菜豆育種成果及未來育種方向

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摘要

豆類作物為全球重要糧食作物之一，其中以菜豆中之乾豆為主要之供應者。其營養價值極高，富含豐富的蛋白質，已開發國家畜牧業發達之前，是為蛋白質主要來源，現今更被戲稱為窮人的蛋白質。臺灣目前菜豆之栽培僅剩供蔬菜用之嫩莢栽培。而歐美及日本等已開發國家則兩者並重，因此相對的臺灣在菜豆之研究及育種上較之為少，但菜豆仍為國人重要之消費蔬菜。近年來國際上逐漸重視到菜豆之營養價值及對人體健康之供獻，因此在機能性食品及健康食品之應用研究上正蓬勃發展。而在全球暖化及環保議題上，被提倡做為主要蛋白質供應。臺灣往在菜豆育種上育成有抗銹病品種台中 1 號，為圓莢、莢色白、但莢長短。寬扁莢形無筋絲菜豆台中 2 號，莢寬 2 公分、長 24 公分、莢色綠、甜度高質脆。台中 3 號，圓莢形、長 18-20 公分、莢色綠、甜度高質柔軟。台中 4 號，半蔓性、圓莢長 20 公分、莢色濃綠、甜度高質柔軟。未來育種方向應朝大莢形方便採收為育種目標。

關鍵字：菜豆、育種、營養

前言

菜豆（*Phaseolus vulgaris* L.）的原種或野生種還有尚未被發現者，植物學上的起源還有許多不明之處。所以植物地理學的研究存在許多異論，但也逐一被討論著。19 世紀末，許多學者雖然在沒有學術性的根據，但仍然希望推定菜豆的原產地為印度到克什米爾。但瑞士植物分類學家 Alphonse de Condolle (1984) 在比較詳細的研究之後認為其原產地應在南美洲大陸。但將原產地限定在南美洲大陸學術性的證據並不充分。認為應以美洲大陸之熱帶以至亞熱帶地區為其原產地較妥當。直至 1935 年蘇聯學者瓦維洛夫（Vavilov, Nkolay Ivanovich）經廣泛的調查之後認為原產地在黑西哥南部及中美洲，而南美洲之秘魯，厄瓜多、玻利維亞為 2 次種源中心。

菜豆原產地在中南美洲，而後逐漸拓展到南北美洲大陸，1492 年哥倫布發現新大陸之後將之引入歐洲，其時間與玉米並沒太大差異。其擴散分佈之途徑考察如下：

美洲大陸內的傳播，菜豆是美洲大陸原住民廣泛栽培的傳統作物，哥倫布首次登陸美洲大陸時，記載在古巴島上已有菜豆之種植。很顯然的在北美大陸印地安人即以玉米桿做為支柱間作菜豆，美利堅合眾國立國之初，即有種實生產及販賣組織之設立，最初 1936

年在紐約州首先有種子販賣。歐洲及非洲之傳播，歐洲菜豆是於 16 世紀後半期由西班牙人首先自美洲大陸引進，早期僅西班牙及義大利種植種實用之菜豆，其後於 17 世紀逐漸擴展到北歐，而首先有莢用菜豆之種植。非洲大陸於近世紀之栽培有較明確的記載，但早期傳入之途徑並不明確。亞洲的傳入，中國最早的記載見於 16 世紀末明李時珍所著本草綱目（1578），印度是於近世紀才傳入。日本是在承应 3 年（1654）隱元禪師自中國（明）引入日本，故叫做隱元豆（インゲンマメ），也被叫做藤豆（フジマメ），但並沒有詳細之記載。日本「本草圖譜」（1829～1844）僅將之記載為豇豆之一種。直至明治初年始由歐美等地大量引入品種。而台灣的栽培最早之記載為 1905 年，已為近代之事，日據時期已有零星栽培，1970 年代引入矮性品種做為秋冬及裏作栽培，並以冷凍外銷嫩莢為主要之經濟作物，現今則以蔓性菜豆為主，栽培面積約 700 公頃，以生產鮮食嫩莢為主。

菜豆於豆類蔬菜中目前被廣泛栽培於溫帶及亞熱帶地區。在溫帶地區綠色嫩豆莢被用做為蔬菜食用，可供做鮮食、冷凍或製罐。成熟可食用豆仁者，被稱之為海軍豆 navy beans、白豆 white beans、北方豆 northern beans 或 pea beans，消費量極大。在低緯度地區，乾豆為中低階層家庭主要蛋白質的來源，在某些熱帶地區葉子甚至被做為煮食之蔬菜，或是食用青豆仁。在爪窪 Java，嫩葉更被作為沙拉 salad 食用。採收後的草莖亦可供做飼料。

分　類

菜豆品種相當多，所知當中有許多是異名同種，同種異名。早期熊沢氏（1965）根據美國種苗目錄中記載已約有 1500 多種。Headrick（1931）的記錄中，軟莢用的有 179 種，鮮種仁用 22 種，乾豆用 55 種。鮮種仁用者是在美洲大陸發現前之品種分化逐漸改進而來。17 世紀初，蔓性種或無蔓種，粒形或種仁顏色之變異性記錄相當多。到 18 世紀當時品種之記載，僅有 5 種蔓性品種，而莢用品種之利用並不普遍，至白人移往美洲大陸時嫩莢之利用才開始盛行。Boswell （1945）認為 現今莢用品種是於 100 年前才開始分化發展的。

菜豆品種分類並未確立理想之分類方法，主要可依據種子的形狀、顏色及植株性狀，但品種的育成經過或血統關係仍有許多不清礎之處。而以蔬菜之利用，植株性狀，莢之利用等，實用性來分類者較多。

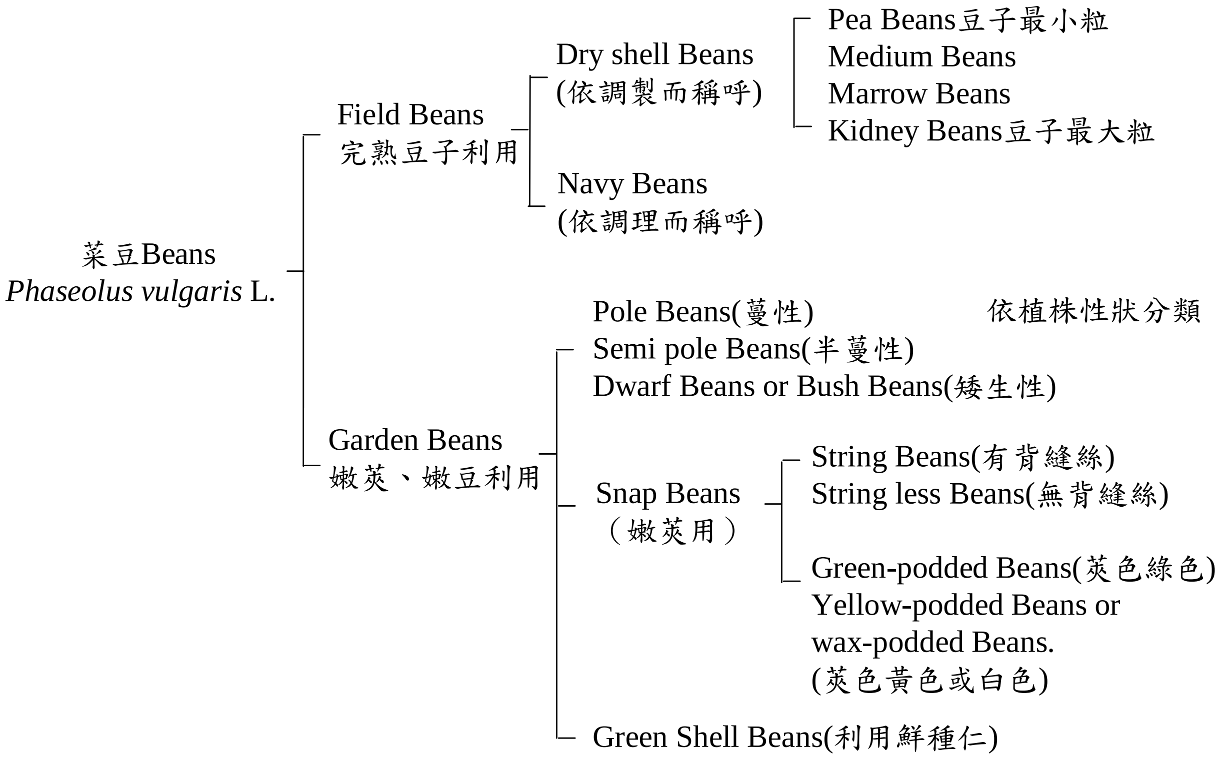

圖1.菜豆食用分類法（渡邊1969）

大致上菜豆之用途可分為利用完熟種實（乾豆）之 field beans（田豆）及利用嫩莢或鮮種仁之 garden beans（園藝豆）兩大類。嫩莢用之軟莢豆稱之為 snap bean，鮮種仁用者稱之為 green shell bean。而依植株生長習性，則有蔓性、半蔓性及矮性。莢色則有綠莢、黃莢、白莢。莢形大致可分為扁莢、扁圓莢，圓莢，以及筋絲有無之區分。菜豆為短日植物，但開花習性受溫度影響極大，因此品種之感光性、感溫性的差異，仍有各地區適應性品種存在。

台灣因非為菜豆之原產地且栽培歷史極短，因此多數的品種均為引入之外來種，而因產業發展之變異，栽培品種更替極快。如早期加工外銷則以矮性為主，現今以蔓性為主要之栽培系統，且大多以嫩莢用為主要之栽培，鮮種仁或乾豆之栽培只見於田野零星之家庭栽培。

營養價值

菜豆含有極豐富營養，相對而言是為廉價蛋白質食物。菜豆(Green snap beans)含有，6.2% 蛋白質， 0.2%脂肪及 63%碳水化合物。乾豆營養成份為，水分 12.0%、蛋白質 22.9%、

脂肪 1.3%、碳水化合物 60.6%及礦物質 3.2%：Ca, 260 mg、P, 410 mg 及 iron, 5.8 mg。熱量 346 calories/100 g。維他命含量，維他命 B_1(硫氨素 thiamine) 0.6、核黃素(riboflavin) 0.2、菸鹼酸(nicotinic acid) 2.5 及維他命 C(抗壞血酸 ascorbic acid) 2.0 mg/100。礦物元素，鈉 Na 43.2、鉀 K 1160、鈣 Ca 180、鎂 Mg 183、鐵 Fe 6.6、銅 Cu 0.61、磷 P 309、硫 S 166 及氯 Cl 1.8 mg/100 g，碘 I (1.4 g/100 g)、錳 Mn (1.8 mg/100 g)及砷 arsenic (0.03 mg/100 g)。

未成熟嫩莢每 100 克含熱量 32- 27 卡、水份 90.1-91.4 g、蛋白質 1.9-1.7 g、脂肪 0.2 g、總碳水化合物 7.1- 6.0 g、 1.0 g 纖維及灰份 0.7 g。kidney beans 生豆莢每百克可食部份含 150 卡熱量、水份 60.4% 、蛋白質 9.8 g、脂肪 0.3 g、總碳水化合物 27.8 g、纖維 2.3 g 、灰份 1.7 g 、59 mg 鈣、 213 mg 磷、 3.6 mg 鐵、 10 g 維他命 A、 0.38 mg 維他命 B_1、0.12 mg 核黃素、1.5 mg 菸鹼酸(niacin)、 7 mg 維他命 C。未煮之熟乾豆(白、紅、花)，每百克可食部份含 340、343 及 349 卡熱量、水份 10.9、10.4 及 8.3%、蛋白質 22.3，22.5 及 22.9 g、脂肪 1.6，1.5 及 1.2 g、總碳水化合物 61.3，61.9 及 63.7 g、纖維 4.3，4.2 及 4.3 g、灰份 3.9，3.7 及 3.9 g。整個種子每百克含 86 mg 鈣、247 mg 磷、716 mg 鐵、5 g 維他命 A、 0.54 mg 維他命 B_1、0.19 mg 核黃素、2.1 mg 菸鹼酸、3 mg 維他命 C。

採收後的植株可做為飼養牛、羊、馬等動物的粗飼料，為較玉米、高粱更好的乾草料。含水份 10.9、蛋白質 6.1、脂肪 1.4、游離氮 34.1、纖維 40.1、灰份 7.4；鈣 1.7、磷 0.1、鉀 1.0、可消化蛋白 3.0，總可消化營養 45.2%，營養比 14.1。

但少數報導食用菜豆根會造成人類及動物暈眩。種子則含有胰蛋白及凝乳蛋白抑制脢。少數生豆仁或乾豆具毒蛋白，但其易被高溫破壞，因此煮食後可去除其毒性。

育　種

在全球上豆類作物是主要糧食作物，因含有豐富之營養，且生產容易，目前廣泛分佈全球各地，其蛋白質取得較動物蛋白質便宜，因此稱之為窮人的蛋白質。所以世界各地育種極為發達。臺灣早期發展雜糧、油料作物時，曾積極發展大豆、花生、紅豆之育種，但後期幾乎停止了所有研究。菜豆除早期發展蔬菜加工外銷時，引進一些矮性品種，高雄改良場選育出高雄早生之外，幾無進展。而蔓性品種也多為引入後馴化之地方品系，研究及育種上很少，除台中改良場育成抗銹病品種台中一號後便停滯很久。由於產業結構之變動，臺灣菜豆栽培面積亦漸趨減少。除了產業改變之外，因長期以來並未廣泛收集種源因此，缺乏育種材料。

菜豆為自交作物因此育種程序相對簡易，一般透過種源收集之後，予以雜交、選拔、繁殖、區域試驗、病虫害檢定、推廣，即可完成。

遺傳基因

國際上對於菜豆遺傳因子之研究歷史極悠久，且持續在進行，並以完成多樣基因定序之研究。目前已發現之遺傳基因如下表，由表列之基因可發現多數為控制形態、色澤基因，以及病害、病毒病抗病基因。但至目前並未發現，控制溫度感受性基因，因此在耐熱性育種上目前並未有突破性。dt-1a dt-2a 及 dt-1b dt-2b 為控制對日長感受性之基因，但其受溫度影響極大。因此感溫性基因或許可從其中去尋找。另外菜豆存在有配子體基因 Ga 稱之為花粉攜帶基因，隱性 ga 基因促進繁殖。而 gas 基因則造成雌、雄雙方不稔性，可用做為育成雜交 F_1 品種。另外其中仍有許多構造基因與酵素之生合成有關，可做為研發功能性或機能性用途，如淬取抗病、抗蟲或機能性物質。

Gene	Description
A	Confers resistance to the alpha race of anthracnose (Mc Rostie 1919).
Acc	Accompanying colors, i.e., the formerly "apheliotropic effects of Rst on the color of pods, the top edge of the standard, and the hypocotyls" (Prakken 1974).
ace	acera (Latin): produces shiny pod (Yen 1957).
Adk	Structural gene for adenylate kinase enzyme (Weeden 1984).
Am	Amaranth: with No and Sal geranium flower color, and scarlet flower with Beg No Sal (Lamprecht 1948b, 1961a).
Amv-1	High level resistance to a strain of alfalfa mosaic virus (Wade and Zaumeyer 1940).
Amv-2	Resistance to the same strain of alfalfa mosaic virus as for Amv (Wade and Zaumeyer 1940).
Ane	Anebulosus (Latin): produces nebulous-mottling on testa (Prakken 1977a); observable only in cu J and C/cu J backgrounds.
aph	Aphyllus (Latin): plants have only two leaves, both unifoliate, 4 to 6 nodes, and are sterile (Lamprecht 1958).
Arc	with Bip gives virgarcus seed coat pattern, with bip gives virgata; arc with Bip gives arcus, with bip gives bipunctata; extends seed coat color in partly colored seeds (Lamprecht 1940b).
Are	confers resistance to four races of anthracnose (Mastenbrock 1960); also confers resistance to the lambda and epsilon races (Tu 1984).
arg	argentum (Latin): with Y produces a "silver" or greenish gray pod (Lamprecht 1947b), formerly s (Currence 1930, 1931); arg with y gives a white pod (Currence 1931; Lamprecht 1947b).
Arl (Arc)	structural gene for the seed protein arcelin (Osborn et al. 1986).
asp	asper (Latin): very dull (nonshiny) seed coat that is slightly rough textured due to the pyramidal shape of the outer epidermal palisade cells (Lamprecht, 1940c).
B	(Br, Vir) as used by Lamprecht (1932a, 1939, 1951a). With P gives a seed coat that is whitish with a pale lilac tinge, his Veilchenartig Weiss, with a yellowish brown hilum ring; described by Smith (1961) as gray-white. With other color factors it changes chamois to bronze (1932a). According to Prakken (1934, 1940-41) B with the basic color factors produces a gray-greenish-brown seed coat without a hilum ring, and changes yellow-brown to mineral-brown. Its use with suitable genes as a bluing factor (Lamprecht 1932a; Prakken 1934; Sirks 1922; Tjebbes and Kooiman 1922b) appears to be similar to its original concept; this effect is regarded by Smith (1939) to be due to a distinct gene, Bl. Similar or equivalent genes, according to Feenstra (1960) are the C of Tschermak (1912), the D of Shull (1908),

	the E of Kooiman (1920), the H of Shaw and Norton (1918), and the L of Sirks (1922).
bc-u	strain-unspecific complementary gene, giving resistance to strains of bean common mosaic virus (BCMV) only when together with one or more of the strain-specific resistance genes (Drijfhout 1978b).
bc-11	with bc-u gives resistance to BCMV strains NL1 and NL8 (Drijfhout 1978b).
bc-12	with bc-u gives resistance to BCMV strains NL1, NL2, NL7, and NL8 (Drijfhout 1978b).
bc-21	with bc-u gives resistance to BCMV strains NL1, NL4, NL6, and NL7 (Drijfhout 1978b).
bc-22	with bc-u gives resistance to BCMV strains NL1, NL2, NL5, NL6, NL7, and NL8 (Drijfhout 1978b).
bc-3	with bc-u gives resistance to all strains of BCMV (Drijfhout 1978b).
Bcm	confers temperature-sensitive resistance to blackeye cowpea mosaic virus. Tightly linked, if not identical, to the I gene for resistance to bean common mosaic virus (Provvidenti et al. 1983; Kyle and Provvidenti 1987).
Beg	with P gives begonia red flower color (Lamprecht 1948b).
Bip	bipunctata (Latin): Bip and bip combine with Arc and arc to form seed coat patterns based on the hilum; extends seed coat color in partly colored seeds (Lamprecht 1932d, 1940b).
blu	Blue flower color mutant (Bassett 1992a).
Bpm	confers resistance to bean pod mottle virus (Thomas and Zaumeyer 1950); symbol proposed by Provvidenti (1987).
Bsm	confers resistance to bean southern mosaic virus (Zaumeyer and Harter 1943); symbol proposed by Provvidenti (1987).
By-1	confers strain-specific resistance to pea mosaic virus, a strain of bean yellow mosaic virus (Schroeder and Provvidenti 1968).
By-2	strain-unspecific gene for temperature sensitive resistance to bean yellow mosaic virus (Dickson and Natti 1968).
C	with P, sulfur-white or primrose yellow testa; no color in the hilum ring (Lamprecht 1932a, 1939, 1951b; Tjebbes and Kooiman 1922b). According to Feenstra (1960) this C is the equivalent of the B of Tjebbes (1927), of Kooiman (1920), and of Sirks (1922), and the Cm of Prakken (1934).
C/c	inconstant (ever-segregating) mottling with color genes (Lamprecht 1932a, 1939; Prakken 1940-1941; Shaw and Norton 1918; Tschermak 1912). According to Prakken (1974) the "complex C locus" includes 6 tightly linked loci, including M, Pr, Acc, C/c, R, and Cst.
ccr	completely recessive: the heterozygote Cccr shows the pure dark pattern color CC, without mottling as in Cc and Ccu (Nakayama 1965).
Ccir	circumdatus (Latin): lateral accumulation of medium sized spots on the testa (Lamprecht 1947a).
C ma (M, Rma)	responsible for constant (non-segregating) mottling of the seed coat; the colors depend on other genes (Emerson 1909a; Shull 1908; Smith 1939, 1947; Tschermak 1912). Later interpreted to be an allele of R and redesignated Rma (Lamprecht 1947a). M was originally used by Shull (1908) for inconstant mottling. M with Ro and V produces marbling of the pod (Lamprecht 1940a, 1951b). According to Prakken (1974), C, R, and M are 3 distinct but very closely linked loci that are included in the "complex C locus."
C r	indistinct, inconstant mottling of the seed coat (Lamprecht 1940a, 1947a; Smith 1939).
C res	resperus (Latin): sprinkled or speckled seed coat (Lamprecht 1940a, 1947a).
C rho	rhomboidus (Latin): rhomboid spotting of the testa (Lamprecht 1947a).
C st	striping on seed coat and pod (Kooiman 1931; Lamprecht 1939; Sirks 1922; Smith 1939; Tjebbes and Kooiman 1919b; Tschermak 1912); considered by Lamprecht (1947a) to be due to Rst. The Cst allele in 'La Gaude' has the pleiotropic effect of producing blackish violet zebra-like veins on the standard petal of the flowers (Prakken 1977a).

[C st R Acc] (Aeq)	with v also "darkens" the tip of the banner petal (Prakken 1972b and 1974), i.e., the otherwise white standard has a red tip; the genes R and Acc are tightly linked within the "complex C locus" (Prakken 1974); the Terminalverstärkung der Blütenfarbe character of Lamprecht (1961a) does not require his Uc, Unc genes to account for its highly variable penetrance.
cu (inh, ie)	unchangeable: produces a creamish testa (Feenstra 1960); the modifier genes G, B, and V do not change the pale background color of P J cu (Prakken 1970).
[cu Prpi] (Prp, cui, Nud)	with T P V produces cartridge buff seed coats, with very tight genetic linkage to a syndrome of anthocyanin intensification effects: purple flower buds, intense purple flowers, purple pods, purple petioles and stems, and a blush of purple on leaf lamina as found in Royal Burgundy (Bassett 1994a; Kooiman 1931); a series of purple pod "alleles" exist at the complex C locus (Bassett 1994a; Okonkwo and Clayberg 1984). The same anthocyanin intensification syndrome has been reported repeatedly (but incompletely), each time with a new gene symbol: Nud by Lamprecht (1935e), cui by Nakayama (1964), and Prp by Okonkwo and Clayberg (1984).
[cu prpst] (prpst)	with T P V produces cartridge buff seed coats with very tight genetic linkage to green pods with purple stripes as found in Contender (Bassett 1994a)
[C Prp] (Prp)	with T P J B V produces black seed coats and purple pods as found in Preto 146 (Bassett 1994a).
cv	a completely recessive c that does not show heterozygous mottling and has no effect on seed coat color except with V, producing a grayish brown with G B V (Bassett 1995b).
[C R] (R)	with P produces a red seed coat (Emerson 1909b; Lamprecht 1935a; Tjebbes and Kooiman 1921) that has been variously described as light vinaceous (Tjebbes and Kooiman 1921), light purple vinaceous (Lamprecht 1947a), and deep oxblood red (Smith 1939), the differences possibly due to modifying genes. The flowers are red (Tjebbes and Kooiman 1922b). It does not affect the color of the hilum ring (Lamprecht 1939). R, Rcir, Rr, Rres, Rrho, and r are allelic, according to Lamprecht (1947a); but Prakken (1977b) has shown that Cst patterns can exist without the R locus red color. Therefore, the striping, marbling, and other patterns are more correctly designated as properties of the C locus, and the bracket notation, [C R], is used to indicate two genes with nearly unbreakable linkage (Bassett 1991b).
[C r] (r)	with appropriate modifier genes gives white seed coat (Emerson 1909b; Lamprecht 1940a, 1947a).
Ca	caruncula stripe pattern, originating at the caruncula and extending away from the hilum (Lamprecht 1932c and 1934a).
Cam	confers temperature sensitive resistance to cowpea aphid-borne mosaic virus. Tightly linked, if not identical, to the I gene for resistance to bean common mosaic virus (Provvidenti et al. 1983; Kyle and Provvidenti 1987).
Cav	Caruncula verruca (Latin): causes a wrinkling of the testa radiating from the caruncula (Lamprecht 1955). The heterozygote is less distinct.
cc	chlorotic cup leaf mutation (Nagata and Bassett 1984).
chl	pale green chlorophyll deficiency (Nakayama 1959a).
cl	circumlineatus (Latin): in partly colored seed coats, each of the color centers and even the smallest dots are bordered by a sharp precipitation-like line (Prakken 1972b).
cml	chlorotic moderately lanceolate leaf mutant (Bassett 1992c).
Co-1 (A)	an anthracnose [Colletotrichum lindemuthianum (Sacc. & Magnus) Lams.-Scrib.] resistance gene discovered by McRostie (1919) and found in the Andean variety Michigan Dark Red Kidney; linked to the RAPD marker OF10530.
Co-2 (Are)	an anthracnose resistance gene discovered by Mastenbroek (1960) and found in the Mesoamerican differential variety Cornell 49242; linked to RAPD markers OQ41440 , OH20450 , and B3551000.
Co-3 (Mexique 1)	an anthracnose resistance gene discovered by Bannerot (1965) and found in the Mesoamerican variety Mexico 222; tentatively given the gene symbol Co-3.
Co-32	an allele for anthracnose resistance at the Co-3 locus found in the Mesoamerican variety Mexico 227 (Fouilloux 1979).

Co-4 (Mexique 2)	an anthracnose resistance gene discovered by Bannerot in 1969 (Fouilloux 1976, 1979) and found in the Mesoamerican differential variety TO; tentatively given the gene symbol Co-4.
Co-5 (Mexique 3)	an anthracnose resistance gene discovered by Bannerot in 1969 (Fouilloux 1976, 1979) and found in the Mesoamerican differential variety TU and G2333, selection 1360; tentatively given the gene symbol Co-5.
Co-6	an anthracnose resistance gene discovered by Schwartz et al. (1982) and found in the Mesoamerican differential variety AB 136; tentatively given the gene symbol Co-6 and linked to RAPD markers OAH1780 and OAK20890.
Co-7	an anthracnose resistance gene discovered by Pastor-Corrales et al. (1994) and found in the Mesoamerican differential variety G2333 and selection 1308 from G2333; tentatively given the gene symbol Co-7.
cr-1 cr-2	complementary recessive genes for crippled morphology, i.e., stunted plants with small, crinkled leaves (Coyne 1965; Finke et al. 1986).
cry	crypto-dwarf: a dwarfing gene; with Fin intermediate height (Nakayama 1957); with la produces long internodes resulting in slender type of growth in bush (fin) but not in tall (Fin) forms (Lamprecht 1947b). 矮性基因
cs	chlorotic stem mutant (Nagata and Bassett 1984).
Ct	for curved pod tip shape; ct for straight pod tip (Al-Muktar and Coyne 1981).
ctv-1 ctv-2	confer resistance to beet curly top virus (Schultz and Dean 1947); symbol proposed by Provvidenti (1987).
cyv (by-3)	confers high level resistance to clover yellow vein virus, formerly known as the severe, necrotic, or pod-distorting strain of bean yellow mosaic virus (Provvidenti and Schroeder 1973; Tu 1983); symbol proposed by Provvidenti (1987).
D (Can, Ins)	color gene with basic factors (Feenstra 1960; Kooiman 1920; Prakken 1934; Tjebbes and Kooiman 1922b); has a dark hilum ring (Prakken 1940-41). According to Lamprecht (1960) this D is the equivalent of his B.
Da	straight pod (Lamprecht 1932b). 直荚基因
Db	polymeric with Da for straight pod (Lamprecht 1932b, 1947b). [Polymeric genes have identical functions (expression) but different loci].
def	defectus: the action of G is counteracted by def/def such that C J G b v has only partly developed yellow brown color at the ventral side and on the dorsal side pale greenish yellow color in an irregular area of variable size; in C J G B v the def action changes mineral brown to a more greenish brown, a suppressing action on G (Prakken 1972b).
dgs (gl, le)	dark green savoy leaf mutant (Frazier and Davis 1966b; Nagata and Bassett 1984). According to Nagata and Bassett (1984), dgs is synonymous with the wrinkled leaf mutant of Moh (1968) and the gl (glossy) of Motto et al. (1979); also synonymous with the le (leathery leaf) of Van Rheenen et al. (1984).
dia	diamond leaf mutant (Nagata and Bassett 1984). Leaflets are angular, slightly chlorotic, thick, and reduced in area.
Diap-1	structural gene for diaphorase enzyme (Weeden and Liang 1985).
Diap-2	structural gene for diaphorase enzyme (Sprecher 1988).
diff	diffundere (Latin): with exp gives completely colored testa except for one end of the seed; diff with Bip Arc gives maximus phenotype, with bip Arc gives major phenotype; extends seed coat color in partly colored seeds (Lamprecht 1940b).
dis	dispares (Latin): mottled or striped flower of scarlet runner bean (Lamprecht 1951c).
Dl-1 Dl-2 (DL1 DL2)	complementary genes for dosage-dependent lethality and developmental abnormality; Dl Dl Dl2 Dl2 is lethal, Dl dl Dl2 Dl2 and Dl Dl Dl2 dl2 are sublethal, Dl dl Dl2 dl2 is temperature dependent abnormal,

	and Dl Dl dl2 dl2, dl dl Dl2 Dl2, Dl dl dl2 dl2, dl dl Dl2 dl2, and dl dl dl2 dl2 are normal; Dl inhibits root development and Dl2 inhibits shoot development (Shii et al. 1980).
do	dwarf out-crossing mutant (Nagata and Bassett 1984). Out-crossing rates up to 56% are observed due to delayed pollen dehiscence (Nagata and Bassett 1985). 雜交基因
ds (te)	dwarf seed: produces small seeds and short pods with deep constrictions between the seeds; cross pollination with Ds gives normal size seeds and pods on ds/ds plants, breaking the usual dominance of maternal genotype over embryo genotype for seed size development (Bassett 1982); the xenia effect was first described by Tschermak (1931) and the trait was named tenuis (Latin) for "narrow" pod by Lamprecht (1961a).
dt-1a dt-2a	daylength temperature: produce early, day-length neutral flowering with complex temperature interactions (Massaya 1978). 日長中性
dt-1b dt-2b	daylength temperature: control flowering response to short days with complex temperature interactions; dt-2b causes increased production of branches (Massaya 1978).
dw-1 dw-2	duplicate genes causing dwarf plant (Nakayama 1957). 矮性基因
Ea Eb	polymeric genes for "flat" pod, elliptical in cross-section vs. ea eb round pod (Lamprecht 1932b, 1947b; Tschermak 1916). 莢形
ers (restr)	erasure: with t and other pattern genes for partly colored seeds ers blocks color expression only in color zones (trout series) beyond those close to the hilum (Bassett and Blom 1991) in a manner similar to the e of Tschermak (1912) and the restr of Prakken (1972b).
ers-2	erasure: with t ers and other pattern genes for partly colored seeds ers-2 blocks color expression in color zones (soldier series) close to the hilum, resulting in a pure white seed coat (Bassett and Blom 1991).
Est-1	structural gene for most anodal esterase enzyme (Weeden and Liang 1985).
Est-2	structural gene for second most anodal esterase enzyme (Weeden and Liang 1985).
exp	expandere (Latin): with diff gives solid color to seed coat except for one end of the seed, giving minimus and minor phenotypes (Lamprecht 1940b).
F	confers resistance to the F strain of anthracnose (McRostie 1919). 炭疽病
Fa	basic gene for pod membrane (Lamprecht 1932b).
fast	fastigate shape of seed (Lamprecht 1934a).
Fb Fc	supplementary genes for pod membrane (Lamprecht 1932b).
fa fb fc	weak pod membrane; pod may be constricted (Lamprecht 1932b); may give 9:7, 15:1, or 63:1 ratios (Lamprecht 1932b, 1947b).
Fcr, Fcr-2	with t P give flower color restoration by complementary dominant gene action, i.e., changing white flowers to the color provided by the V locus (Bassett 1993b).
fd	delayed flowering response under long days (Coyne 1970).
Fe-1 Fe-2	Ferrum (Latin): complementary dominant genes controlling resistance to leaf chlorosis due to iron deficiency in plants grown on calcareous soils (Coyne et al. 1982; Zaiter et al. 1987).
Fin (in)	Finitus (Latin): indeterminate vs. fin determinate plant growth (Lamprecht 1935b; Rudorf 1958); long vs. short internode; later vs. earlier flowering. 節間長短及花期
Fop-1	confers resistance to the Brazilian race of Fusarium oxysporum f. sp. phaseoli (Ribeiro and Hagedorn 1979).
Fop-2	confers resistance to the U.S. race of Fusarium oxysporum f. sp. phaseoli (Ribeiro and Hagedorn 1979).
Fr	a fertility restoring gene (Mackenzie and Bassett 1987) for the cytoplasmic male sterility source derived from CIAT accession line G08063 (Bassett and Shuh 1982). Restoration is partial in F1>, complete and irreversible in fertile F2> segregants, i.e., the gene alters the mitochondrial DNA, deleting a fragment of

	at least 25 kilobases in restored plants (Mackenzie et al. 1988; Mackenzie and Chase 1990).
Fr-2	a fertility restoring gene that is derived from CIAT accession line G08063 and that restores fertility without deleting the same mitochondrial DNA fragment affected by Fr (Mackenzie 1991).
G (Flav, Ca, Och)	with P grayish white (Speckweiss) testa; changes chamois to yellow-brown (bister); gives its color in various combinations to the hilum ring (Lamprecht 1932a, 1933, 1936, 1939; Sirks 1922). Used similarly by Prakken (1934, 1940-41) except that he believes it gives color to the caruncula stripe instead of the hilum ring. The yellow-brown factor. The equivalent of C of Shaw and Norton (1918). Prakken (1970) believed that Flav, Ca, and Och are synonyms for G.
Ga	gametophyte factor, which achieves complete selection for pollen carrying Ga, i.e., no pollen carrying ga achieves fertilization (Bassett et al. 1990). 花粉輸送基因
gas	gamete-sterile: causes both male and female sterility (Lamprecht 1952b). 不稔基因
glb	glossy bronzing leaf mutant (Bassett 1992c).
Gpi-c1	structural gene for glucose phosphate isomerase enzyme, i.e., the more anodal of the two cytosolic isozymes (Weeden 1986).
Gr	in the presence of ih, produces green dry pod color; in the presence of Ih, produces tan dry pod color; gr in the presence of ih or Ih, produces tan dry pod color (Honma et al. 1968).
Hbl (LHB-1)	controls expression of halo blight tolerance in leaves (Hill et al. 1972).
Hbnc (SCHB-1)	controls expression of halo blight tolerance resulting in nonsystemic chlorosis of leaves (Hill et al. 1972).
Hbp (PDHB-1)	controls expression of halo blight tolerance in pods (Hill et al. 1972).
hmb	controls expression of sensitivity to the herbicide metobromuron, where Hmb expresses metobromuron insensitivity (Park and Hamill 1993).
Hss	hypersensitivity soybean: confers a rapid lethal necrotic response to soybean mosaic virus (SMV) that is not temperature sensitive (Kyle and Provvidenti 1993).
Hsw	hypersensitivity watermelon: confers temperature sensitive resistance (lethal hypersensitivity) to watermelon mosaic virus 2. Very tightly linked, if not identical, to the I gene for bean common mosaic virus (Kyle and Provvidenti 1987).
Ht-1 Ht-2 (L-1 L-2)	genes of equal value for height of plant (Norton 1915). They also increase length of seed (Frets 1951).
I	confers temperature sensitive resistance to bean common mosaic virus. Tightly linked, if not identical, to Bcm, Cam, Hsw, and Hss (Ali 1950; Kyle et al. 1986; Kyle and Provvidenti 1993). The I gene (or the complex I region) conditions resistance and/or lethal necrosis to a set of nine potyviruses, BCMV, WMV, BlCMV, CAbMV, AzMV, ThPV, SMV, PWV-K, and ZYMV (Fisher and Kyle 1994).
Ia Ib	parchmented vs. ia tender pod (Lamprecht 1947b). Flat or deep (elliptical cross-section) vs. round pod (Lamprecht 1932b, 1947b, 1961a).
ian-1 ian-2 (ia)	indehiscent anther where the heterozygote produces partial indehiscence (Wyatt 1984); currently, two unlinked mimic genes can produce indehiscent anther (Wyatt, personal communication).
lbd	leaf-bleaching dwarf mutant (Bassett 1992c).
ico	internodia contracta (Latin): internodes 4-7 cm long instead of the normal 8-11 cm (Lamprecht 1961b). 節間
Igr (Ih)	inhibits the action of Gr, conferring tan dry pod color in the presence of Gr or gr (Honma et al. 1968).
ilo	inflorescentia longa (Latin): 5-7 long internodes in the inflorescence instead of the usual 2-3 (Lamprecht 1961b).
ip	inhibits the action of P (Nakayama 1958).
iter	iteratus-ramifera (Latin): with ram produces triple branched inflorescence (Lamprecht 1935b, 1935d).

	開花節位
iv	inhibits the action of V with respect to the color of the hypocotyl and testa; is lethal with vlae (Nakayama 1958).
iw	immature white seed coat in the presence of p (Baggett and Kean 1984).
J (Sh)	Joker: with P gives light yellow-brown or pale ochraceous buff testa (Lamprecht 1933), Rohseidengelb testa (Lamprecht 1939), raw silk testa (Lamprecht 1932a, 1951a) and the same color to the hilum ring (Lamprecht 1951a; Prakken 1934). The equivalent of the Sh of Prakken (1934). Similar in effect to Ins (Lamprecht 1936) and Asp (Lamprecht 1940c). It causes seed coats to glisten and to darken with age (Lamprecht 1939); j produces dull (mat) seed coat (Prakken 1940-41).
Ke	potassium utilization efficiency (Shea et al. 1967).
L	Löschungsfaktor (German): inhibits (or limits) the partial coloring of the testa; with t producing an entirely white testa (Schreiber 1934). L and l combine with Z and z to produce several color patterns (Schreiber 1940).
la	Lamm: with cry gives long internode; la with Fin is dwarf; la cry fin is slender (Lamprecht 1947b).
Lan	lanceolate leaf mutant; Lan Lan is usually a zygotic lethal, and survivors are dwarfs that do not flower; Lan lan segregates 2:1 (lanceolate to normal) in selfed progeny (Bassett 1981).
Ld	leaf distortion resembling phenoxy herbicide injury, with interveinal clearing, slight chlorosis, necrotic scarring of the midrib, altered leaf shape, and extra leaflets (Rabakoarihanta and Baggett 1983).
Lds (Ds)	Ld suppressor (Rabakoarihanta and Baggett 1983).
Lec	structural gene for the seed protein lectin or phytohemagglutinin (Osborn et al. 1986).
Li (L)	long vs. li short internodes (Lamprecht 1947b; Norton 1915).
lo	plants have a short inflorescence (Lamprecht 1958).
lr-1 lr-2	the double recessive genotype produces leaf rolling of trifoliolate leaves through the third or forth nodes, ending in stem and apical necrosis and death of the plant (Provvidenti and Schroeder 1969).
mar	margo: broad colored zone around hilum ring (Lamprecht 1933).
Me	structural gene for malic enzyme (Weeden 1984).
Mel (Me)	confers nematode resistance to Meloidogyne incognita (some isolates of race 1), M. Javanica, and M. arenaria (Omwega et al. 1990).
Mel-2 (Me-2)	confers nematode resistance to Meloidogyne incognita race 1 (isolates to which Mel is susceptible), race 2 and race 3, but is susceptible to M. javanica and M. arenaria (Omwega and Roberts 1992).
mel-3 (me-3)	confers temperature sensitive nematode resistance (resistant at 26 C but susceptible at 28 C) to the same species, races, and isolates as with Mel-2 (Omwega and Roberts 1992).
Mf	mancha na flor (Portuguese): brownish-violet blotch on the base of the standard flower petal (Vieira and Shands 1969).
mi, mia	micropilar stripe pattern (Lamprecht 1932c and 1934a); both 3:1 and 15:1 segregations were observed.
Mic (Mip)	micropyle inpunctata (Latin): small dots near the micropile (Lamprecht 1940c).
miv	minor intervallis (Latin): end of seed flattened and a short distance between funicles (Lamprecht 1952a).
Mrf	Mosaico rugoso del frijol (Portuguese): confers immunity to bean rugose mosaic virus (Machado and Pinchinat 1975).
Mrf 2	Mosaico rugoso del frijol (Portuguese): confers the localized lesion type of resistance to bean regose mosaic virus; the order of dominance in the allelic series is Mrf>Mrf 2>mrf (Machado and Pinchinat 1975).

mrf	mosaico rugoso del frijol (Portuguese): confers susceptibility (systemic infection) to bean rugose mosaic virus (Machado and Pinchinat 1975).
ms-1	an induced mutant for genic male sterility, where no pollen is produced but female fertility is unimpaired (Bassett and Silbernagel 1992).
Mue	structural gene for methylumbelliferyl esterase (Garrido et al. 1991).
mu mutator	locus that produces mutations of us to Us, thus giving normal green leaf sectors in yellow leaves due to us mu, where the ratio of normal to variegated plants is 15:1 (Coyne 1966).
Nag	structural gene for N-acetyl glucoseaminidase enzyme (Weeden 1986).
Nd-1 Nd-2 (D-1 D-2)	additively control the variation in node number on the main stem of determinate beans and additively control the number of days to flowering (Evans et al. 1975).
nie	an induced mutation for ineffective nodulation by Rhizobium (Park and Buttery 1994).
nnd (sym-1)	an induced mutation for non-nodulation by Rhizobium, i.e., lacking capacity for symbiosis (Pedalino et al. 1992).
nnd-2	an induced mutation for non-nodulation by Rhizobium (Park and Buttery 1994).
No	with V Sal and Am produces nopal red (light salmon with brownish tinge) flower color; no geranium to salmon red (Lamprecht 1948b, 1961a).
nts (nod)	nitrogen tolerant supernodulation: an induced mutation that permits abundant nodulation in the presence of high nitrogen (Park and Buttery 1989).
Nudus	See [c Nud].
ol	overlapping leaflets mutant (Bassett 1992c).
P	basic color gene (Emerson 1909a; North and Squibbs 1952; Prakken 1934; Schreiber 1934; Shaw and Norton 1918; Shull 1908; Skoog 1952). P without color genes is colorless as is p (Lamprecht 1939; Smith 1939). According to Feenstra (1960) P is the equivalent of the A of Tschermak (1912), of Kooiman (1920), and of Sirks (1922).
pgri (Gri, vpal)	griseoalbus (Latin): pgri with J B V produces grayish white (blubber white) seed coat without a hilum ring, giving the dominance order P>pgri>p (Bassett 1994b; Lamprecht 1936); pgri with J B V produces flowers with very pale lavender wing petals and two dots of violet on the upper edge (center) of an otherwise near white standard petal (Bassett 1992b); formerly a second basic color factor like P (Lamprecht 1936).
pa	pale green leaves (Smith 1934).
pc	persistant green pod color (Dean 1968).
pg (pa1)	pale-green foliage mutant (Wyatt 1981).
Pha	structural gene for the seed protein phaseolin (Osborn et al. 1986).
Pmv	confers incomplete dominance for resistance to peanut mottle virus (Provvidenti and Chirco 1987).
ppd (neu)	photoperiod-insensitive gene found in Redkloud with a syndrome of effects (Wallace et al. 1993); an allele-specific associated primer is now available for ppd (Gu et al. 1995); probably the same locus as Neu+ for short day vs. neu for day neutral flowering response to length of day of Rudorf (1958).
Pr	Preventing the "flowing out" of red color (Prakken 1972b and 1974); pr with pattern alleles at C and R allow the red color in the dark pattern color zones to "flow out" into the light pattern color areas, producing various light red hues such that the contrast between the dark and light pattern colors is very small; tightly linked to the C locus.
prc (pc)	progressive chlorosis mutant (Nagata and Bassett 1984); redesignated prc (Awuma and Bassett 1988).
Prx	structural gene for peroxidase enzyme, i.e., the most cathodal of the peroxidase isozymes (Weeden 1986).

punc	punctatus (Latin): causes dotting of the testa (Lamprecht 1940c).
ram	ramifera (Latin): branched inflorescence (Lamprecht 1935b).
Rbcs (rbcS)	small subunit of the rubisco enzyme (Weeden 1984).
rf-1	reclining foliage due to downward slanting petioles (Bassett 1976).
rf-2	reclining foliage mutant due to downward slanting petioles (Bassett and Awuma 1989).
rf-3	reclining foliage mutant due to downward slanting petioles (Bassett and Awuma 1989).
rfi (i)	reclining foliage inhibitor: recessive epistatic factor to rf-1 and rf-3 (Bassett 1976; Bassett and Awuma 1989).
Rfs (m)	reclining foliage suppressor: dominant suppressor of rf-1 (Bassett 1976).
Rk	red kidney: with P J pinkish buff seed coat (Gloyer 1928; Smith 1939); with J (Sh) chamois or cream testa (Smith and Madsen 1948).
rk	red kidney: with r for white seed gives a pink or red testa (Smith 1939); with J (Sh) gives testaceous (the buff of kidney bean) testa (Smith 1939, 1947); rk J (Sh) are dominant over red-brown but recessive to cream (Smith 1939; Smith and Madsen 1948); not effective with C but modifies J (Lamprecht 1961c).
rkd (lin)	dark red kidney: with J (Sh) red-brown or garnet-brown testa (Smith and Madsen 1948). Found in 'Dark Red Kidney'; with P T C, v or vlae, rkd always gives red veins in the wing petals, whether clear or faint (Prakken 1972a and b); in some genetic backgrounds the red veins are incompletely recessive (dominant ?), i.e., Rk/rkd gives very faint red veins (Prakken 1972b).
rn-1 rn-2 (r r)	together confer resistance to root-knot nematode, where 2-4 dominant alleles give susceptible reaction and 1 dominant allele gives intermediate resistance in a 11:4:1 ratio (Barrons 1940).
rnd	round leaf mutant with lateral leaflet tips rounded (Nagata and Bassett 1984).
Ro	with Pur (V) gives dark purple pod, with pur (v) gives rose pod color (Lamprecht 1951b); Lam-Sanchez and Vieira (1964) report Ro V gives dark purple pod and Ro v gives red pod; Okonkwo and Clayberg (1984) report Ro as a second locus, along with Prp, giving purple pods.
Sal	with P and Am salmon to geranium red flower color and a reddish tinge to the testa; with Aeq the effect is similar to V (Lamprecht 1948b); sal with P and Am give clear amaranth flower (Lamprecht 1961a).
sb	spindly branch mutant; the stems are thinner and more highly branched than normal (Awuma and Bassett 1988).
sbms	spindly branch male sterile mutant; allelic with sb; anthers are atrophied and produce no viable pollen, but there is no loss of female fertility (Bassett 1991a)
sb-2	spindly branch mutant; the stems are thinner and more highly branched than normal (Bassett 1990).
sb-3	spindly branch mutant; the stems are thinner and more highly branched than normal (Bassett 1990).
sil	silver colored leaves and severe plant stunting under high intensity light (Frazier and Davis 1966a; Nagata and Bassett 1984).
Skdh	structural gene for shikimate dehydrogenase enzyme (Weeden 1984).
sl	stipelless lanceolate leaf mutant (Nagata and Bassett 1984) gives a lanceolate leaf form with loss of stipels from the terminal leaflet.
Smv	confers incompletely dominant resistance to soybean mosaic virus (Provvidenti et al. 1982).
St	stringless pod; st gives a complete string (Prakken 1934); has modifiers. 無筋絲基因
Sur	Sursum versus (Latin): causes leaves and petioles to point downward (Lamprecht 1937) with pulvinule rotated 180 . See Xsu.
sw-1 sw-2	the double recessive genotype produces seedling wilt (Provvidenti and Schroeder 1969), i.e., epinasty

	of primary leaves, necrosis of terminal bud, and death of the plant in primary leaf stage.
T	self-colored seed coat and colored flowers (Emerson 1909a; Lamprecht 1934b; Shaw and Norton 1918).
t (z-1)	a seed coat pattern gene, required for all partly colored seed coat patterns, gives white flowers (Schreiber 1934; Shaw and Norton 1918) and green cotyledons and hypocotyls (Prakken, 1972); functions with Z and z (Lamprecht 1934b; Sax 1923; Shaw and Norton 1918); functions with Z and L (Schreiber 1940).
Th-1 Th-2	genes of equal value for seed thickness (Frets 1951).
Tm	confers immunity to tobacco mosaic virus (Thompson et al. 1952).
To	cell wall fiber (Prakken 1934).
Tor (T)	torquere (Latin): twining habit vs. tor non-twining (Norton 1915; Lamprecht 1947b); confers phytochrome-controlled climbing habit in indeterminate bush bean types (Kretchner et al. 1961; Kretchmer and Wallace 1978).
Tr	testa rupture (Dickson 1969); an incompletely dominant gene with 25-30% penetrance.
tri	tricotyledonae (Latin): produces three cotyledons (Lamprecht 1961b) with 40-50% penetrance.
trv	confers resistance to tobacco ringspot virus (Tu 1983); symbol proposed by Provvidenti (1987).
Ts	temperature-dependant string formation (Drijfhout 1978a); St ts is without string, St Ts gives incomplete string, and st Ts and st ts have complete string.
tw	twisted pod character produces pod rotation that is highly variable, from slight to more than 360 degrees in snap bean germplasm (Baggett and Kean 1995).
uni	unifoliata (Latin): unifoliate leaves; complete sterility (Lamprecht 1935c); this material is lost, and no allelism tests were made with other unifoliate mutants before uni-1 was lost.
Uni-2	a dominant mutation for unifoliate true leaves (Garrido et al. 1991).
uninde	induced mutation with unifoliate leaves with node dependent expression; partial fertility and shows reversion to normal leaflet number at higher nodes (Myers and Bassett 1993).
uninie	unifoliate leaves with node independent expression (natural mutant); completely female sterile but male- fertile and shows consistently strong expression of the unifoliate trait at higher nodes (Myers and Bassett 1993).
Ur-1	a rust [Uromyces appendiculatus (Pers.) Unger var. appendiculatus] resistance gene discovered by Ballantyne (1978) and found in the Mesoamerican source B1627.
Ur-2	a rust resistance gene discovered by Ballantyne (1978) and found in the Mesoamerican source B2090.
Ur-22	a rust resistance allele at the Ur-2 locus discovered by Ballantyne (1978) and found in the Mesoamerican source B2055.
Ur-3 (Ur-3, Ur-4)	a rust resistance gene discovered by Ballantyne (1978) (see also Ballantyne and McIntosh 1977) and found in the Mesoamerican sources Aurora, Mex 235, and Nep-2; linked to the RAPD marker OK14620.
Ur-32	a rust resistance allele at the Ur-3 locus discovered by Stavely (1990) and found in the Mesoamerican source PI 181996; linked to the RAPD markers OAC20490 and OAE19890.
Ur-4 (Up-2, Ur-C)	a rust resistance gene originally discovered by Ballantyne (1978) as Ur-C and rediscovered by Christ & Groth (1982) as Up-2; found in the Andean source Early Gallatin; linked to the RAPD marker OA141100.
Ur-5 (B-190)	a block of eight tightly linked dominant genes (Ur-5A through Ur-5H) for rust resistance found by Stavely (1984) and present in the Mesoamerican rust differential variety Mexico 309; linked to the RAPD markers OF10970 and OI19460.
Ur-6 (Ura ,	a rust resistance gene originally discovered by Ballantyne (1978) as Ur-G and rediscovered by Grafton

Ur-G)	et al. (1985) as Ura; an Andean gene present in Olathe and the rust differential variety Golden Gate Wax. Allelism test data is limited for this gene.
Ur-7 (RB11)	a rust resistance gene discovered by Augustin et al. (1972) and found in the Mesoamerican variety GN 1140; tentatively redesignated Ur-7.
Ur-8 (Up-1)	a rust resistance gene discovered by Christ & Groth (1982) and found in the Andean variety U.S. #3; tentatively redesignated Ur-8.
Ur-9 (Urp)	a rust resistance gene discovered by Finke el al. (1986) and found in the Andean variety Pompadour Checa; tentatively redesignated Ur-9.
us	unstable gene that mutates to Us in presence of mu to produce green leaf sectors in a yellow leaf background due to us mu, resulting in variegation (Coyne 1966).
V (Bl)	with P produces pale glaucescens testa without a hilum ring (Lamprecht 1939). The color ranges from pale violet to black depending upon other color genes present (Lamprecht 1932a; Prakken 1934). According to Prakken (1972a) the Bl of Smith is the same as V. Bl with the basic color factors produces purple-violet seed coat (Smith 1939; Tjebbes and Kooiman 1921, 1922a), changes oxblood red to purple (Smith 1939), and is responsible for bluish tints to plant colors (Tjebbes and Kooiman 1921). bl with appropriate genes produces red seed coat (Tjebbes and Kooiman 1922a). According to Feenstra (1960) V is the equivalent of the B of Shull (1908) and of Tschermak (1912), the F of Kooiman (1931), the G of Shaw and Norton (1918), and the Z of Sirks (1922).
vlae (Cor)	with T P gives laelia (pink) flowers and rose stem (Lamprecht 1935e); with P C J G B produces mineral brown seed coats with the black corona character (Bassett 1995a). The Cor locus of Lamprecht (1934a, 1936) is a synonym.
v	white flowers and with P C J G B produces mineral brown seed coat (Lamprecht 1935e).
var	variegated: environment-sensitive gene, in combination with mu and us produces yellow lethal plants in a ratio of 63 normal:1 variegated (Coyne 1966).
vi (virf)	virescent foliage mutant (Graften et al. 1983).
wb	with T P V gives flowers with a white banner petal and wings of pale violet; the gene is from the P. coccineus PI 273666 (Bassett 1993a).
Wmv	confers resistance to watermelon mosaic virus 2 (Provvidenti 1974; Kyle and Provvidenti 1987).
Xsu	ex parte sursum versus: causes the leaves and petals to point downward (Lamprecht 1961b); effect is similar to Sur, but pulvinule is rotated only 90 .
y	with Arg produces yellow wax pod; with arg the pod is white; Y with Arg produces green pod; Y with arg gives a greenish gray (silvery) pod (Currence 1931; Lamprecht 1947b).
Z	zonal seed coat patterns: affects the size of eye pattern on seed coat (Smith 1939; Tschermak 1912); enters into sellatus and piebald patterns (Lamprecht 1934b); with L and t accounts for seven seed coat patterns (Schreiber 1940).

臺灣育種成果及未來展望

臺灣因菜豆栽培之歷史不長，所以在品種之研究上相當貧乏，早期均為引種後直接推廣，其後則因自行採種而流傳成為地方品系，且因經濟結構改變，食用乾豆之花豆、大紅豆、米豆等栽培逐漸減少，因此可供育種之種源並不多。目前流傳的品系，以小粒白莢俗稱敏豆之品系為多，分別為白仁白花泛稱白雪者及黑仁紅花統稱泰國紅骨兩大系統。此兩者均為蔓性品系，矮性品種已鮮有栽培，僅登記有農友早生及高雄三號兩個品種。而俗稱醜豆者則為早期 Kentucky Wonder 褐仁 Kidney Bean 系統，再者為農友綠衣 Marrow Bean 白仁品種。民間則零星栽培有俗稱鵠豆、虎豆、花梨豆之 Pinto Bean，種源可謂極為匱乏。

近年，筆者陸續由中南美洲廣泛引進各類品系，育成 St 顯性基因控制之無筋絲品種，台中二號-蔓性、寬扁莢、Marrow Bean 白仁品種，莢寬 2 公分、莢長 24 公分、極早生 40 天可採收。台中三號-蔓性、圓莢、Snap Bean 白仁品種，莢寬 1 公分、莢長 18 公分、早生 53 天可採收。台中四號-蔓性、圓莢、Snap Bean 白仁品種，莢寬 1 公分、莢長 20 公分、莢色濃綠、早生 50 天可採收。早期台中場育成之台中一號為由波多黎各引入抗銹病品系 15-RR-BK 與日本黑仁衣笠輪迴雜交育成者，但因莢形短、莢硬，且因銹病 Race 變異極快，抗病性已有退化，因此栽培並不廣泛。

為因應臺灣農業結構之改變，將來育種方向應朝大莢易採收、早生、收穫期長、無筋絲、品質佳、食味評價高等方向發展。臺灣菜豆發展至今大都以集中在特定產區如南投魚池、埔里、信義，嘉義阿里山、中埔，高雄三民、甲仙，屏東里港、九如、鹽埔。由於產地集中，某些地區幾乎形成週年栽培，因此，病蟲害發生嚴重，如 Bacterial brown spot(*Pseudomonas syringae* pv. *syringae* van Hall)、Bacterial wilt(*Curtobacterium flaccumfaciens* pv. *flaccumfaciens* (Hedges) Collins & Jones、Common bacterial blight *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye、Fuscous blight *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye、Halo blight *Pseudomonas syringae* pv. *phaseolicola* (Burkholder) Young et al.、Wildfire *Pseudomonas syringae* pv. *tabaci* (Wolf & Foster) Young et al.；Alternaria leaf and pod spot *Alternaria alternata* (Fr.:Fr.) Keissl.、Angular leaf spot *Phaeoisariopsis griseola* (Sacc.) Ferraris、Anthracnose *Colletotrichum lindemuthianum* (Sacc. & Magnus) Lams.-Scrib.、Aphanomyces root and hypocotyl rot *Aphanomyces euteiches* Drechs f. sp. *phaseoli* W. F. Pfender & D. J. Hagedorn、Black root rot *Thielaviopsis basicola* (Berk. & Broome) Ferraris、Damping-off and stem rot, Rhizoctonia *Rhizoctonia solani* Kühn *Thanatephorus cucumeris* (A. B. Frank) Donk [teleomorph]、Damping-off, Pythium *Pythium* spp.、Diaporthe pod blight *Diaporthe phaseolorum* (Cooke *et* Ellis) Sacc.、Downy mildew *Phytophthora nicotianae* Breda de Haan var. *parasitica* (Dastur) G. M. Waterhouse、Downy mildew (of lima) *Phytophthora phaseoli* Thaxt.、Fusarium root rot *Fusarium solani* (Mart.) Sacc. f. sp. *phaseoli* (Burkholder) W. C. Snyder & H. N. Hans.、Fusarium yellows (Fusarium wilt) *Fusarium oxysporum* Schlechtend.:Fr. f. sp. *Phaseoli* J. B. Kendrick & W. C. Snyder、Pythium diseases、Russet *Plectosporium tabacinum* (Van Beyma) M. E. Palm, W. Gams & Nirenberg、Rust *Uromyces appendiculatus* (Pers.: Pers.) Unger、Scab *Elsinoe phaseoli* Jenk.、*Sphaceloma* species [anamorph]、Southern blight *Sclerotium rolfsii* Sacc. *Athelia rolfsii* (Curzi) Tu & Kimbrough [teleomorph]、Soybean rust *Phakopsora pachyrhizi* Sydow、Speckle disease *Stagonosporopsis hortensis* (Sacc. & Malbr.) Petr.、Stem rot Unidentified basidiomycete、Web blight *Rhizoctonia solani* Kühn、*Thanatephorus cucumeris* (Frank) Donk. [anamorph]、White mold (Sclerotinia rot)

Sclerotinia sclerotiorum (Lib.) de Bary；以及線蟲 Nematodes, Parasitic、病毒病 Viral Diseases，都值得我們注意加強研究。

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The Achievement of Common Bean Breeding and Aspect in The Future.

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ABSTRACT

The beans crop is one of the global important cereal crops; the kidney bean is regarded as the main supplier among them in the universe beans. Its nutritive is very high and include the abundant protein richly. Before animal husbandry was developed in the already developing country, it is a main source of protein and now it is called with poor man protein in jokily. The culture of kidney bean is only the surplus tender pod culture for vegetables at present in Taiwan, but in America, Europe and Japan regard as equally important in dry bean and fresh bean product. So in Taiwan we only have a few research and breeding study on common bean. But common bean is still as a very important consumption vegetable in Taiwan. We pay attention to nutritive value of the common bean and offering to health gradually in the world in recent years. So is growing vigorously on the application study of function food and healthy food. In the saturation on global warming and environmental protection, common beans are recommended supplying for the main protein.

Key Word：Common Bean、Breeding、Nutrition