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RESEARCH ARTICLE

MORPHOVARIABILITY AND AGRONOMIC CHARACTERISTICS AMONG COMMON BEAN ACCESSIONS FROM THE DEMOCRATIC REPUBLIC OF CONGO (DR-CONGO) GERMPLSM

[1*]Matondo, N. K., [2]Nkongolo, K. K., [3]Mumba, D., [4]Tshilenge, D. K., [1,4]Kizungu, V. and [5]Lubobo, A. K.

[1]National Institute for Study and Agronomic Research, Research Centre of Mvuazi, BP. 2037, Kinshasa 1, DR-Congo
[2]Department of Biological Sciences, Laurentian University, Sudbury, Ontario, Canada, P3E 3C6
[3]Faculty of Agronomy, National Teaching University, BP. 8815, Kinshasa-Binza, DR-Congo
[4]Faculty of Agronomy, University of Kinshasa, BP. 117, Kinshasa XI, DR-Congo
[5]Faculty of Agronomy, University of Lubumbashi, B.P. 1825 Lubumbashi, DR-Congo

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ABSTRACT

Common bean (*Phaseolus vulgaris* L.) is one of the most important grain legumes in the word in term of total production and nutrition. It was domesticated in America, and spread around the world. This crop is cultivated in a very large part of Africa, extent in 30sub-Saharan Africa countries. But only a fraction of its accessions has been characterized based on origin, morphometric traits, agronomic performance and seed composition. This objective of this study is to characterize morphologically and agronomically the Common bean accessions from DR-Congo germplasm, highlight the level of high variability in the Common bean gene pool of the Country.81,11% of Common bean accessions from the germplasm had losangic leaves and 18,99% triangular leaves.50% of plants had white color of flowers, 35,56% of pink color and 14,44% of rosatre white color. Pods colors frequencies were 85,56% yellow, 6,67% red, 6,67% green and 1,11% crimpson.31,11% of accessions had seeds with white color, 21,11% of brown color, 18,88% of yellow color, 6,67% of red color, 3,33% of brown chestnut color, 2,22% of striated color, 2,22% of cream-coloured color, 2,22% of chocolate striated cream-coloured, 2,22% of red mottled color and 9,99% various the accessions colors (1,11% pink, 1,11% red dark, 1,11% red checkmate, 1,11% red striated white, 1,11% yellow checkmate, 1,11% grey sink, 1,11% grey striped, 1,11% light crimson and 1,11% crimson with white points). The stems colors were 78,89% green, 20% anthocyanin and 1,11% red. There were significant differences among accessions for all the quantitative traits analyzed. In this germplasm, 18,89% of the accessions were high than 1 m tall, 20% between 1 m to 0.50 m tall and 61,11% less than 0.50 m tall. Plant height and stem diameter were negatively correlated, while plant height and number of leaves per plant were positively and significantly correlated to each other. A negative correlation was observed between leaflet length and plant height. Grain yields were highly and significantly correlated to the number of pods and seeds per plant. Based on grain yield resistance over the two years of trials at the location, thirty three accessions have been identified as adapted to the local conditions of the main growing common bean region in the DR-Congo.

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INTRODUCTION

Common bean is one of the five main legume crop cultivated in DR-Congo. Its cultivated landraces were also initially distributed through America and at 16ème century, it was extend throughout USA, Europe, Africa, and Asia (Baudouin et *al*., 2001). *Phaseolus vulgaris* L. is among the first plants to be domesticated, 8,000 to 10,000 years before the present times. Common bean, in particular, played a very significant role in the food and the traditional regimes of all pre-Colombian civilizations. Although cultivated in tropical, subtropical, subequatorial and moderated areas, this species is considered as the principal food leguminous plant of the areas of average altitude of Latin America and of central and eastern Africa (Baudoin *et al*., 2001). The International Institute of Genetic Resources of Plants (IBPGR) holds approximately 32,000 accessions of *Phaseolus vulgaris* L. Of other institutions in the whole world maintain half of the accessions *of Phaseolus vulgaris* L, and the most significant among them include CIAT (Colombia), INRA of Versailles (France), etc., while the private selectors have collections of work. The largest collection found to CIAT (Colombia) maintains approximately 36,000 genotypes (PABRA, 2015). Only one small fraction of the genotypes of these common beans (*Phaseolus vulgaris* L.) was characterized on the basis of their

Corresponding author:* **Matondo, N. K.
National Institute for Study and Agronomic Research, Research Centre of Mvuazi, BP. 2037, Kinshasa 1, DR-Congo

origin, the morphometric traits, the agronomic performance and the seed chemical composition (protein, zinc and iron). Many research has been conducted on genetic diversity with the assistance of the SSR markers (Blair *et al*.., 2010; Asfav et *al*.., 2009; Blair *et al*., 2009; Zhang *et al*., 2008; Blair *et al*., 2007; Blair et *al*., 2006; Diaz et *al*., 2006; Gomez *et al*., 2004; Blair *et al*., 2003; Gaitan *et al*., 2002; Beebe et *al*., 2001; Beebe et *al*., 2000; Becerra *et al*., 1994; Singh et *al*., 1991); on the common bean bio fortification (Blair *et al*., 2009) and in fields evaluations (CIAT, 1992a). Ninety tropical common beans (*P. vulgaris* L.) varieties from CIAT and three stations of INERA (Mulungu, Gandajika and Mvuazi) have bean evaluated. These varieties had been the principal varieties and represented the most available for this evaluation. Phenotypic evaluation of common bean germplasm is a fundamentally important step for the management of collections and determining genetic diversity. The knowledge of the genetic variation within accessions from germplasm collections is essential to the choice of strategy to incorporate useful diversity into the program, to facilitate the introgression of genes of interest into commercial cultivars, to understand the evolutionary relations among accessions, to better sample germplasm diversity, and to increase concervation efficiency (Fu, 2003; Mudibu, 2013). A more comprehensive assessment of genetic diversity would allow curators and users to manage and access ex situ collections more efficiency. Germplasm evaluation includes descriptive, agronomic and composition data. Traits described by colors, shapes, appearances or forms are classified in the descriptive category. Agronomic data consist of scored or measured traits such as lodging, shattering, seed weight, plant height and maturity date (Nelson *et al*., 1988). Currently, seed composition data include seed proteins, and the high content of iron and zinc; the content in iron and zinc determine the membership of varieties to the group of the strengthened bio varieties (PABRA n° 5, sd. Many phenotypic characters of common bean are significantly influenced by environmental conditions under which the plants are grown. Protein, enzyme and DNA markers can be used to assess genetic diversity, but their application in germplasm identification is limited and expensive (Li and Nelson, 2001, Chen, 2002; Mudibu *et al*., 2011). There are insufficient data on genetic diversity of common bean germplsm collections African countries including particularly DR-Congo. The basic objective of the study is to characterize morphologically and agronomically the common bean accessions from the DR-Congo germplasm for conservation and breeding purpose.

MATERIALS AND METHODS

Field experiments were conducted over two years (2012 and 2013) during two seasons in Western DR-Congo (Figure 1). The site was located at INERA agricultural research center (14°49'51''E, 5°45'34''S; and433 m in altitude). The region falls within the Aw4 climate type according to Köppen classification characterized with four to five months of dry season (from mid-May to mid-October) coupled with seven months of rain season, sometimes interrupted by a short dry season in January/February. Daily temperature averages 25°C and annual rainfall is close to 1.375 mm (INERA, 1992). Mvuazi sols consist of a collection of sandy on clay sediment more often based on a shallow lateritic old slab. The plot of each trial was ploughed a ridged at a spacing of 0.40 x 0.20 m. Gross plot size (experimental unit) was 4 m long and 1.60 m wide. Two seeds were sown at every 20 cm to a depth of about 2-3 cm. Manual weeding was carried out as to keep the field clean. The experiment was a completely randomized block design (RCBD) with four replicates. The trial was conducted with no fertilizer or pesticide applications. Twenty onecharacters in total were selected for germplasm characterization. The descriptive data included leaf shape, pod color, pod form, seed size and seed coat color. The characterization was based on the keys of the descriptors developed at the joint point by CIAT and IPGRI, while the evaluation of the accessions was based on the "standard System for the evaluation of the germoplasm of bean" developed by the CIAT (1992) with some modifications. In addition, Munsell color order system was used for precise color validation for leaves, pods and seeds. Leaf shape was determined according to UPOV (2005). The description of the symptoms and the identification of the diseases will be pressed on the "standard System for the evaluation of the germoplasme of bean" of the CIAT (1992), and on the guide on the harmful insects and the diseases of cowpea (Singh and Allen (1979) and on the practical guide on the insects, diseases and nutritive deficiencies of common bean in Africa, of Allen *et al*. (1996).

The agronomic data include plant height at maturity, stem diameter at the first internodes, leaflet length and leaflet width, leaf surface area, pod length and pod width, number of leaves per plant, number of stem ramification per plant, length of inflorescence, length of stem ramification, number of pods per plant, number of seeds per pod, days to 50% flowering, days to 50% of morphologic maturity, days to 50% of physiologic maturity, pod and grain yield per ha, weight per 100 seeds, rate dehusking and rate of seeds. Plant height was measured as the length of the main stem from the soil surface to the terminal node at maturity. Data were subjected to analysis of variance (ANOVA) using Statistix 8.0 and R (version i3.1.3) softwares. Main effects were separated by least significant difference (LSD) at P=0.05 level. The relations among means were calculated using Pearson correlation test at P=0.05 level.

RESULTS

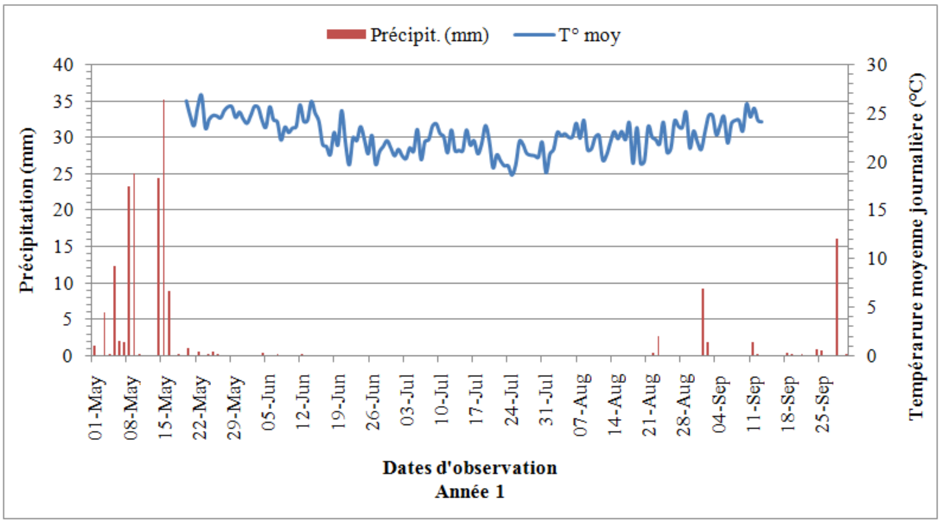
Qualitative traits

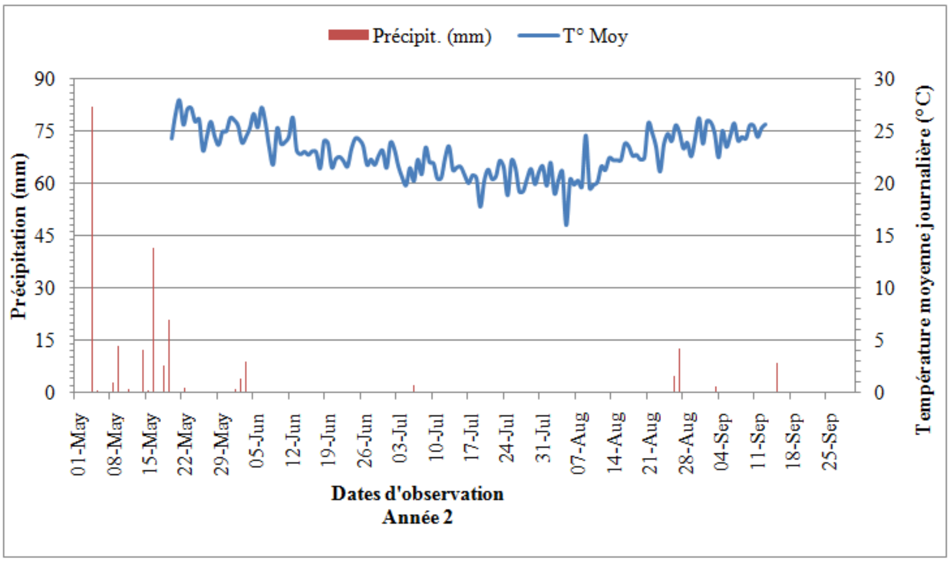
Qualitative characteristics are described in table 1.The leaves of all the analyzed accessions were normal green for the accessions. Some 3% of accessions had green-clear leaves. 81,11% of common bean accessions had losangic and 18,99% of triangular leaves. At the flowering, 50% of plants had white color of flowers, 35,56% of pink color and 14,44% of rosatre white color. At the morphological maturity, the frequencies for the pod color were 85,56% yellow, 6,67% red, 6,67% green and 1,11% crimson ; 31,11% of the accessions having seeds of white color, 21,11% of brown color, 18,89% of yellow color, 6,67% of red color, 3,33% of brown chestnut color, 2,22% of striated color, 2,22% of cream-coloured color, 2,22% of chocolate striated cream-coloured color, 2,22% of red mottled color and 1,11% of pink color, dark red, red checkmate, red striated white, yellow checkmate, grey sink, grey striped, light crimson and crimson with white points. The stems colors were 78,89% green, 20% anthocyanin and 1,11% red.

Pod yield per hectare, grain yield per hectare, number of pods per plant, number of seeds per pod and weight of 100 seeds

Five main components of yields were totally analyzed. They include pods yield per hectare, grain yield per hectare, number of pods per plant, number of seed per pod and weight of 100 seeds (Table 2).

Figure 1. Location of experimental sites: (A) Democratic Republic of Congo (in black); (B) Details on the map of the Democratic Republic of Congo. The arrow indicates the trial location (Mvuazi)





Figures 2 et 3. Graphiques sur les précipitations et la température de Mvuazi au cours des périodes expérimentales

Table 1. Sources, leaf shape, pod color, pod form, seed size and seed color of 90 Common bean accessions from the DR-Congo gene pool

Accessions	Source/Origin	Stem color	Leaf shape	Flower color	Pod color at 50% morphologic maturity	Pod form	Seed size	Seed color
BF 10	INERA, Mvuazi, DR-Congo	Anthocyanin	Triangular	Rosatre white	Red	Curved	Medium	Pink
BOMBE (BF 12)	INERA, Mvuazi, DR-Congo	Green	Triangular	Pink	Yellow	Curved	Medium	Grey-dark
HUGWE	INERA, Mvuazi, DR-Congo	Green	Triangular	White	Yellow	Right	Large	Crimson with white points
LOLA NAIN	INERA, Mvuazi, DR-Congo	Anthocyanin	Losangic	Pink	Yellow	Right	Large	Yellow
LOLA VOLUBILE	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Medium	Yellow
LUMBUA (L 4)	INERA, Mvuazi, DR-Congo	Anthocyanin	Triangular	White	Yellow	Curved	Medium	Lifeless yellow
LUNDAMBA	INERA, Mvuazi, DR-Congo	Green	Triangular	Rosatre white	Yellow	Right	Large	Yellow
MANSEKI	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Large	Yellow
MATELA	INERA, Mvuazi, DR-Congo	Green	Triangular	Rosatre white	Yellow	Curved	Large	White
MBIDI	INERA, Mvuazi, DR-Congo	Green	Triangular	Pink	Yellow	Right	Large	Yellow
NGWAKU-NGWAKU	INERA, Mvuazi, DR-Congo	Green	Triangular	Pink	Yellow	Right	Large	Yellow
NK 001/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Large	White
NK 004/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Large	White
NK 006/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Medium	White
NK 008/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Large	White
NK 009/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Medium	White
NK 011/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Large	White
NK 019/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Medium	White
NK 030/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Large	White
NK 033/08	INERA, Mvuazi, DR-Congo	Green	Losangic	Rosatre white	Yellow	Curved	Medium	Yellow
NK 035/08	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Large	Yellow
NK 051/08	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Medium	Yellow
NK 052/08	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Small	Yellow
NK 053/08	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Large	Yellow
NK 056/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Medium	White
NK 057/08	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Red	Curved	Medium	Yellow
NK 058/08	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Curved	Large	Yellow
NT 001/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Small	White
NT 002/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Small	White
NT 006/09	INERA, Mvuazi, DR-Congo	Green	Losangic	Rosatre white	Yellow	Curved	Medium	White
NT 007/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Small	White
NT 011/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Small	White
NT 012/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Small	White
NT 018/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Small	White
NT 019/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Small	White
NT 023/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Small	White
NT 026/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Large	Yellow
NT 032/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Small	White
NT 034/09	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Curved	Medium	White
NT 037/09	INERA, Mvuazi, DR-Congo	Green	Losangic	Rosatre white	Yellow	Curved	Medium	White
NTENDEZI	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Large	White
PV 18	INERA, Mvuazi, DR-Congo	Anthcyanin	Losangic	Pink	Yellow	Curved	Small	Brown
PVo 14	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Large	Red
PVo 14/2	INERA, Mvuazi, DR-Congo	Green	Losangic	Pink	Yellow	Right	Large	Mottled red
PVo 14/5	INERA, Mvuazi, DR-Congo	Green	Losangic	Rosatre white	Yellow	Right	Large	Brown
TUTA	INERA, Mvuazi, DR-Congo	Green	Losangic	White	Yellow	Right	Small	White
AFR 708	INERA, Mulungu, DR-Congo	Green	Losangic	Pink	Yellow	Curved	Large	Brown
BRD 194	INERA, Mulungu, DR-Congo	Anthcyanin	Losangic	Pink	Yellow	Right	Large	Red-dark

Continue……………….

CIM 9314-36	INERA, Mulungu, DR-Congo	Green	Losangic	Rosatre white	Yellow	Curved	Large	Brown
CODMLB 007	INERA, Mulungu, DR-Congo	Green	Losangic	White	Green	Right	Large	Reddish-brown striated cream
CODMLB 009	INERA, Mulungu, DR-Congo	Green	Losangic	White	Green	Right	Large	Mottled red
CODMLB 078	INERA, Mulungu, DR-Congo	Green	Triangular	White	Yellow	Right	Large	Reddish-brown striated cream
HM 21-7	INERA, Mulungu, DR-Congo	Green	Losangic	Pink	Yellow	Right	Large	Spotled cream
K 131	INERA, Mulungu, DR-Congo	Green	Losangic	White	Red	Right	Small	Spotled cream
LIB 1	INERA, Mulungu, DR-Congo	Green	Losangic	White	Yellow	Curved	Small	Yellow
M'SOLE (Ubusosera 6)	INERA, Mulungu, DR-Congo	Anthocyanin	Triangular	White	Yellow	Curved	Medium	Cream
MAHARAGI-SOJA (G2858)	INERA, Mulungu, DR-Congo	Green	Triangular	White	Yellow	Curved	Small	Cream
MOORE 88002	INERA, Mulungu, DR-Congo	Green	Trangular	Rosatre white	Yellow	Curved	Large	Yellow
RED WOLAITA	INERA, Mulungu, DR-Congo	Anthocyanin	Triangular	White	Red	Right	Small	Red
RWR 10	INERA, Mulungu, DR-Congo	Green	Losangic	White	Yellow	Right	Large	Red
TB 426 F/1-6	INERA, Mulungu, DR-Congo	Rouge	Triangular	White	Yellow	Right	Medium	Red checkmate
UNB 81010	INERA, Mulungu, DR-Congo	Anthcyanin	Triangular!	White	Red	Curved	Small	Red
URB (92)25	INERA, Mulungu, DR-Congo	Green	Losangic	White	Yellow	Curved	Medium	White
VCB 81013	INERA, Mulungu, DR-Congo	Green	Losangic	White	Green	Curved	Medium	White
ZKA 93-6M/95	INERA, Mulungu, DR-Congo	Anthocyanin	Losangic	White	Red	Curved	Small	Light purple
ZKA 93-10M/95	INERA, Mulungu, DR-Congo	Green	Losangic	Pink	Yellow	Right	Large	Yellow
A 445 (NTOMO)	CIAT, Colombie	Anthocyanin	Losangic	Pink	Purple	Curved	Medium	Spotled cream
DOR 715	CIAT, Colombie	Green	Losangic	White	Yellow	Right	Small	Brown
FEB 192	CIAT, Colombie	Anthocyanin	Losangic	Pink	Green	Right	Small	Brown
FLET WOOD	CIAT, Colombie	Green	Losangic	Rosatre white	Yellow	Curved	Small	White
G 16157 (NITU)	CIAT, Colombie	Green	Losangic	Rosatre white	Yellow	Curved	Large	Red striated white
G 858 (KIANGARA)	CIAT, Colombie	Green	Triangular	Pink	Yellow	Curved	Large	Yellow checkmate
MIB 753	CIAT, Colombie	Anthocyanin	Losangic	Pink	Yellow	Curved	Medium	Brown
MIB 760	CIAT, Colombie	Anthocyanin	Losangic	Pink	Green	Right	Small	Striated
MIB 779	CIAT, Colombie	Anthocyanin	Losangic	Pink	Yellow	Curved	Medium	Brown
NUA 3	CIAT, Colombie	Green	Losangic	Pink	Yellow	Curved	Large	Brown
NUA 4	CIAT, Colombie	Green	Losangic	Rosatre white	Yellow	Right	Large	Brown
NUA 9	CIAT, Colombie	Green	Losangic	White	Yellow	Right	Large	Brown
NUA 12	CIAT, Colombie	Green	Triangular	Pink	Yellow	Curved	Large	Brown
NUA 31	CIAT, Colombie	Green	Losangic	White	Green	Right	Large	Brown
NUA 35	CIAT, Colombie	Anthcyanin	Losangic	Pink	Green	Curved	Small	Striated
NUA 70	CIAT, Colombie	Green	Losangic	Pink	Yellow	Curved	Large	Brown
NUA 75	CIAT, Colombie	Green	Losangic	White	Yellow	Right	Large	Brown
NUA 81	CIAT, Colombie	Green	Losangic	Pink	Yellow	Curved	Large	Brown
NUA 84	CIAT, Colombie	Green	Losangic	Rosatre white	Yellow	Right	Large	Brown
NUA 87	CIAT, Colombie	Green	Losangic	Pink	Yellow	Curved	Large	Brown
NUA 99	CIAT, Colombie	Green	Losangic	Pink	Yellow	Curved	Medium	Brown
NUV 37	CIAT, Colombie	Anthocyanin	Losangic	Pink	Yellow	Curved	Medium	White
NUV 41	CIAT, Colombie	Anthocyanin	Losangic	White	Yellow	Curved	Medium	Red
T-3 (MVUAZI)	CIAT, Colombie	Anthocyanin	Losangic	White	Yellow	Right	Medium	Red

Table 2. Pod yield, grain yield, number of pods and seeds per plant, weight of 100 seeds, days to 50% flowering and 50% of morphologic and 50% of physiologic maturity for 90 Common bean

Accessions	Pod yield/ha (Kg)	Grain yield/ha (Kg)	Number of pods/plant (Mean number)	Number of seed/pod (Mean number)	Weight of 100 seeds (Gram)	Number of day to 50% flowering (Mean number)	Number to 50% of morphologic maturity (Mean number)	Number to 50% of physiologic maturity (Mean number)
NK 056/08	3625.0	1722.2	5	4	25.687	37	74	89
NT 037/09	2611.1	861.1	5	4	35.227	38	75	89
DOR 715	2361.1	1347.2	12	6	18.473	37	75	85
LOLA Volubile	2000.0	1208.3	6	4	40.040	37	73	91
NT 002/09	1972.2	1111.1	7	6	24.647	41	82	99
NT 018/09	1972.2	1097.2	8	5	24.753	39	78	94
NT 006/09	1944.4	986.1	6	4	28.273	39	78	99
NT 023/09	1875.0	958.3	7	6	23.340	40	79	94
NK 006/08	1791.7	1041.7	8	4	30.907	35	72	87
NT 011/09	1777.8	986.1	6	4	26.993	39	77	92
NUV 37	1722.2	875.0	5	4	35.413	37	73	93
FLET WOOD	1666.7	1013.9	8	5	23.907	40	76	93
LUNDAMBA	1611.1	958.3	5	3	40.380	39	75	90
NT 032/09	1597.2	1013.9	5	5	26.540	40	80	99
NT 007/09	1583.3	861.1	6	5	23.673	41	79	93
NK 001/08	1569.4	1027.8	7	4	33.280	34	72	86
NK 008/08	1569.4	986.1	6	3	35.500	34	71	84
NT 012/09	1555.6	986.1	7	5	25.407	41	81	95
NT 001/09	1541.7	888.9	7	5	23.700	41	83	96
NT 019/09	1541.7	819.4	6	5	24.100	39	79	96
K 131	1527.8	875.0	8	5	21.220	43	79	93
NT 026/09	1527.8	833.3	5	4	39.600	39	75	91
NK 057/08	1500.0	1041.7	6	4	36.413	33	69	84
NK 019/08	1472.2	1027.8	4	3	31.447	34	72	87
NK 009/08	1458.3	847.2	8	5	24.487	35	74	91
CODMLB 009	1402.8	680.6	4	3	46.807	38	76	86
NK 004/08	1388.9	680.6	6	4	31.553	36	74	91
MOORE 88002	1361.1	805.6	4	4	39.767	37	73	87
VCB 81013	1347.2	750.0	4	5	34.133	40	89	100
TUTA	1333.3	652.8	7	5	22.133	40	78	93
BOMBE (BF 12)	1333.3	805.6	6	4	35.467	41	75	90
BRD 194	1291.7	791.7	5	2	49.480	33	75	87
AFR 708	1277.8	861.1	4	2	42.800	37	75	90
NK 033/08	1263.9	791.7	5	3	37.253	34	70	88
TB 426 F/1	1263.9	791.7	6	4	25.647	37	75	90
NK 011/08	1222.2	750.0	5	3	36.283	34	71	84
URB(92)2	1222.2	722.2	5	3	23.497	40	78	94
HM 21-7	1222.2	736.1	5	2	42.120	36	75	89
LUMBUA (L4)	1194.4	791.7	3	3	31.033	37	75	85
A 445 (NTOMO)	1194.4	722.2	5	5	23.253	42	79	93
CODMLB 078	1194.4	583.3	4	3	51.440	37	75	87
MIB 760	1180.6	472.2	5	4	24.993	39	76	96
NT 034/09	1180.6	597.2	6	5	23.193	38	78	97
MIB 753	1166.7	472.2	5	3	22.250	43	77	89
PV 18	1111.1	541.7	7	5	16.180	44	78	92
G 16157 (N	1111.1	736.1	4	2	49.873	33	73	83

Continue……………….

NTENDEZI	1083.3	472.2	4	3	33.020	35	71	83
MANSEKI	1083.3	597.2	4	4	37.683	38	72	88
RWR 10	1083.3	569.4	5	3	40.807	40	78	88
NK 030/08	1083.3	694.4	5	3	32.967	35	71	85
NK 058/08	1041.7	652.8	4	3	34.400	34	71	82
T-3 (MVUAZI)	1041.7	666.7	6	4	25.620	38	75	89
NUA 87	1000.0	583.3	3	3	41.660	36	75	90
UNB 81010	1000.0	638.9	4	5	20.833	44	80	97
CIM 9314-3	986.1	569.4	4	2	38.407	35	75	87
CODMLB 007	944.4	472.2	2	3	44.333	38	75	84
NK 053/08	944.4	583.3	4	3	35.420	35	74	87
NUA 35	930.6	402.8	5	5	13.580	44	78	90
NUV 41	930.6	513.9	3	5	24.860	42	82	94
NK 051/08	930.6	611.1	4	3	37.627	34	71	82
NK 035/08	930.6	569.4	4	4	30.360	33	70	83
NK 052/08	916.7	597.2	4	3	36.833	35	71	83
FEB 192	902.8	513.9	5	5	21.377	42	74	90
NUA 81	875.0	458.3	4	3	36.943	37	75	87
NUA 31	875.0	458,3	4	2	38.257	39	76	87
MBIDI	861.1	486.1	3	4	40.520	33	70	83
PVo 14/2	861.1	513.9	3	2	40.947	35	73	84
PVo 14	847.2	402.8	3	2	42.920	34	68	82
NUA 4	847.2	569.4	3	2	53.373	38	78	88
M'SOLE	833.3	500.0	3	4	24.687	39	80	99
MIB 779	805.6	388.9	2	3	23.460	41	79	92
BF 10	791.7	444.4	3	5	23.600	38	75	89
HUGWE	777.8	444.4	3	3	40.433	33	71	85
NGWAKU-NGWAKU	777.8	500.0	3	3	38.607	34	69	85
PVo 14/5	750.0	402.8	2	3	51.420	33	68	82
NUA 70	722.2	486.1	3	4	34.823	36	74	84
NUA 84	722.2	472.2	3	3	39.610	37	76	89
ZKA 93-6 M	708.3	375.0	2	6	23.720	39	73	86
NUA 99	694.4	513.9	3	3	37.513	37	76	88
NUA 9	680.6	430.6	2	2	48.023	38	78	89
MATELA	680.6	375.0	2	4	38.533	36	72	85
NUA 12	666.6	444.4	3	3	38.977	37	75	88
RED WOLAITA	666.7	333.3	3	5	25.793	42	76	90
NUA 3	583.3	375.0	2	2	47.793	38	81	88
LIB 1	444.4	180.6	3	3	24.803	43	84	95
LOLA Nain	430.5	250.0	1	2	41.167	35	72	83
MAHARAGI-SOJA	402.8	125.0	2	5	15.477	43	80	87
NUA 75	361.1	291.7	1	2	51.710	41	79	90
G 858 (KIA	319.4	138.9	1	2	42.747	35	72	83
ZKA 93-10 M	305.6	111.1	1	2	32.287	38	73	88
LSD (0.05)	1181.4	681.52	0.94	0.29	5.1309	0.08	0.05	0.06

Table 3. Plant height, stem diameter, number of leaves, leaflet width, leaf surface, number of ramification per plant, pod length and width in 90 Common bean accessions from DR-Congo gene pool

Accessions	Plant height (cm)	Stem diameter	Number of leaves/plant	Leaflet length (cm)	Leaflet Width (cm)	Leaf surface (cm^2)	Number of ramification/plant	Length inflorescence (cm)	Length ramification (cm)	Pod length (mm)	Pod width (mm)	Rate of dehusking (%)	Rate of seeds (%)
NT 019/09	192.56	5.4200	19	4.667	3.7500	14.980	1	5.4233	56.667	105.22	8.933	43.81	61.36
NT 023/09	169.75	4.7033	25	4.707	3.6233	14.360	2	4.7067	57.667	105.55	10.653	52.79	53.13
VCB 81013	166.06	3.5167	17	5.427	4.0967	18.257	1	3.5233	21.333	104.62	9.903	49.46	63.62
NT 018/09	163.21	4.9833	21	4.680	3.4700	13.340	2	4.9833	29.667	102.34	9.797	49.13	58.09
NT 001/09	159.68	4.7733	16	5.447	4.7033	23.097	1	4.7733	2.000	98.71	8.830	54.45	61.04
NT 006/09	147.80	4.2400	15	4.417	3.1400	11.997	1	4.2433	14.667	107.38	8.887	46.46	55.45
NT 011/09	146.33	4.1433	20	5.230	3.7300	16.337	2	4.1433	43.667	111.94	8.907	47.46	67.74
NT 012/09	145.82	4.2933	16	4.743	3.5033	13.817	1	4.3000	6.333	98.84	8.173	50.13	81.28
NT 002/09	144.22	4.6000	17	5.170	4.1833	17.877	2	4.6033	31.333	112.86	9.167	52.46	55.12
NT 032/09	138.08	3.6267	19	5.180	3.6567	15.490	1	3.6300	30.000	106.55	9.197	76.10	76.95
NT 007/09	131.29	4.1533	16	4.197	3.4400	11.877	1	4.1667	14.667	100.73	9.383	47.13	61.68
TUTA	115.18	3.7767	17	5.177	4.0467	18.113	2	3.7500	13.667	98.73	8.303	48.79	49.46
NT 034/09	110.58	3.8067	12	4.180	3.0900	11.360	1	3.8100	7.333	103.82	8.773	51.13	56.77
NUV 37	109.34	3.6433	13	5.253	3.7733	18.117	2	3.6533	13.667	113.48	9.257	53.79	49.79
FLET WOOD	106.32	3.5733	13	4.187	2.9067	10.000	1	3.5700	11.000	84.47	7.783	52.46	70.51
NT 037/09	104.54	3.6767	15	5.400	3.6133	17.523	2	3.6833	10.000	114.57	9.547	21.05	60.38
MIB 760	100.22	5.1000	20	4.550	3.5867	13.753	2	5.1000	20.667	100.77	8.547	40.52	37.27
NUV 41	99.87	3.7733	13	4.640	3.0833	12.113	2	3.7733	17.667	95.43	9.123	49.46	73.20
URB (92)2	99.58	4.8567	15	5.583	3.8567	20.890	2	4.8633	35.000	88.47	9.257	43.48	90.06
NK 056/08	97.69	4.0600	14	4.213	3.0067	10.383	2	4.0633	16.667	100.63	8.913	45.80	46.13
LIB 1	92.82	4.1500	14	4.073	2.5730	8.740	2	4.1533	41.333	80.25	8.343	62.98	74.96
NT 026/09	92.29	4.7033	20	4.173	3.0133	10.327	2	4.7033	29.667	104.09	9.803	46.79	66.16
PV 18	89.73	3.6300	18	3.650	2.7033	8.233	4	3.6333	13.333	81.51	8.273	46.13	52.46
LOLA Volubile	87.05	3.5967	11	3.757	2.5900	8.177	1	3.6000	6.667	111.17	9.220	50.46	70.51
BOMBE (BF 12)	85.44	3.9067	13	4.387	3.3600	12.753	1	3.9100	10.333	87.57	8.463	55.12	65.22
A 445 (NTOMO)	84.34	4.6433	15	5.583	4.0933	18.880	2	4.6533	17.153	91.44	8.507	46.79	75.24
LUNDAMBA	82.85	4.3033	16	3.737	3.2467	10.300	2	4.3233	20.000	101.01	9.130	47.13	73.50
MANSEKI	79.49	3.7367	12	3.860	2.6700	8.610	1	3.7400	8.000	107.76	9.093	52.46	56.44
MIB 753	76.24	5.0300	19	5.090	3.5167	14.687	3	5.0367	19.333	98.92	9.083	27.92	72.90
ZKA 93-6 M	73.19	4.9167	13	4.273	3.5300	12.793	2	4.9200	20.000	112.43	8.883	41.50	55.78
HUGWE	61.16	3.9733	10	4.427	2.7133	11.047	1	3.9833	10.000	86.04	11.197	45.80	72.31
M'SOLE	60.53	5.3700	12	3.827	3.2267	10.387	2	5.3467	8.000	76.96	8.963	51.13	69.28
RED WOLAITA	50.61	3.9800	17	3.737	2.1867	6.747	3	3.9867	17.667	98.51	8.413	40.52	76.67
NUA 35	55.93	5.5600	15	4.937	3.8133	15.400	3	5.5633	11.667	81.20	7.120	26.73	49.46
MOORE 88002	53.72	3.9167	10	4.463	2.9167	11.347	2	3.9033	8.667	111.73	9.053	54.45	65.85
DOR 715	48.09	4.9667	16	5.810	3.4567	17.147	3	4.9733	16.333	86.65	8.533	47.13	90.84
BF 10	47.10	4.6000	11	4.393	3.1967	11.790	2	4.5933	23.333	91.98	8.027	52.46	61.68
MIB 779	46.66	6.1733	18	5.317	3.7467	16.847	3	6.1733	33.667	101.43	7.877	23.26	33.45
T-3 (MVUAZI)	44.79	5.0133	16	5.783	4.1033	20.483	4	5.0167	9.000	103.89	6.613	55.45	73.20
NTENDEZI	39.78	4.8800	7	9.663	7.0500	56.110	3	4.8800	5.000	102.46	8.977	18.66	51.13
K 131	39.60	5.1367	15	5.903	3.8933	20.470	3	5.1400	8.033	83.32	7.780	52.79	65.85
ZKA 93-10 M	37.14	4.4200	18	5.273	3.9300	16.987	2	4.4233	7.667	91.52	9.527	61.68	51.13
LUMBUA (L 4)	35.19	3.4733	9	4.860	3.4600	14.547	1	3.4833	5.333	89.20	9.660	42.16	86.87

MAHARAGI-SOJA	31.84	3.5567	14	6.207	3.9667	20.140	2	3.5600	7.667	80.62	7.960	13.30	65.85
TB 426 F/1	31.53	3.3767	11	5.010	3.4533	14.493	2	3.3833	4.667	103.80	7.727	58.74	67.74
UNB 81010	31.25	5.1667	13	5.280	3.7567	17.053	2	5.1767	6.340	80.77	7.093	53.13	76.95
CODMLB 078	30.86	5.6767	10	9.113	6.4033	48.750	3	5.6800	11.667	115.34	9.820	50.79	50.79
NUA 84	29.44	4.3100	10	8.493	6.5100	45.393	2	4.3133	7.667	102.07	10.337	65.85	79.43
G 16157 (N	28.31	5.1567	8	8.147	4.6933	35.753	2	5.1600	9.333	101.28	8.913	48.79	89.25
MATELA	27.93	4.4967	10	6.663	4.9067	31.297	2	4.1200	14.000	101.24	9.043	38.88	81.80
NK 008/08	27.90	4.6467	11	8.363	5.6300	39.880	3	4.6467	8.000	118.51	7.413	53.13	72.31
HM 21-7	27.67	4.9633	8	8.527	5.9933	43.770	3	4.9667	8.000	101.90	9.230	51.13	72.01
NK 009/08	27.64	4.3800	9	7.350	5.4700	33.877	2	4.3767	5.333	93.66	10.003	44.14	75.24
CODMLB 007	27.20	5.3967	7	8.890	6.4700	50.393	1	5.4033	7.000	111.35	10.360	41.50	46.46
PVo 14	26.50	5.2300	10	9.857	6.3167	51.113	3	5.2367	9.667	103.33	9.427	54.13	35.35
NUA 12	26.18	4.7033	8	8.157	5.8800	43.970	2	4.7067	6.117	97.99	9.793	49.13	93.35
FEB 192	25.70	3.6933	12	4.230	3.1800	12.333	2	3.7033	4.667	80.63	8.247	73.79	54.45
CODMLB 009	25.43	6.9200	8	9.060	6.3833	48.053	1	6.9200	6.993	104.52	10.420	51.79	53.13
PVo 14/2	25.16	5.0000	11	8.990	5.6600	43.347	2	5.0033	11.333	84.38	9.923	57.76	64.58
NK 001/08	24.95	5.5033	9	11.070	7.6467	70.280	3	5.1667	8.480	110.91	8.410	52.13	80.49
CIM 9314-3	24.46	5.0667	8	8.103	6.4933	44.800	2	5.0733	9.000	108.82	10.923	45.14	69.59
NK 030/08	24.32	4.3367	9	10.113	7.0800	58.813	2	4.4433	5.000	105.83	8.730	49.79	87.54
NK 035/08	24.13	4.5900	10	6.983	5.2900	32.910	3	5.5933	6.667	117.98	8.157	49.46	89.04
NUA 87	23.81	4.2900	9	7.757	6.0000	38.647	3	4.2933	7.000	107.96	9.880	49.79	71.11
AFR 708	23.28	4.8300	10	9.537	6.9567	62.347	3	4.8333	9.333	102.44	10.343	46.13	98.47
NK 004/08	23.17	5.1400	7	8.073	5.6133	38.637	3	5.1433	8.000	96.53	9.027	55.12	42.49
PVo 14/5	21.52	4.2533	9	7.247	5.1367	31.797	2	4.2600	6.667	110.82	10.883	54.45	53.13
MBIDI	22.33	4.2367	8	7.337	5.5300	33.480	2	4.2500	7.667	101.31	9.467	45.47	63.94
NUA 4	22.28	4.8456	13	7.680	4.4467	28.587	2	5.3267	8.333	95.39	8.960	51.13	92.14
RWR 10	22.15	4.7233	11	6.123	3.7267	18.927	3	4.7333	7.667	93.07	7.793	40.19	81.28
NK 052/08	22.09	5.2567	10	7.270	5.1467	31.663	2	5.2567	5.667	106.71	7.853	50.79	89.45
BRD 194	22.01	4.9967	12	7.270	3.9367	24.197	3	5.0000	7.667	83.28	11.123	23.26	84.54
NK 057/08	21.56	4.1167	9	7.733	5.6300	35.677	2	4.1233	6.810	102.90	8.097	53.13	95.62
NK 019/08	21.53	4.1100	9	8.973	5.7967	43.350	2	4.1133	7.667	104.78	9.073	52.46	97.44
NUA 70	21.20	4.5767	8	11.063	8.8333	80.133	2	4.4533	5.667	102.06	10.020	26.14	61.68
NGWAKU-NGWAKU	20.97	3.9500	8	6.903	4.7400	26.823	2	3.9533	5.667	99.09	8.810	50.79	89.04
NK 006/08	20.88	4.6233	10	9.017	6.1633	46.153	3	4.5633	8.333	102.26	7.787	48.13	89.04
NK 011/08	20.79	4.5233	9	9.420	6.8467	53.120	2	4.4533	7.000	98.37	9.290	49.13	80.49
NK 033/08	20.67	4.2500	8	7.347	5.2333	35.067	2	4.2533	6.333	112.78	8.293	57.43	67.42
NUA 75	20.18	5.0333	9	5.730	3.6233	16.960	2	5.0367	5.333	92.34	9.253	93.35	100.00
NUA 81	19.95	5.1467	9	8.647	6.4667	46.220	2	5.1533	9.000	105.08	9.817	48.46	73.20
NUA 3	19.78	4.1467	8	8.647	5.3233	40.693	2	4.1467	4.667	100.52	9.360	88.15	100.00
G 858 (KIA	19.54	3.8467	7	6.637	4.8733	27.350	1	3.8500	4.083	80.75	9.240	70.15	34.07
NUA 9	19.53	4.2367	8	5.887	3.8633	19.450	2	4.4167	6.333	97.00	9.437	66.80	96.77
NUA 31	19.42	4.9433	8	8.380	6.1467	47.633	2	4.9433	8.000	101.39	10.697	40.52	78.88
NK 058/08	19.39	4.4533	10	8.000	5.4600	36.113	3	4.3733	7.333	102.24	8.187	51.13	86.41
NK 051/08	19.28	4.4433	9	8.493	6.7600	47.517	2	4.4467	8.263	106.34	8.860	44.47	98.92
NUA 99	18.58	4.5233	9	8.600	5.9333	42.560	2	4.5267	8.333	95.93	9.477	56.77	94.31
LOLA Nain	18.55	3.9733	7	6.770	4.7033	26.240	1	3.9833	5.333	96.64	9.570	55.12	78.34
NK 053/08	17.78	5.0367	11	8.370	6.2100	44.720	3	5.0433	18.000	103.07	8.523	52.46	91.60
LSD (0.05)	39.090	1.973	0.55	2.4973	1.9722	22.883	0.73	1.5943	20.041	14.160	1.2174	11.23	21.54

Table 4. Pearson's correlations among morphological and agronomic traits in 90 Common accessions from DR-Congo germplasm

Phenotypic and agronomic traits	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21
V1	1.0000																				
V2	0.9302	1.0000																			
V3	-0.0034	0.0164	1.0000																		
V4	0.0482	0.2234	0.0508	1.0000																	
V5	-0.1348	-0.0809	0.0378	0.2444	1.0000																
V6	0.6261	0.6723	0.0780	0.1002	-0.3413	1.0000															
V7	0.3952	0.3586	-0.0449	-0.1429	-0.6674	0.4840	1.0000														
V8	0.4055	0.3614	-0.0528	-0.1622	-0.4319	0.3606	0.6377	1.0000													
V9	-0.0651	-0.0266	0.0811	0.1375	0.4043	-0.0731	-0.3689	-0.5115	1.0000												
V10	-0.0479	-0.0178	0.0790	0.0618	0.3067	-0.0499	-0.2568	-0.4127	0.9440	1.0000											
V11	0.2549	0.2873	0.1479	0.0798	0.0661	0.3827	0.0039	-0.0044	0.2544	0.2982	1.0000										
V12	0.2588	0.2033	-0.0033	-0.1140	-0.4021	0.3559	0.4125	0.5827	-0.3652	-0.2996	0.1569	1.0000									
V13	0.3271	0.3184	0.0946	0.0418	0.2690	0.0910	0.1274	0.1348	0.2093	0.2676	0.1675	0.0220	1.0000								
V14	0.0102	0.0208	-0.1277	0.0651	0.4223	-0.1435	-0.2383	0.0233	0.1622	0.1511	0.0145	-0.0773	0.0953	1.0000							
V15	-0.0331	0.0075	0.0712	0.0822	0.3498	-0.0393	-0.2974	-0.4348	0.9640	0.9742	0.2781	-0.3319	0.2549	0.1707	1.0000						
V16	-0.0695	-0.1433	-0.0722	-0.2529	-0.4581	-0.0260	0.3104	0.3928	-0.4455	-0.3933	-0.1282	0.3495	-0.2581	-0.2162	0.4190	1.0000					
V17	0.2660	0.2532	-0.0439	-0.0561	-0.2781	0.3596	0.3486	0.5342	-0.2228	-0.1416	0.2821	0.6266	0.1238	0.0214	0.1847	0.2087	1.0000				
V18	0.0950	0.1240	0.0540	0.0668	0.0094	0.2024	-0.1039	-0.2222	0.3206	0.3360	0.4683	0.0928	0.0811	-0.1277	0.3266	-0.0870	0.0732	1.0000			
V19	0.2517	0.2869	0.1467	0.0946	0.0935	0.3744	-0.0195	-0.0081	0.2506	0.2874	0.9832	0.1671	0.1702	0.0179	0.2681	-0.1197	0.2782	0.4694	1.0000		
V20	0.0242	0.0174	-0.1050	-0.0538	-0.2438	0.0663	0.2841	0.4023	-0.2204	-0.1977	-0.0495	0.3181	-0.1657	-0.0620	-0.2167	0.6421	0.2433	-0.1578	-0.0254	1.0000	
V21	0.1839	0.1768	-0.0802	-0.1269	-0.3430	0.2267	0.4360	0.6181	-0.4000	-0.3348	-0.0151	0.3721	-0.0530	-0.0235	-0.3585	0.4972	0.3532	-0.1254	-0.0025	0.6393	1.0000

V1= Pod weight per Ha ; **V2**=Grain weight per Ha ; **V3**=Dehusking rate ; **V4**=Seeds rate ; **V6**=Number of pod per plant ; **V7**=Number of seed par pod ; **V8**=Plant height ; **V9**=Leaflet length ; **V10**=leaflet width ; **V11**=Stem diameter ; **V12**=Number of leaves per plant ; **V13**=Pod length ; **V14**=Pod width ; **V15**=Leaf surface ; **V16**=Days to 50% flowering ; **V17**=Ramification length ; **V18**=Number of ramification ; **V19**=Inflorescence length ; **V20**=Days to 50% morphologic maturity ; **V21**= Days to 50% physiologic maturity.

Pods yield varied from 3625.0 kg/ha for NK 056/08 to 305.6 kg/ha for ZKA 93-10M. Also, grain yield varied from 1722.2 kg/ha for NK 056/08 to 111.1 kg/ha for ZKA 93-10M. The number of pod per plant ranged from 12 for DOR 715 to 1 for LOLA Nain, NUA 75, G 858 (KIANGARA) and ZKA 93-10M . The number of seed per pod ranged from 6 for DOR 715, NT 002/09, NT 023/09 and ZKA 93-6M to 2 for BRD 194, AFR 708, HM 21-7, G 16157 (NITU), CIM 9314-3???, NUA 31, PVo 14/2, PVo 14, NUA 4, NUA 9, NUA 3, LOLA Nain, NUA 75, G 858 (KIANGARA) and ZKA 93-10M. The accessions BRD 194, AFR 708, HM 21-7, G 16157 (NITU), CIM 9314-3???, NUA 31, PVo 14/2, PVo 14, NUA 4, NUA 9, NUA 3, LOLA Nain, NUA 75, G 858 (KIANGARA) and ZKA 93-10M had the smallest number of seeds per pod and DOR 715, NT 002/09, NT 023/09 and ZKA 93-6M the largest number of seed. The weight of 100 seeds raged from 53.373 g for NUA 4 to 13.580 g for NUA 35. The accessions NK 057/08, BRD 194, G 16157 (NITU), NK 035/08, MBIDI, HUGWE and PVo 14/5 showed 50% of flowering after 33 days while the accession PV 18, UND 81010 and NUA 35 were the latest to flower with 50% of flowering after 44 days. The accessions PVo 14 and PVo 14/5 showed 50% of morphologic maturity after 68 days while the accession VCB 81013 was the latest to get 50% of morphologic maturity after 89 days. The accessions NK 058/08, NK 051/08 and PVo 14 showed 50% of physiologic maturity after 82 days while the accession VCB 81013 was the latest to get 50% of physiologic maturity after 100 days. Grain yield were highly and significantly correlated to the number of pods per plant and seed per pod (Table 4). There was no correlation between grain yield per hectare and weight of 100 seeds. Moreover, it was no correlation between pod yield per hectare and weight of 100 seeds.

Pod length, pod width, rate of dehusking and rate of seeds

The values for pod length, pod width, rate of dehusking and rate of seeds are summarized in table 3. Pod length varied from 118.51 mm for NK 008/08 to 76.96 mm for M'SOLE. Pod width varied from 11.197 mm for HUGWE to 7.093 mm for UNB 81010. The rate of dehusking varied from 93.35% for NUA 75 to 13.30% for MAHARAGI-SOJA. The rate of seeds varied from 100% for NUA 3 to 33.45% for MIB 779. As with the other parameters measured, there were significant differences among accessions for pod and width. The two parameters were positively correlated. A positive correlation was found among these two components and the seed yield per hectare, also positive correlations were observed between the length and width of pod with the weight of 100 seeds (Table 4).

Plant height, stem diameter and number of leaves per plant

The mean values for plant height, stem diameter and number of leaves per plant are presented in Table 3. Plant height varied from 192.56 cm for NK 019/08 to 17.78 cm for NK 053/08. The stem diameter ranged from 6.9200 cm for CODMLB 009 to 3.3767 cm for TB 426 F/1. The number of leaves per plant varied from 25 for NT 023/09 to 7 for NTENDEZI, CODMLB 007, NK 004/08, G 858 (KIANGARA) and LOLA Nain. Among these three parameters, the plant height was negatively correlated with the stem diameter, whereas it was positively correlated with the number of leaves per plant in the study.

Leaflet length and width, leaf surface area, length inflorescence and number of ramification per plant

Leaflet length varied from 11.070 cm for NK 001/08 to 3.650 cm for PV 18. Leaflet width varied from 8.8333 cm for NUA 70 to 2.1867 cm for RED WOLAITA. Leaf surface varied from 80.133 mm^2 for NUA 75 to 6.747 mm^2 for RED WOLAITA. Length inflorescence varied from 6.9200 cm for CODMLB 009 to 3.3833 cm for TB 426 F/1. The number of ramification varied from 4 for PV 18 and T-3 (MVUAZI) to 1 for NT 019/09, VCB 81013, NT 001/09, NT 006/09, NT 012/09, NT 031/09, NT 007/09, NT 034/09, FLET WOOD, LOLA Volubile, BOMBE (BF 12), MANSEKI, HUGWE, LUMBUA (L 4), CODMLB 007, CODMLB 009, G 858 (KIANGARA) and LOLA Nain. Significant differences were observed among the length and the width of leaflet, which extended from 2,50 to 1,97. The correlation between the leave surface and the leave length was 0,9640, and strongly significant. The same tendency was also observed between the leave surface and the leave width where the correlation was 0,9742 (Table 4). A negative correlation was observed between the leave length and the plant height. The number of ramifications per plant is also employed like taxonomic characteristic (Mudibu *et al.*, 2011). The average number of ramifications per plant varied from 25 to 7 (Table 3).

DISCUSSION

In this study, the genetic diversity of common bean was based on the differences in morphological and agronomic traits. This evaluation is significant for the programs of selection, because the varieties of common bean are adapted to the specific agro-ecological areas and the phenotypes are strongly influenced by environmental factors (Mirindi *et al*., 2015; Marcio Zilio *et al*., 2013; White *et al*., 2013). In addition, SSR molecular markers were preferred to reach the genetic variability of the common bean germplasm. Information on the genetic variability of the common bean accessions of Africa, and central Africa in particular, is very limited (Blair *et al*., 2010). Indeed, no precise study was still to date undertaken in RD-Congo. A common bean collection of the DR-Congo germoplasm was characterized for the first time by using SSR molecular markers by Matondo *et al*. in 2013. The genetic report was drawn up and the data confirmed that the genetic base of the common bean cultivars in the DR-Congo collection is very narrow. With an aim of crossing and conservation, the morphological and agronomic characterization of the existing accessions in DR-Congo is required to support or supplement the molecular data. Traits as the pod number and seed number are correlated with the quantitative traits such as the yield components. They represent significant taxonomic characteristics for the germplasm evaluation. Compared to the results of Marcio Zilio *et al*. (2013), this study confirmed a positive and significant correlation between the 50% flowering and the yield, and between 50% flowering with the 50% physiological maturity and the 50% morphological maturity. In this study, it was noticed that the accessions with the shape of losangic leaves (sheets) have a smaller surface of leaves (sheets), but a greater seed yield compared with the varieties with triangular leaves (sheets). The losangic leaves (sheets) had a larger surface for the leaves (sheets). This has a positive impact on the seed yield. Indeed in the present study, the majority of the entries with high yield of seed were characterized by the shape of losangic sheet. The leave (sheet) is a very significant plant body for photosynthesis. The numbers of leaves (sheets) per plant and the leaves surface are significant characteristics for the germplasm characterization. In the present study, the average number of leaves (sheets) per plant extended from 7 to 25, contrary for example to that from 16 to 44 found by Mudibu (2013) on soybean. Puech *et al*. (1974) evaluated several genotypes in France and reported that the maximum number of the leaves (sheets) per plant was 14 for soybean. Such a difference can be allotted to the genetic differences between the common bean accessions used in the present comparative study with the genetic materials of Puech *et al*. (1974). Among the other analyzed parameters, the number of leaves (sheets) per plant was negatively correlated with the weight of 100 seeds. The value of this correlation is -0.4021 for bean. As for soybean, the genotypes having a high number of leaves (sheets) per plant produced a low weight of 100 seeds. This can be allotted to the fact that the higher leaves (sheets) cover the lower and basic leaves (sheets), which affect the quantity of photosynthetic products (Mudibu, 2013).

The color of pod occurs in various nuances of yellow, green, crimson and red. Roughly 85.56% of the accessions in the germplasm of Mvuazi are yellow, 7.78% green, 5.56% red and 1.11% crimson. In addition, the seed color has a genetic model more complicated. Significant differences were observed among the accessions for all the analyzed quantitative traits. Identically to the results of Marcio Zilio *et al*. (2013), the results of this study indicate the presence of variability for the majority of these characteristics, and accentuate the level of variability in the genetic inheritance of common bean in Mvuazi and in DR-Congo. As for Mudibu *et al*. (2011), in comparison with the undertaken molecular studies, each accession is single and no redundancy was identified among the studied materials. The height of seedling to maturity is a significant characteristic in the common bean germplasm and the evaluation of the accession. The majority of the common bean accessions used dwarf (of less than 0.5 m height), then are followed by the voluble ones (of more than 1 m height). Indeed, in this evaluated germoplasm, 61.11% of the accessions were less than 0.5 m from height, 20% ranging between 0.5 m and 1 m, and 18.89% superiors to 1 m. Under irrigation, the common bean reach a size appreciably higher compared with not irrigated. The distribution height of common bean, although various, resembles a normal distribution which is in conformity with the quantitative traits.

The correlations among the yield components were in conformity with the data reported by Puech *et al*. (1974) in France, Wegner (1976) in Liberia, and Kabalan (1998) in Lebanon. Of this study, 82.22% have higher yield than 750 kg/ha; 11.11% have yield ranging between 500 kg/ha and 6.67% have lower yield than 500 kg/ha). Many accessions of the genetic inheritance of DR-Congo produce well in the site of Mvuazi which is a good site of evaluation for common bean in low altitude, and where the conditions are favorable for the common bean culture. The seed yield is one of the most significant criteria of selection for the selectors. It is influenced by different components of yield which include the number of pods and seeds per plant, and the weight of 100 seeds (Rotzier *et al*., 2009). In the present study, the correlation between the seed yield and the number of pods and seeds per plant were significantly high, and higher (0.6723 and 0.3586) respectively. A positive and significant correlation was observed between the weight of 100 seeds and the length and the width of pod. The correlations between the weight of 100 seeds and other measured parameters were negative for the number of pod/plant, the number of seeds/pod, the plant height, the number of leaves (sheets) /plant, the number of days with 50% flowering, the length of ramification, the number of days with 50% of morphological maturity and 50% of physiological maturity. Antalikova *et al.* (2008) described negative correlations between the plant height and the seed yield. The present study revealed a significant positive correlation between the two characteristics. At all species of plant, the cycle, the architecture of plant and the seed yield are controlled by many genes and thus are strongly affected by the environmental conditions (Silva *et al*., 2009; Dawo *et al.*, 2007). Precipitations, temperatures and the photoperiods during the growth season are determining environmental factors affecting the yield of seed (Patil *et al*., 1976; Sachansky, 1976). Sachansky (1976) brought back significant variations of seed yield for the same genotype cultivated under the different precipitations and temperatures in Tanzania. In the same way, (Mirindi *et al*., 2015) increasing twelve genotypes of common bean in DR-Congo under various conditions of environment and of photoperiod reported significant differences in the seed yield. Precipitations for the growth periods in the present study were estimated at 302.3 mm (in first season) and at 29.6 mm (in second season), while the average temperatures varied from 19 to 26°C. This represents good conditions for the common bean growth.

The days to 50% of flowering, the days to 50% of morphological maturity and 50% of physiological maturity also represent common bean characteristics ordered by several genes. The common bean plant flower early when the duration of the day is short, and the use of short-cycle genotypes can lead to increased yield (Marcio Zilio *et al*., 2013). The photoperiods and the reactions at the various temperatures are the key factors used to determine the agro ecological areas for the growth of bean common varieties (Mirindi *et al.,* 2015; Marcio Zilio *et al*., 2013). The shortening of seed filling period caused by high temperatures was among the principal causes of the significant reduction of yield (Allen, 1994). The data of this study indicate the genetic variability during days of flowering among the analyzed accessions. Based on the seed yield during two years of the work in Mvuazi, thirty-three accessions were identified as adapted to the local conditions of low altitude for the common bean culture, among which eleven better accessions having productions with the top of the ton per hectare, of which NK 056/08, DOR 715, LOLA Volubile, NT 002/09, NT 018/09, NK 006/08, NK 057/08, NK 001/08, NK 019/08, FLET WOOD, NT 032/09; which to be added twenty-two another promising accessions among which NT 006/09, NT 011/09, NK 008/08, NT 012/09, LUNDAMBA, NT 023/09, NUV 37, K 131, NT 037/09, NT 007/09, NT 001/09, AFR 708, NT 026/09, NK 009/08, NT 019/09, MOORE 88002, BEND (BF 12), BRD 194, NK 033/08, TB 426 F/1-6, VCB 81013 and NK 011/08.

Conclusion

The information presented herein will be useful to curators and breeders for a better management of common bean germplasm or collection, *in situ* conservation, cataloging and development of specific improvement breeding program or strategies.

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REFERENCES

Allen D.J., Ampofo J.K.O. et Wortman C.S., 1996. Ravageurs, maladies et carences nutritives du haricot commun en Afrique. Guide pratique. Cali, Colombie ; Centre International d'Agriculture Tropicale ; Wageningen, Pays-Bas ; Centre technique de Coopération Agricole et Rurale, 132 p.

Allen, D., Ampofo, J.K.O. et Wortman C.S. 1996. Ravageurs, maladies et carences nutritives du haricot commun en Afrique, CIAT, Wageningen, p. 132 p.

Allen, L.H. Jr., 1994. Carbon dioxide increase: Direct impacts on crops and indirect effects mediated through anticipated climatic changes. *In* Boote K.J., Bennett J.M., Sinclair T.R., Paulsen G.M. (eds). Physiology and Determination of crop yield. American Society of Agronomy, Crop Science Society of America, and Soil Science society of America, Madison, Wisconsin, pp. 425-49.

Antalikova G., Zakova M. and Benedikova D. 2008. Characterization of Soybean traits variability by Cluster Analysis. *Agric*., 54: 45-53.

Asfav A., Blair MW. and Almekinders C. 2009. Genetic diversity and population structure of common bean (*Phaseolus vulgaris* L.) landraces from the East African Highlands. *Theor. Appl. Genet*., 120: 1-12.

Baudoin, J.P., Vanderborght, T., Kimani, P.M. et Mwang'ombe, A.W. 2001: Haricot commun (*Phaseolus vulgaris* L.). *In* Agriculture en Afrique tropicale. Direction Générale de la Coopération Internationale (DGCI), Bruxelles, Belgique, Romain H. Raemaekers (Coordonnateur), pp. 337-355.

Becerra-Velazquez L. and Gepts P., 1994. Diversity of Common bean (*Phaseolus vulgaris* L.) in its Centers of origin. Genome 37: 256-263.

Beebe S., Rengifo J., Gaitan-Solis E., Duque MC. and Tohme J. 2001. Diversity and origin of Andean landraces of Common bean. *Crop Sci*., 41: 854-862.

Beebe S., Skroch P., Tohme J., Duque MC., Pedraza F. and Nienhhuis J. 2000. Structure of genetic diversity among Common bean landraces of Middle American origin based on correspondence analysis of RAPD. *Crop Sci*., 40: 264-273.

Blair MW., Astudilloc C., Crusak M., Graham R. and Beebe S. 2009b. Inheritance of seed iron and zinc content in common bean (*Phaseolus vulgaris* L.). *Mol. Breed*., 23 : 197-207.

Blair MW., Diaz JM, Hidalgo R., Diaz LM. And Duque MC., 2007. Microsatellite characterization of Andean races of Common bean (*Phaseolus vulgaris* L.). *Theor. Appl. Genet*, 116 : 29-43.

Blair MW., Diaz LM., Buendia HF. and Duque MC. 2009a. Genetic diversity, seed size associations and population structure of a core collection of common beans (*Phaseolus vulgaris* L.). *Theor. Appl. Genet*. 119 : 955-973.

Blair MW., Giraldo MC., Buendia HF., Tovar E., Duque MC., and Beebe SE., 2006. Microsatellite marker diversity in Common bean (*Phaseolus vulgaris* L.). *Theor. Appl. Genet*. 113 : 100-109.

Blair MW., Laura FG., Kimani PM. and Butare L. 2010. Genetic diversity, inter-gene pool introgression and nutritional quality of common bean (*Phaseolus vulgaris* L.) from Central Africa. *Theor. Appl. Genet*., Vol 121 : 237-248.

Blair MW., Pedraza F., Buendia H., Gaitan-Solis E., Beebe S., Gepts P. and Tohme J. 2003. Development of a genome-wide anchored microsatellite map for common bean (*Phaseolus vulgaris* L.). *Theor. Appl. Genet*. 107 : 1362-1374.

Chen Y., 2002. Evaluationof diversity in Glycine soja and genetic relationships within the subgenus Soja. Ph.D. Thesis, University of Illinois, p. 156.

CIAT, 1982. Phaseolus vulgaris Descriptors. AGPG: IBPGR/81/1, IBPGR Secretariat, Rome, Italy, 37 p.

CIAT, 1992a. Actes de la Conférence sur le lancement des variétés, la production, et la distribution des semences de haricot dans la région des Grands lacs. CIAT African Workshop Series n° 18, Goma, Zaïre, 220 p.

CIAT, 1992b. Système standard pour l'évaluation du germoplasme du haricot. Aart Schoonoven et Marcial A. Pastor-Corrales (Compilateurs). Traduit de l'anglais.Cali, Colombie, 50 p.

Cober E.R. and Voldeng H.D. 2001. Low R:FR light quality delays flowering of E7E7 soybean lines. Crop Sci., 41: 1823-1826.

Dawo, M.I., Sanders, F.E., Pilbeam, D.J., 2007. Yield, yield components and plant architecture in the F3 generation of common bean (Phaseolus vulgaris L.) derived from across between the determinate cultivar 'Prelude' and an interminate landrace. Euphytica, V. 156, N° 1, p. 77-87.

Diaz LM. and Blair MW. 2006. Race structure within the Mesoamerican gene pool of Common bean (*Phaseolus vulgaris* L.) as determined by microsatellite markers. Theor. *Appl. Genet*. 114: 143-154.

Fu Y.B., 2003. Applications of bulking in molecular characterization of plant germplasm: a critical review. Plant Gen. Res; 1: 161-167.

Gaitan E., Duque MC., Edwards K. and Tohme J., 2002. Microsatellite repeats in common bean (*Phaseolus vulgaris* L.): isolation, characterization, and cross-species amplification in *Phaseolus spp*. *Crop Sci*., 42: 2128-2136.

Gomez O., Blair MW., Frankow-Lindberg B. and Gulllberg U., 2004. Molecular and phenotypic diversity of common bean landraces from Nicaragua. *Crop Sci*., 4: 1412-1418.

IBPGR, 1982. Phaseolus vulgaris Descriptors. AGPG:IBPGR/81/1, IBPGR Secretariat, Rome, Italy, 37p.

INERA, 1992. Rapport Annuel de Climatologie 1989-1992. INERA-Mvuazi, Bas-Zaïre, 24 p.

Kabalan R., 1998. Soybean water consumption and production : a case study from Beka. Thesis for Diploma of Advanced Studies (DEA). AUPLF-UREF: Lebanese University, Saint Joseph University, University holy spirit kaslik in partnership with "National Institute of Agronomy", Paris-Grignon, pp. 1-29.

Lee S.H., Bailey M.A., Mian MAR, Carter Jr T.E., Ashley D.A., Hussey R.S. and Parrolt W.A., 1996a. Molecular markers associated with soybean plant height, and maturity across locations. *Crop Sci*., 36:728-735;

Lee S.H., Bailey M.A., Mian MAR, Shipe E.R., Ashley D.A., Parrolt W.A., Hussey R.S. and Boerma H.R., 1996b. Identification of quantitative trait loci for plant height, lodging, and maturity in a soybean population segregating for growth habit. *Theor. Appl. Genet*., 92: 516-523.

Li Z. and Nelson R., 2001. Genetic diversity among soybean accessions from three countries measured by RAPDs. *Crop Sci*., 41: 1337-1347.

Mansur L.M., Ort K.G., Chase K., Jarvil T., Cregan P.B. and Lark K.G., 1996. Genetic mapping of agronomic traits using recombinant inbred line of soybean. *Crop Sci*., 36: 1327-1336.

Marcio Zilio, , Souza C.A., Coelho C.M.M., Miquelluti D.J. and Adelina F.M., 2013. Cycle, canopy architecture and yield of common bean genotypes (*Phaseolus vulgaris* L.) in Santa Catarina State. Acta Scientarum Agronomy, Maringa, Vol. 35, N°1, pp. 21-30

Matondo N.K., Yao K.N, Kyalo M., Skilton R., Nkongolo K.K., Mumba D. et Tshilenge D.K., 2013. Assessment of the genetic diversity and the relationship among common bean (*Phaseolus vulgaris* L.) accessions from DR-Congo germplasm using SSR molecular markers, en instance de publication.

Mirindi C., Mbikayi N., kijana R., Elukessu K., Bakulikira R., Koleramungu, Mongana E. et Rubabura J.A., 2015. Comportement et adaptabilité de quelques varieties biofortifiées du haricot commun (*Phaseolus vulgaris* L.)en conditions agro-écologiques des provinces du Nord et Sud Kivu à l'Est de la RD Congo. *International Journal of Innovation and Scientific Research*, Vol. 18, N°2, pp. 252-261.

Mudibu J., Nkongolo K.K.C. and Kalonji-Mbuyi A., 2011. Morphovariability and agronomic characteristics of soybean accessions from the Democratic Republic of Congo (DR-Congo) gene pool. *Journal of Plant Breeding and Crop Sciences*, Vol. 3(9), pp. 260-268.

Mudibu J., Nkongolo K.K.C. and Kalonji-Mbuyi, 2013. Morphovariability and agronomic characteristics of soybean accession from the Democratic Republic of Congo (DR-Congo) gene pool. *Journal of plant Breeding and Crop Science*, Vol. 3(11), pp. 260-268.

Mudibu, W.K.J., 2013. Evaluation de la diversité génétique et essai de selection participative des accessions de soja (Glycine max) du Pool génétique de la RD Congo « Apport de l'irradiation gamma sur la diversité ». Thèse de Doctorat en Génétique et Amélioration des plantes, UPN, 183 p.

Nelson R.L., Amdor P.J., Ort J.H., and Cavins J.F., 1988. Evaluation of the USDA soybean germplasm collection: maturity group 000 to IV (PI 427.136 to PI 445.845). U.S. dept. *Agr. Tech. Bull*., 1726 :188 p.

PABRA, 2015. PABRAinfographic_final.Pdf. 3p.

Pabra, sd. Des haricots de meilleure qualité pour l'Afrique … Kampala, Uganda, 8 p.

Patil V.D., Makne V.G. and Salunke M.R., 1976. Performance of soybean genotypes in Marathwada region of Maharashira, India. *Trop. Grain Legume Bull*., 5: 33-35.

Puech J., Lencrerot P., hernadez M., 1974. Role of environmental factors in soybean quantitative and qualitative production I. Growth, development and yield under irrigated and non irrigated conditions (in French). Ann. Agron. N° 25, 5: 659-679;

Rotzier D. Stamp P., Epiz, Betrix C.A., De Groote J-C, Moullet O., Schori A. 2009. Agronomic relevance of lanceolate leaf in soybean. *Revue Suisse Agric*., 41 (3): 153-159;

Sachansky S., 1976. Testing of some soybean varieties under irrigation conditions in the United Republic of Tanzania. Trop. *Grain Legume Bull*., 5: 36-37.

Shahi J.P. and Pandey M.P., 1981. Association of seed impermeability with flowering and maturity duration soybean. Trop. *Grain Legume Bull*., 22: 19-22.

Silva, C.A., Abreu, A.F.B., Ramalho, M.A.P., 2009. Associão entre arquitetura de planta et produtividade de gràosemprogênies de feijoeiro de porte e prostrado. Pesquisa Agropecuaria Brasilero, V. 44, N° 12, p. 1647-1652.

Singh S., Gutierrez A., Molima A., Urrea C. and Gepts, P., 1991. Genetic diversity in cultivated Common bean. *Crop Sci*., 31: 23-29.

Singh S.P., Gepts P. and Debouck D.G., 1991. Races of common bean (Phaseolus vulgaris L., Fabaceae), *Econ. Bot*., 45: 379-396.

Singh S.R. and Allen D.J., 1979. Cowpea pests and diseases. Manual series, N°2, International Institute of Tropical Agriculture, Ibadan, Nigeria, 113 p.

UPOV, 2005. Principes directeurs pour la conduit de l'examen de la Distinction, de l'Homogénéité et de la Stabilité. Haricot commun. Geneva, Switzerland, 46 p.

Wang K.J., Li X.H. and Li F.S., 2008. Phenotypic diversity of the big seed type subcollection of wild soybean (Glycine soja Sieb. Et zucc.) in China. *Genet. Res. Crop Evol*., 55(8): 1335-1348

Wenger O.E., 1976. Performance of some soybean varieties in Liberia. Trop. Grain Legume bull., 3:8-9.

White J.W., Ochoa R.M., Ibarra F.P. and Singh S.P., 2013. Inheritance of seed yield, maturity and seed weight of common bean (*Phaseolus vulgaris* L.) under semi-arid rainfed conditions. Published online 2013 Mar 6. Doi: 10.3389/fphys.2013.00035, PMCID; PMC 3589705.

Zhang X., Blair MW., and Wang S., 2008. Genetic diversity of Chinese Common bean (Phaseolus vulgaris L.) landraces assessed with simple sequence repeat markers. *Theor. Appl. Genet*., 117: 629-640.

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