity.

The weight of a seed of S13 represented 14% of that of FM (Table 3). The weight of a seed of S13 in the present work is in agreement with that reported by García-Nava *et al*. (2014) and by García-Uriostegui (2015), who also cultivated it in the greenhouse. The weight of the seed per plant was lower in S13 with respect to FM (Table 3). The number of seeds per plant for S13 was 4.4 times higher than for FM, which is directly related to a greater number of normal pods in S13 (Table 3), a condition that according to Schwanitz (1966) characterizes wild plants. García-Nava *et al*. (2014) obtained lower values (1120) when growing it in a smaller pot (4.5 kg of substrate).

A greater number of seeds per plant is a physiological stratagem of the wild form to ensure its survival in natural environments (Schwanitz, 1966), while in the domesticated, even when the number of seeds is smaller, some values of anthropogenic importance increase as the increase in seed size (Peña *et al*., 2012). There is a difference in the number of seeds per pod between S13 with 4 and FM with 6 seeds per pod, which coincides for S13 with García-Uriostegui (2015), and for FM with that indicated by Fanjul *et al*. (1982).

**Table 3. Production, weight of one seed, number of seeds per plant and per pod in wild bean (S13) and domesticated (Flor of Mayo X16441) in stage R9F.**

| Type of bean | Seed production (g $pl^{-1}$) † | Weight of a seed (mg)† | Number of seeds per plant †† | Number of seeds per pod |
|---|---|---|---|---|
| Wild | 129.65 b | 42.38 b | 3067 a | 4 (± 1.19) b |
| Domesticated | 213.8 a | 305 a | 698 b | 6 (± 1.03) a |

Averages with different letters are statistically different ($p$<0.05); †= weight data at 12% humidity. ††= it was determined based on the weight of seed per plant and the weight of 100 seeds at the time of harvest.

Germination test was performed approximately 15 days after the harvest. S13 reached 100% germination at 24 h after the start of the test, while FM reached it at 48 h, decreasing the percentage of healthy plants on the ninth day, becoming statistically equal in both types of beans (88 and 84). %, respectively). It has been considered that the wild bean has physical latency (Korban *et al*., 1981), caused by the impermeability of the seed according to Gepts and Debouck (1991). In the present study, latency was not detected, additionally, Gómez *et al*. (1999) indicate that for the case of S13, the thread is the main structure through which the imbibition is carried out, even when the testa is impermeable. In relation to the leaf area in both bean forms, the maximum value was recorded in stage R8, in the case of S13 the plant conserved a large number of leaves in the period from R8 to R9F without statistical difference between them. In FM there was a marked decrease in the leaf area (more than 50%) in the R9F compared to the maximum. The leaf area per plant between S13 and FM was statistically the same in stages R6 and R8, while in R9F it was higher in S13 (comparison not shown in Figure 1).

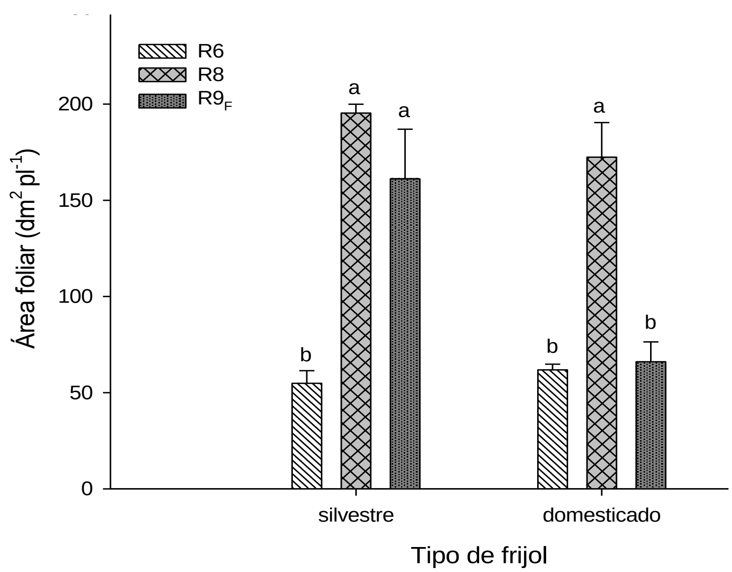


**Figure 1. Leaf area of wild bean (S13) and of domesticated Flor of Mayo X16441 (FM) in three phenological stages, cultivated in hydroponics and greenhouse.** Bars with different letter within types are statistically different ($p$< 0.05). R6= beginning of the flowering stage; R8= start of the pod filling stage; R9F= harvest maturity.

Dry weight of organs. In R8, the dry weight (PS) of the leaf blades was statistically lower in S13 (65.27 g) with respect to FM (81.35 g). It is important to note that pericarp PS per plant was higher in S13 than in FM (144.91 g vs 82.28 g) (implicit weights in the total of Table 4), this greater weight in S13 is related to what Miranda points out (1979) by indicating that in the pericarp the fiber content and its components have been reduced in domesticated beans. Smartt (1988) points out that the tissues of the primitive pods are extremely lignified, which would explain the greater weight of the pericarp in the wild form. SP of the shank presented differences between S13 and FM in stages R8 and $R9_F$ (Table 4).

**Table 4. Dry weight of organs and total per plant (g) in wild beans (S13) and domesticated (Flor of Mayo X16441) in three phenological stages.**

| Phenological stage | Type of bean | Fallen organs | Stem | Root | Total |
|---|---|---|---|---|---|
| R6 | S13 | 0.13 a | 36.71 a | 3.34 b | 40.06 a |
| | FM | 0.35 a | 39.49 a | 4.55 a | 44.03 a |
| R8 | S13 | 2.8 a | 177.14 b† | 13.43 a | 190.57 b |
| | FM | 2.07 a | 207.28 a† | 13.73 a | 221.01 a |
| $R9_F$ | S13 | 73.87 a | 575.33 a† | 16.83 a | 592.16 a |
| | FM | 73.18 a | 512.96 b† | 18.95 a | 531.91 b |

Averages with different letters are statistically different ($p<0.05$). R6 = start of the flowering stage, R8= start of the pod filling stage; R9F= harvest maturity; †= the dry weight of the pods with their seeds was included, but only in R9F the dry weight of the seeds is 12% moisture.

In stage R8 the weight in FM was greater, because the pods have started filling and the weight represented by the growing seed, together with the weight of the leaf blades that persisted, make it larger. In $R9_F$, the total weight per plant in the FM was greater than that of S13; According to Miranda (1979), domestication has reduced the number of branches per plant, leaves and knots per inflorescence, among other variables. The above, it is deduced that in the domesticated form a greater proportion of photoassimilates was assigned to the seed, while in the wild form they are assigned to the other organs. Said photoassimilates in S13 and FM were mainly assigned to the stem and branches, since the weight of the leaves (implicit in the weight of scion of Table 4), fallen organs and root did not show statistical differences in $R9_F$. A higher total dry weight per plant in S13 shows a more prolonged activity of the leaves to produce photoassimilates reflected by a greater value of the DAF (Table 5).

**Table 5. Duration of leaf area and pod filling index in wild bean (S13) and domesticated (Flor of Mayo X16441) cultivated in hydroponics and greenhouse.**

| Type of bean | DAF (days) | | | | IV† (%) | |
|---|---|---|---|---|---|---|
| | R6-R8 | | $R8-R9_F$ | | | |
| Wild | 50.04 | a | 178.23 | a | 47.3 | b |
| Domesticated | 49.2 | a | 95.41 | b | 72.07 | a |

Averages with different letters are statistically different ($p<0.05$). The comparison is between bean type; DAF= duration of leaf area; IV= pod filling index; R6 = beginning of the flowering stage; R8= Start of the pod filling stage; R9F= harvest maturity; †= calculation with seed weight 12% humidity.

The dry weight of the root in S13 with respect to that of FM was different only in stage R6 where FM was greater and could also be indicating its precocity; for the stages R8 and R9F there are no differences between both materials. The dry weight of the root reflects that there was a development of this in both types of beans from both R6 to R8, and from R8 to R9F (Figure 2).

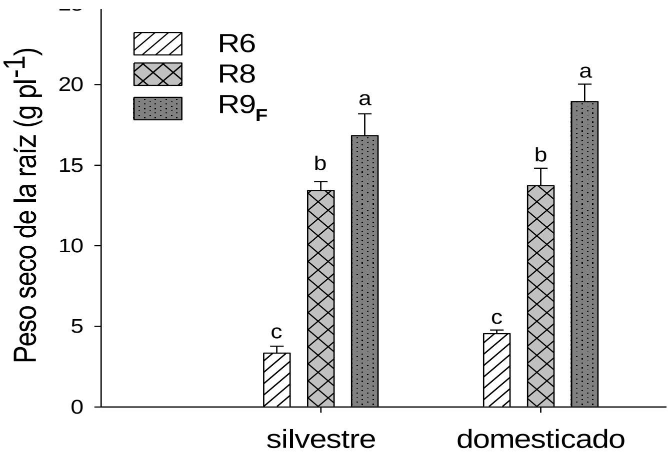


**Figure 2. Dry root weight in wild bean (S13) and domesticated (Flor of Mayo X16441) in three phenological stages.** Averages with different letters are statistically different (*p*< 0.05). R6= beginning of the flowering stage; R8= start of the pod filling stage; R9F= harvest maturity.

The DAF was greater in S13 in the period from R8 to R9F (Table 5). This is due to the fact that the IAF from R8 to R9F remains the same in S13 (3.91 and 3.22, respectively), while in FM it decreased drastically from 3.45 to 1.32. The DAF provides an estimate of the time in which the foliage is functional as a photosynthetic producer (Rodriguez-Montero and Leihner, 2006). The foregoing indicates that S13 could have a longer period for the formation of new fruits; however, we have no evidence that this necessarily occurs because in a domesticated type I growth habit it was observed that although many flowers are produced in the second half of the flowering period, these did not translate into fruits (Prieto and Kohashi, 1981). The rate of pod filling (IV) in the FM is greater with respect to S13 (Table 5), which, together with the pericarp weight results, reaffirms that a greater amount of photoassimilates is probably assigned to the wild bean leaflets. The DAF was lower in the period between R6 and R8 with respect to the period from stage R8 to R9F, both in FM and S13 (comparison not shown in Table 5).

The net assimilation rate is the rate of increase in weight per unit leaf area (Tanaka and Yamaguchi, 2014), for S13 was 0.05 (g $dm^{-2}$ $day^{-1}$) and 0.07 for FM, between stage R8 and R9F, being statistically different, which implies that FM accumulates biomass more quickly. In the present study, when the CI calculation does not include the dry weight (PS) of the fallen organs or the root has been called traditional harvest index (ICT) (Wallace *et al*., 1972). Also, the modified harvest index (ICM) is the one in which the PS of the fallen organs was included (Kohashi *et al*., 1980), but not necessarily that of the root. Both the ICT and the ICM is higher in domesticated beans, which was already expected because the domestication of this material has been based on a larger seed size. Concomitantly, it results that for both domesticated and wild bean, the inclusion of the PS of the fallen organs simultaneously with the PS of the root in the calculation of the IC, turns out to be significantly different compared with the ICT (Table 6).

**Table 6. Harvest index in wild bean (S13) and domesticated (Flor of Mayo X16441) cultivated in hydroponics and greenhouse.**

| Type of bean | ICT† | $ICT_{CR}$† | ICM† | $ICM_{CR}$† |
|---|---|---|---|---|
| Wild | 0.26 b | 0.25 b | 0.23 b | 0.22 b |
| Domesticated | 0.49 a | 0.47 a | 0.42 a | 0.4 a |

Averages with different letters are statistically different ($p$<0.05); ICT= traditional harvest index, where dry weight of fallen organs is not included; ICM= modified harvest index, includes dry weight of fallen organs; ICMCR= includes root dry weight; †= seed weight 12% moisture. In biological yield, dry pericarp weight was included.

## Conclusions

In terms of phenology, the wild form S13 has a longer cycle than the FM domesticated, which is related to a greater production of dry matter and represents an advantage of S13 in climates that do not present frosts because it can take more time to use energy solar to produce seed. The previous characteristic is concomitant with a greater leaf area and its duration in S13 with respect to the FM so it has greater possibilities to continue generating photosynthates to be used in the reproductive structures that are in development. The mentioned characteristics favor their survival in natural environments and could be used for the genetic improvement of the domesticated form. The FM domesticated form presented a greater: seed size, harvest index, pod filling index, which represent an advantage with respect to S13. A higher value of the harvest index in FM indicates that a higher proportion of photosynthates is assigned to seed production (more efficient plant for grain yield). The higher rate of filling of the pod in FM compared to S13 indicates a higher proportion of photosynthates assigned to the grain than to the pericarp.

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