



HarvestPlus
Better Crops • Better Nutrition



Crop Product Profile

**Iron Beans
Colombia**



01. Executive Summary

Colombian agricultural area is 49492 hectares. This means that only 45% of the national territory is intended for agriculture. This economic activity is the second relevant in the country and represents 7% of the GNP. According to the country's agricultural area the five (5) most planted crops are coffee green, rice paddy, oil palm, sugar cane and maize. However, the five (5) most productive crops are sugar cane, oil palm, potatoes, rice paddy and bananas.

The FAO has reported that by 2030, the Colombian population

will present an undernourishment problem that could be close to 3,77%, showing a total of 1,9 million people affected by it.

Colombia has the support of the HarvestPlus office, which works towards the improvement of staple food crops like the iron beans, zinc maize, zinc rice, vitamin A orange sweet potatoes and vitamin A cassava. This office, together with the International Food Policy Research Institute (IFPRI), has as main objective to tackle the nutritional deficiencies through biofortified beans with the highest content of Iron and zinc.

Colombia's per capita consumption of beans is 2-3 kg/year (Minagricultura). To date, two varieties have been released (BIO101, BIO107) with 60% more iron and 50% more zinc.

02A. Popular varieties planted in Colombia

Line	Developed by	Year of release	Main characteristics	Yield (ton/ha)
BIO 101	Fenalce	2016	High Iron content (83 ppm) and Zinc (44 ppm), bush, red grain color	1.5
BIO 107	Fenalce	2016	High Iron content (83 ppm) and Zinc (44 ppm), bush, red grain color	1.5
BIO 102	Fenalce	2018	High Iron content (86ppm) and Zinc (86ppm), climbing, tolerant to anthracosis, leaf spot and rust.	1.9
Corpoica Rojo 39	Corpoica/Agrosavia	2018	High Iron content (88ppm) and Zinc (37ppm), bush, drought tolerant.	1.28
Diacol Calima	Corpoica/Agrosavia	1971	Bush bean, red mottled, resistant to leaf spot and cercospora spot.	1.8
Cargamanto rojo	Landracea	N/A	Climbing and red mottled	2 - 2.5
Cargamanto blanco	Landracea	N/A	Climbing and cream mottled with red	2

Yield values correspond to the average of the sites where the line is commercialized.

*All the green materials were developed and release funded by HarvestPlus

03. Productive regions:

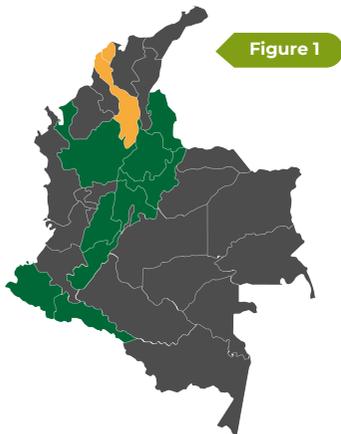


Figure 1
Traditional beans production across the country

Region	State	Area planted	%
Andina (A)	Huila	20,895	23,0
	Santander	17,500	18,9
	Antioquia	14,149	15,3
	Nariño	14,803	16,0
	Cundinamarca	7,820	8,5
	Norte de Santander	6,000	6,5
	Tolima	5,600	6,1
	Putumayo	2,879	3,1
Caribe (B)	Boyacá	1,820	2,0
	Bolivar	780	0,8
	Atlántico	489	0,5

04. Preferred planting and harvesting seasons for the crop in the country.



Cycle A

Bush:
March - April

Climbing:
February - April



Cycle B

Bush:
August - September

Climbing:
August - October

Top agronomic traits for biofortified beans in Colombia



Early maturity

Relevance for adoption on farmers and producers

A reduction in the number of days to harvest will represent a greater income in a shorter period compared to other materials with late maturity. It also has greater chances to sell the production with a better price. Early maturity will let varieties enter the market when prices are still high and increase crop profitability.

Trait indicators commonly used for crop improvement:

Days to anthesis (Phenotypic)
Days to maturity (Phenotypic)
Heading seeding interval (Phenotypic)



Drought tolerance

Relevance for adoption on farmers and producers

Drought-tolerant varieties will develop acceptable grain yield even under stress conditions. This characteristic will allow incomes based in the commercialization of the production achieved in challenging environments.

Trait indicators commonly used for crop improvement:

Segregating populations under drought environment to evaluate:

- a) Nutrient acquisition/Uptake efficiency (Analytic)
- b) Water use efficiency Photosynthesis (Analytic)
- c) Radiation use efficiency (Analytic)
- d) Deep Root development (Phenotypic)
- e) Grain number maintenance (Phenotypic)
- f) Grain fill duration and rate. (Phenotypic)



Golden Mosaic Virus (BGYMV)

Relevance for adoption on farmers and producers

BGYMV tolerant varieties will be capable of surviving under the sustained presence of the disease. This characteristic will allow an acceptable production of the grain under the infestation of the virus.

Trait indicators commonly used for crop improvement:

Selection pressure in segregating populations under infestation of whitefly (*Bemisia tabaci* - biotype B) as vector of the virus BGYMV for evaluate resistance to the disease

Top agronomic traits for biofortified beans in Colombia



Antracnosis

Relevance for adoption on farmers and producers

Antracnosis tolerant varieties will be capable of surviving under the sustained presence of the disease. This characteristic will allow an acceptable production of the grain under the infestation of the fungi.

Trait indicators commonly used for crop

Selection pressure in segregating populations under infestation of *Colletotrichum lindemuthianum* for evaluate tolerance and resistance to the disease



Ascochyta

Relevance for adoption on farmers and producers

Ascochyta tolerant varieties will be capable of surviving under the sustained presence of the disease. This characteristic will allow an acceptable production of the grain under the infestation of the fungi.

Trait indicators commonly used for crop

Selection pressure in segregating populations under infestation of *Phoma exigua* var *diversispora* for evaluate tolerance and resistance to the disease



Rust

Relevance for adoption on farmers and producers

Rust tolerant varieties will be capable of surviving under the sustained presence of the disease. This characteristic will allow an acceptable production of the grain under the infestation of the fungi.

Trait indicators commonly used for crop

Selection pressure in segregating populations under infestation of *Uromyces phaseoli* for evaluate tolerance and resistance to the disease

Top agronomic traits for biofortified beans in Colombia



Bean common mosaic virus

Relevance for adoption on farmers and producers

Bean common mosaic virus tolerant varieties will be capable of surviving under the sustained presence of the disease. This characteristic will allow an acceptable production of the grain under the infestation of the virus.

Trait indicators commonly used for crop

Selection pressure in segregating populations under infestation of whitefly (*Bemisia tabaci* - biotype B) as vector of the virus (BCMNV) for evaluate resistance to the disease



Whitefly

Relevance for adoption on farmers and producers

Pest management with different products is recommended to control this type of issue. However, whitefly tolerant varieties will be capable of surviving under the complete productive cycle even with a sustained presence of the insect. This characteristic makes the plants less attractive for the insect feeding and it's less probable to cause a consequent death of the plant.

Trait indicators commonly used for crop

Selection pressure in segregating populations under infestation of *Bemisia tabaci*/*Trialeurodes vaporariorum* in controlled environments to evaluate tolerance and resistance to the disease



Weevils

Relevance for adoption on farmers and producers

Pest management with different products is recommended to control this type of issue. However, weevils tolerant varieties will be capable of surviving to the complete productive cycle even with a sustained presence of the insect. This characteristic makes the plants less attractive for the insect feeding and it's less probable of causing a consequent death of the plant.

Trait indicators commonly used for crop

Selection pressure in segregating populations under infestation of *Zabrotes subfasciatus*/*Acanthoscelides obtectus* in controlled environments to evaluate tolerance and resistance to the disease

Top post harvest and marketing traits for biofortified beans in Colombia



Grain/Seed color

Relevance for adoption on farmers and producers

Grain/seed color, together with the size, are the components of which is commonly named "Market class". It is the consumer's first approach upon beans, since it relates to acceptance or rejection. It's also a factor that determines the price of the production between farmers, traders and consumers. Beans has a wide variation of colors, white, cream, red, purple, brown, pink, black, yellow, among others.

For Colombia, the most appreciate type is kidney beans and red mottled beans, which is commonly used in different local recipes.

Trait indicators commonly used for crop improvement

A) Munsell color system: (Analytic): includes all the variations for the visible range of the electromagnetic spectrum and comprises three parameters. Place the bean grains next to the Munsell tables. Select the color in the Munsell charts that matches the color of the grains

Hue: Represents the specific hue and appears at the top of every page. **Value:** indicates the lightness divisions and is displayed vertically.

Chroma (Chroma or Saturation): represents the purity divisions and is presented horizontally.

B) Scale using the Minolta colorimeter (Lxaxb) or Smartphon app Techkon Color Catcher™ (Analytic)

C) Visual scales and comparisons between common market class (Phenotypic)



Grain/seed shape

Relevance for adoption on farmers and producers

Grain/Seed shape, together with the color and size, are the components of which is commonly named "Market class". The physical appearance of the grains defines its price in the market, which is define by length and shape. Variations in size and shape are mainly genetic. Bean grain can have various shapes (round, oval, elongated, kidney-shaped, among others).

Trait indicators commonly used for crop improvement

Visual scales and comparisons between common market class (Phenotypic)

1: round; 2: ovoid; 3: elliptical; 4: small almost square; 5: elongated-ovoid; 6: elongated-ovoid at one end; 7: elongated-almost square; 8: kidney-straight on the side of the thread; 9: kidney-curved on the side of the thread



Grain/seed size

Relevance for adoption on farmers and producers

Grain/Seed size, together with the color and shape, are the components of which is commonly named "Market class". The physical appearance of the grains defines its price in the market, which is define by length and shape. Variations in size and shape are mainly genetic.

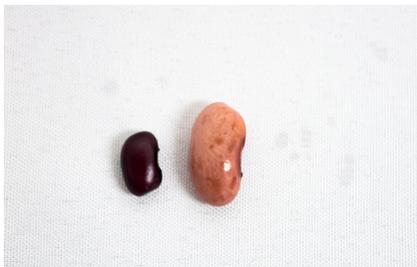
Trait indicators commonly used for crop improvement

A) 100 seeds weight (Phenotypic): select 100 grams of beans whole and without signs of deterioration. Put the beans in the container and record their weight.

<18= Very small
18-25gr = Small
26-40gr= Medium
>40 gr= Large

B) 100 seeds volume (Phenotypic): Select 100 bean grains and put them into a cylinder with 50 mL with distilled or deionized water. Record the volume of water displaced by the sample.

Top post harvest and marketing traits for biofortified beans in Colombia



Water absorption capacity during soaking (CAA)

Relevance for adoption on farmers and producers

Determines the capacity of the grain to absorb and retain water after and during the cooking process. This characteristic allows the identification of materials that have been affected by wrong post harvesting practices and inappropriate drying of the seed. In the worst case, the most affected seeds can suffer from physiological problems that prevents the seed coat (Testa) from absorbing the water necessary to soften its tissues, therefore it will not be edible or even processed for canned beans. This effect is normally described as "Low permeability of coat (testa)" or even "hard coat".

Trait indicators commonly used for crop improvement

Water absorption capacity during (Analytic):

CAA is calculated according to the difference between the weight of the dry material (PMS) and the final weight after soaking (PMR), using the following formula.

Ranks
 >100% - Without problems
 70 - 100 - Moderate
 40 - 69 - Severe
 0 - 39 - Very severe

$$CAA = \frac{PMR - PMS}{PMS} \times 100$$



Cooking time

Relevance for adoption on farmers and producers

Another characteristic of legumes is their ability to increase their volume and weight -one, two or three times the original size- during the cooking process. Therefore, the cooking time represents one of the most important qualities parameters in beans. A short cooking time is a characteristic that represents an attribute of culinary quality. The cooking times can be prolonged by two different processes related to the water absorption of the grains: the first process is "low permeability of the seed coat (testa)" and the second is called "difficult to cook" and manifests itself in those grains that absorb enough water, but fail to soften after soaking and, therefore, cooking time is affected.

Trait indicators commonly used for crop improvement

A) Culinary procedure (phenotypic): Manually clean 50 grams of beans, wash with distilled or deionized water and soak with a 4:1 ratio of distilled or deionized water / beans, for 18 hours, at room temperature. Heat 200 mL of distilled or deionized water to boiling in beakers, using the heating plates. Once the boiling point has been reached, add the bean sample previously soaked and drained. At this time start the count.

< 30 minutes - Ideal/Shorter cooking time
 > 40 minutes - Long cooking time

B) Mattson cooker equipment: The cooking time by this method is defined as the time required for 80% of the grains to pass through the punches. Heat 1600 mL of distilled or deionized water until they are boiled in the beakers, using the heating plates.



Phytate content

Relevance for adoption on farmers and producers

Breeding for higher micronutrient mineral content in beans is correlated with an increase of phytic acid, a main inhibitor of mineral absorption in humans. Phytic acid is the main storage form of phosphorus and mineral storage in the bean seed and plant. Absorption of iron and zinc in biofortified crops could be limited by its antinutrient content, such as phytic acid. In the case of beans, common processing techniques (including soaking, boiling, and refrying) have been shown to reduce phytic acid by solubilizing them in the soaking water. In particular, anti-nutritional compounds hamper the potential nutritional impact since some of these can generate digestion issues in the consumers when are in higher levels.

Trait indicators commonly used for crop improvement

Total Phytic Acid using polyprep prefilled chromatographic columns (Analytic):

After measuring phytic acid, it could be calculated the molar ratio together with the iron content of the sample.

Convention bean: 15 Phytic acid/Fe molar ratio
 Biofortified bean: 13 phytic acid/Fe molar ratio
 Ipa bean: 1 phytic acid/Fe molar ratio.

Quick reference guide

Top marketing traits of interest for beans in Colombia

Characteristic	Dry consumption	Canned industry
Grain/seed color	Red, White, Black,Pink	Black, red, white
Grain/seed shape	Round/Ovoid	kidney-straight on the side of the thread/ kidney-curved on the side of the thread
Grain/seed size	Small/Very small/Medium	Small/Medium
Water absorption capacity during soaking (CAA).	>100% - Without problems 70 - 100 - Moderate	>100% - Without problems
Cooking time	30 minutes -Ideal/ Shorter cooking time	30 minutes -Ideal/ Shorter cooking time
Phytate content	Low	Low

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