Development and Evaluation of NSIC-Approved Improved Varieties of Bush and Pole Snap Beans (*Phaseolus vulgaris* L.) for Commercialization in Northern Philippines

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ABSTRACT

Snap bean is an important vegetable legume in the Northern Philippines. To meet the demands of snap bean farmers and consumers for better commercial varieties, the snap bean breeding program team has continued developing and identifying at the BSU-IPB Highland Crops Research Station (HCRS), accessions and advanced breeding lines as promising varieties not only for the highlands but also for the mid-elevation areas and lowlands. These improved materials were evaluated to identify new improved varieties that are high-yielding, have better resistance to major pests and diseases and with good pod qualities. This resulted in the selection and identification of nine pole snap bean and seven bush snap bean improved varieties with higher yield and better horticultural characteristics than the traditional commercial varieties. All of them were evaluated further in multi-location field trials from 2005-2014 that led to official approval and registration of seven improved varieties of pole snap bean and three new improved varieties of bush snap bean for regional commercialization by the Department of Agriculture-Bureau of Plant Industry-National Seed Industry Council (DA-BPI-NSIC) in November 2008(2), 2009(3), 2014(4) and 2015(1). They were NSIC 2008 PSnBn 1 "Kapangan", NSIC 2008 PSnBn 2 "Mabunga", NSIC 2009 PSnBn 3 "Tublay, NSIC 2014 PSnBn 4 "Itogon", NSIC 2014 PSnBn 5 "Kibungan", NSIC2014 PSnBn 6 "Tuba", and NSIC 2014 PSnBn 7 "Wangal" pole snap bean varieties; and NSIC2009BSnBn 1 "Sablan", NSIC 2009 BSnBn 2 "Bokod" and 2015 BSnBn "Cali" bush snap bean. A Certificate of Registration for commercialization of each variety in the Northern Philippine Highland was given.

Keywords: *Phaseolus vulgaris, germplasm collection, characterization and evaluation, pedigree breeding method, multi-location field trials, new improved varieties*

INTRODUCTION

Snap bean (*Phaseolus vulgaris*) is one of the most important legumes grown in the Philippines. It is locally known as 'habitchuelas' or "Baguio bean", a semi-temperate crop that belongs to family Leguminosae. It is commonly grown in the northern highlands of Benguet, Mountain Province and Nueva Vizcaya, and other mid-elevation areas in the country like Bukidnon, Quezon and Laguna. In 2013, snap bean was planted in around 3,502 hectares of land with volume of production estimated at 15,413 metric tons (MT) (BAS, 2014).

Snap bean is one of the common sources of plant protein in human diets. It is also considered a versatile nutritious specialty vegetable crop not only in the Cordillera Administrative Region (CAR) but in the entire country as well. Snap bean is commonly grown in the Northern Philippine highlands as vegetable and field legumes. In Benguet, snap bean is mainly grown as vegetable legume. There are two types of snap bean commercially grown in the province of Benguet: the vine or pole snap bean type, and the bush or sitting snap bean type. It is a priority crop in the country belonging to the top seven vegetable crops produced in CAR (PCARRD, 2005 and DA-BAS, 2005). It is a vegetable crop whose open-pollinated varieties (OPVs) could be seed produced locally. From 2004 to 2009, there was

a decrease in areas planted with snap bean from 1,798.23 ha to 817.94 ha. Consequently, the volume of production was also reduced from 13,098.70 MT to 6,594.58 MT fresh pods with an average recorded yield of 7.59-8.38 MT/ha. This could be due to the decreasing number of farmers engaged in growing snap bean in the province from 9,903 in 2004 to 5,088 in 2009. (Commodity Production Profile, Benguet Province, 2004-2009). Apparently, snap bean growers were observed to depend mainly on traditional cultivars due to lack of improved varieties. Farmers commonly grow traditional varieties of snap bean like *Alno, Patig* and *Burik*, which are either low-yielding or susceptible to bean rust or with poor pod quality. Their pods are stringy and easily become fibrous with very prominent seed locules that make them suitable for dry bean production as field legume. Since snap bean is a more expensive vegetable legume than other beans in the country, the development of new improved snap bean varieties with high yield, better resistance to major pests and diseases and good pod qualities should be given special attention to meet the dynamic demands of farmers and consumers.

Snap bean growers keep on demanding new improved varieties of both bush and pole snap beans. In an effort to meet this, the joint breeding team of Benguet State University (BSU) and the Institute of Plant Breeding of the University of the Philippines Los Banos, College of Agriculture, Crop Science Cluster (IPB-UPLB-CA-CSC) has continuously developed and identified accessions and advanced breeding lines as promising varieties or potential parents or both not only for the highlands but also for the mid-elevation areas and lowlands at the BSU-IPB Highland Crops Research Station (HCRS). These materials need further evaluation to identify new improved varieties that are high-yielding, with greater resistance to major pests and diseases and with good pod qualities (Tandang, 2007).

REVIEW OF LITERATURE

Varietal evaluation is a stage in plant breeding programs that provides comparison of promising lines or entries developed by the breeder with the local check, usually a commercial variety of the crop. It is only through varietal evaluation that the breeder sees better performance of developed lines or selected entries in terms of growth, yield and quality including resistance to pests and diseases than the existing commercial variety. To determine the true potential of the selected promising varieties of crops, testing must be done not only at the breeding station but also in other locations where the crop is commercially grown.

Tandang *et al.* (1990) recommended *Blue Lake*, BSU # 1, *Patig*, *Burik* and *Alno* for commercial production in the Cordillera Administrative Region and Regions I, II, IV and X. Siloy (1999) reported that *Alno* performed better than *Blue Lake* in terms of pod length, pod diameter and pod yield of secondary growth. In 2005, Neyney evaluated the pod setting and yield potential of six commonly grown pole snap bean varieties in La Trinidad. The study revealed that the six varieties significantly differed in their yield potential. *Violeta* and *Taichung* performed significantly better than the others in terms of number of flower clusters per plant, flowers per cluster, number of pods per plant and number and weight of marketable fresh pods and total pod yields. Thus, he recommended *Violeta* and *Taichung* for commercial production under La Trinidad, Benguet conditions. In 2007, Mulchino evaluated the potential of pole snap bean in Gusaran, Kabayan, Benguet. The study revealed that the six varieties of pole snap bean significantly differed in their yield potential. *Violeta* and *Blue Lake* performed significantly better than the other varieties in terms of pod cluster per plant, pods per plant and number and weight of marketable pods. The highest yield and highest Return on Cash Expense (ROCE) was obtained from *Blue Lake* and *Taichung*. In 2008, Tandang *et al.* again reported some promising varieties or potential parents of snap bean not only for the highlands, but also for the mid- and low elevation areas. Tupeng found out in 2011 that among the five varieties of pole snap beans grown under organic systems of production in La Trinidad, Benguet, *Mabunga* yielded the highest fresh pods at 6.27 kg/5m^2 plot. This was followed by B21 and CPV 60 with 5.20 and 5.08 kg/5m^2 fresh pod yield, respectively.

In 2006, Suyam evaluated the responses of six bush snap beans to mulching. Hab 63 registered the highest number of pods per plant and pod clusters per plant. BBL 274 and "Torrent" had the longest and widest pods and produced the highest number and heaviest marketable pods per plot, total yield per plot and computed yield per hectare. Moreover, in the study of Tipayno (2006) on agronomic characters of five bush snap bean varieties, "Torrent" was significantly highest in terms of number of flowers per cluster, number of pods per cluster, per plant, widest pod length and pod width. It also exhibited the highest ROCE of 25.87%.

In 2010, Gapad conducted a study on agro-morphological evaluation and correlation analysis of bush snap bean germplasm collection of BSU-IPB HCRS, Benguet State University, La Trinidad, Benguet. Significant differences were noted among the eight bush snap bean entries evaluated in terms of days from emergence to last flowering. "Green Crop", BBL 274, "Landmark" and "Contender" were the best entries in terms of pod length, stem diameter, number of branches and marketable fresh pod yield. Acyangan in 2010 also evaluated the agronomic characters of five promising varieties of bush snap beans for organic production under La Trinidad, Benguet conditions. All the five promising varieties namely "Torrent", "Bokod", "Sablan", "Green Crop" and "Hab 19" had comparable number of flowers and pod cluster per plant, pod width, and plant height before last harvest, number and weight of marketable fresh pods per plot, weight of non-marketable pod per plot, total fresh pod yield per plot and computed yield per hectare. The five varieties of bush snap beans exhibited good growth and development under organic production system in La Trinidad, Benguet. "Bokod", "Sablan" and "Hab 19" had the best agronomic characters, return on cash expenses and acceptability rating.

Objectives

The project was undertaken to develop new locally-bred varieties from selected improved varieties of bush and pole snap beans with higher yield and better agro-morphological characteristics than the traditional commercial varieties, and to evaluate promising varieties of snap beans developed and selected at BSU-IPB HCRS.

METHODOLOGY Germplasm

collection and selection

Germplasm collection of pole and bush snap beans was done by requesting different varieties from local and foreign sources like the private seed companies in the United States, Germany, Japan, Taiwan and Turkey namely: Abbot and Cobb Inc, Snow Brand Seed Company Limited, W. Atlee Burpee, Ferry Morse, Mayford Seed Limited, Thompson Morgan Seed Co, Hodder and Jolly Limited, CIAT in Cali, Columbia, USDA in America, and others. A total of 77 accessions of pole snap bean, and 28 accessions of bush snap bean were collected from 1985 to 1986. They were entered in the observational trial at the BSU-IPB Highland Crops Research Station (HCRS) for one regular growing season in 1986-1987 dry season where adaptability was observed and characterization and selection were done (Figure 1).

At the HCRS, the snap bean breeding program considered the specific characteristics and description of desirable varieties as follows: for growth habit, it must be climbing and bush types for high, medium and low elevation areas, and bush type for monocropping and intercropping; two or more pods per cluster; 10-15 harvesting or priming; pods harvestable within 40-70 days after planting considered to be early to medium maturing. They should also be highly prolific, yielding more than 5t/ha marketable yield; stringless pods without suture string, straight slender pods with 0.80-1.00cm diameter, smooth, light green to dark green pods; moderately to highly resistant to bean fly, pod borer, leaf miner, *Fusarium* wilt, *Ascochyta* leaf spot and bean rust; and moderately to highly acceptable to stakeholders with longer post-harvest life than the commercial traditional varieties (Tandang, 2007). Records of selections were carefully kept in order to have complete knowledge of their lineage and characters. Promising varieties and potential parents were

identified and selected based on earliness, prolificacy, and resistance to major pests and diseases. Potential parents were used in the succeeding hybridization activities. Together with selected promising varieties, they were subjected to a series of on-station trials such as preliminary yield trial for one year and replicated yield trials for at least two years by batch or by set of entries. All these activities resulted in identification of top performing pole snap bean varieties such as "Blue Lake", "Burik", "Patig" and "BSU Selection 1"; bush snap bean varieties like "BBL274", "Land Mark". "Contender" and "Green Crop" in 2002, were registered to the IPB's Genetic Resources Registration Office (GRRO) for release as stop gap varieties for commercial production (Tandang, 2007).

Varietal Development

The breeding scheme followed in the snap bean improvement program at BSU-IPB HCRS is summarized in Figure 1. Several potential parents identified from the germplasm collection were involved in the hybridization program including existing commercial varieties through pedigree method of breeding. This is the most common method of breeding self-pollinated crops like snap beans. Characterization and selection were done among F_2 to F_6 segregating populations of the vegetable legumes being developed. Records of selections were also carefully kept to have complete knowledge of their lineage and characters. In the F_7 generation, seeds of the best selections were bulk-produced to have sufficient planting materials for the succeeding series of yield testing. The series of yield testing from preliminary yield trial to advanced yield trials from 2002 -2005 at the HCRS resulted in nine promising varieties of pole snap bean such as "Blue Lake", "N2643", "B-21", "Hav-71", "Violeta", "Taichung", "CPV 60", "CPV 64" and "CPV 69"; and seven bush snap bean promising varieties namely, "Hab 19", "Hab 63", "Hab 323", "Green Crop", "Torrent", "Contender", and "Land Mark".

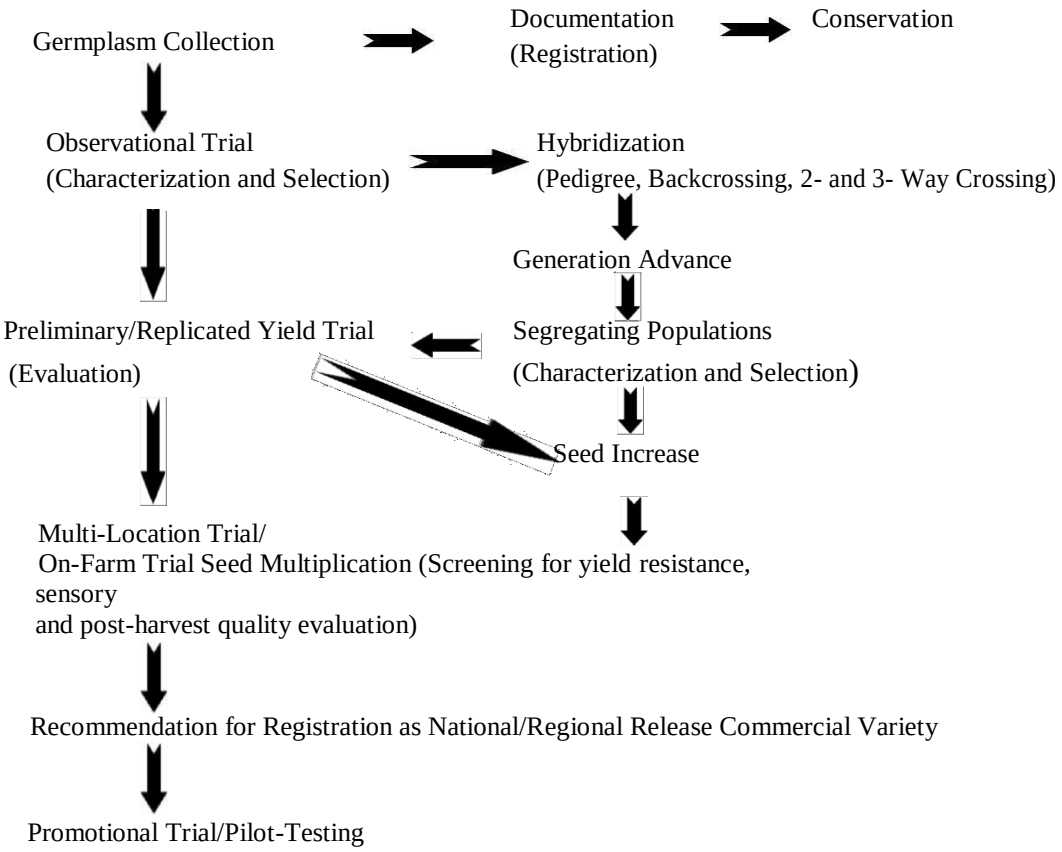

Figure 1. Generalized breeding scheme followed for varietal development and evaluation of snap beans at BSU-IPB HCRS.

Multi-Location/On-Farm Field Trials

Different sets of entries out of the nine promising varieties of pole snap bean and seven bush snap bean were tested through on-station replicated yield trials in 2002-2005, together with their respective check varieties, "Alno" and "Bush Blue Lake 274" (BBL274). They were included in the multi-location field trials from 2005-2009 in Benguet and Nueva Vizcaya. In each location, the trials were laid out following Randomized Complete Block Design (RCBD) with three replications. The varieties were planted in $5m_2$ plot per replication. Two seeds were sown per hill in double row plot spaced at 25 cm between hills and between rows. The farmers' cultural practices were followed in each location.

In different locations, at the peak of harvest, at least ten snap bean farmers and consumers were invited to participate in the sensory and acceptability evaluation and selection of potential varieties for commercialization. They were requested to make their own selection based on plant morphology, yielding ability and pod quality using the rating scale of 1-5 with 1.0-liked very much, 2.0-liked moderately, 3.0-liked nor disliked, 4.0-moderately disliked and 5.0-disliked very much. The reactions of the entries tested to bean rust or *Ascochyta* leaf spot infection and pod borer and leaf miner infestation were also rated using the following rating scale:1= <20% infection/infestation per plot, highly resistant (HR); 2=21-40% infection/infestation per plot, moderately resistant (MR); 3=41-60% infection/ infestation per plot, mildly resistant (R); 4= 61-80% infection/infestation per plot, susceptible (S); 5=81-100% infection/infestation per plot, very susceptible (VS). They were also asked to write in a structured questionnaire provided them, their reasons for choosing or not, the varieties.

The data from different locations were analyzed separately using Analysis of Variance (ANOVA) for RCBD and the significance of differences among variety means was tested using Duncan's Multiple Range Test (DMRT) or LSD test at 5% level. Entries that outperformed or had comparable performance with the check variety across locations and over years of testing by at least 10% in terms of fresh pod yield, and with other desirable or distinct agronomic characters were identified. They were nominated and recommended to NSIC in 2008, 2009, 2014 and 2015 for official approval and registration as new improved varieties of pole and bush snap bean for regional commercialization in the Cordillera Administrative Region.

RESULTS AND DISCUSSION Multi-

Location/On-Farm Field Trials of Snap bean

The results of multi-location field trials for pole snap beans from 2006-2009 are shown in Tables 1 and 2 while those of bush snap bean from 2005-2009 are shown in Tables 3 and 4. Significant differences in yield among entries of pole snap beans and bush snap beans tested in different years are noted in Tables 1 and 3. The nominated varieties to NSIC were selected based on their average yield and other distinct agronomic characters across locations over years (Tables 2 and 4). Nomination of one or two outstanding varieties per year was done so as not to flood the market with new varieties.

As a result of the multi-location field trials, two pole snap bean selections, the "Kapangan" and "Mabunga" were nominated and recommended to the NSIC of the DA-BPI as new pole snap bean varieties for regional commercialization in 2008. They were officially approved and registered on November 20, 2008 as NSIC 2008 PSnBn 1 and NSIC 2008 PSnBn 2, respectively. They were given the popular name "Kapangan" after the name of the leading snap bean production town in Kapangan, Benguet and "Mabunga" for their high prolificacy (Tandang *et al.* 2008 and 2009).

Table 1. Total yield per plot (kg/5m^2) of ten potential pole snap bean entries included in multi-location trials from 2006 to 2009

Entry	2006-2007			2007-2008		2008-2009		Mean
	Balili, La Trinidad	Betag, La Trinidad	Kabayan, Benguet	Betag, La Trinidad	Tuba	Betag, La Trinidad	Mankayan, Benguet	
Blue Lake	10.12a	15.50a	9.11b	-	-	14.80a	4.85bc	10.80
Tublay	-	12.00b	-	18.32ab	9.32d	12.82abc	4.92bc	11.47
Kibungan	-	12.02b	-	16.98abc	11.74a	11.82abc	6.12ab	11.73
Itogon	-	-	-	16.71abc	-	12.00abc	6.61a	11.77
Taichung	9.10b	12.92b	7.80b	18.95a	9.18d	14.38ab	2.99d	10.33
Kapangan	-	13.46a	-	15.51abcd	11.88a	11.40abc	5.54bc	11.56
Mabunga	6.58bc	14.00a	11.59a	14.13bcd	10.90b	-	1.05b	9.78
Tuba	-	12.00b	-	13.77bcd	10.80b	10.24abc	-	11.70
Wangal	-	10.40c	-	11.93de	10.82b	12.54abc	5.90ab-	10.31
Alno (ck)	**6.46bc**	**11.36b**	**7.66b**	**10.02de**	**10.56c**	**9.44cde**	**2.51cd**	**8.97**
CV (%)	5.50	14.52	16.20	13.02	12.80	23.54	18.86	11.73

Within a column, means followed by similar letters are not significantly different using DMRT at 5% level.

Table 2. Other horticultural characters of ten pole snap bean entries included in the multi-location field trials

Entries	Flower Color	Days to Flowering	Days to harvesting		Number of Flower Cluster per Plant	Number of Flower per Cluster	Pod			Seed		Reaction[1] to		
			First	Last			Color	Length (cm)	Width (cm)	Number per Pod	Color	Pod Borer	Bean Rust	Leaf Miner
BlueLake	White	52	63	78	9	5	Green	17.0	1.1	8	White	2	1	2
Tublay	Light Violet	45	55	80	9	5	Green	15.4	1.1	9	Black	2	2	2
Kibungan	Yellow White	45	52	78	7	6	Yellow Green	15.3	1.1	7	Dark Brown	3	2	2
Itogon	Violet	52	60	89	6	7	Dark Green	16.10	1.2	8	Black	2	2	2
Taichung	Violet	52	60	81	25	6	Light Green	15.7	1.0	9	Black	2	2	2
Kapangan	Violet	47	56	82	7	6	Green	17.1	1.1	8	White	2	2	2
Violeta	Violet	49	58	84	27	6	Violet	17.8	0.9	7	Light Brown	2	2	2
Tuba	Violet	48	58	84	9	5	Green	15.0	1.1	6	Black	2	2	2
Wangal	Violet	48	54	85	9	5	Green	15.6	1.2	6	White	3	2	2
Alno (Check)	Violet	48	55	77	9	5	Green	15.0	1.1	8	Black	3	4	2

[1]Pod borer, bean rust and leaf miner rating scale: 1-Highly resistant; 2- Moderately resistant; 3-Resistant; 4-Susceptible; 5-Very susceptible

Table 3. Marketable fresh pod yield per plot(kg/5m2) of eight bush snap bean entries included in multi-location field trials from 2005-2009

Entries	2005-2006	2006-2007		2007-2008		2008-2009		Average
	La Trinidad Benguet	La Trinidad, Benguet	Kayapa, Nueva Vizcaya	La Trinidad, Benguet	Kayapa,Nueva Viscaya	La Trinidad, Benguet	Sablan, Benguet	
Green Crop	13.95$_{a}$	-	7.47$_{bc}$	12.15$_{a}$	10.10$_{a}$	13.92$_{ab}$	-	11.51
Hab 19	7.85$_{c}$	8.28$_{b}$	7.77$_{abc}$	11.71$_{a}$	8.67$_{ab}$	13.12$_{ab}$	6.50	9.12
Contender	12.88$_{a}$	-	10.10$_{a}$	10.37$_{ab}$	8.47$_{ab}$	14.92$_{a}$	-	11.34
Bokod	12.75$_{a}$	7.40$_{bc}$	6.80$_{bc}$	9.87$_{bc}$	7.77$_{abc}$	13.78$_{ab}$	6.66	9.29
Sablan	10.63$_{abc}$	6.81$_{bc}$	7.29$_{bc}$	9.74$_{bc}$	7.47$_{bc}$	11.34$_{ab}$	6.70	8.57
BBL 274 (ck)	11.93$_{ab}$	10.01$_{a}$	8.67$_{ab}$	8.45$_{c}$	7.40$_{bc}$	12.08$_{ab}$	6.34	9.27
Torrent	11.62$_{ab}$	9.57$_{a}$	8.43$_{ab}$	8.12$_{cd}$	7.29$_{bc}$	10.60$_{b}$	-	9.27
Landmark	8.35$_{bc}$	8.69$_{b}$	5.87$_{c}$	7.75$_{d}$	6.80$_{bc}$	12.28$_{ab}$	-	8.49
CV (%)	17.24	20.05	14.53	13.02	12.81	14.27	15.80	

Within a column, means followed by similar letters are not significantly different at 5%level using DMRT.

Table 4. Other horticultural characters of eight bush snap bean entries included in multi-location trials

Entries	Flower Color	Days to Flowering	Days to harvesting		Number of Flower Cluster per Plant	Number of Flowers per Cluster	Pod Color	Pod Length (cm)	Seed Width (cm)	Seed Number per Pod	Seed Color	Reaction to Pod Borer	Reaction to Bean Rust	Reaction to Leaf Miner
			First	Last										
Green Crop	Yellow White	40	50	77	7	5	Dark Green	17.3	1.2	6	Black	2	1	2
Hab 19	Violet	42	52	76	9	5	Green	13.6	0.9	5	Black	2	3	2
Contender	Yellow White	40	50	74	7	6	Light Green	14.7	1.0	5	Light Brown	2	2	4
Bokod	Violet	42	50	74	9	5	Green	13.4	0.9	6	Black	3	2	2
Sablan	Violet	42	50	76	7	6	Green	13.3	0.9	6	Black	2	2	2
BBL 274	Light Violet	42	50	74	9	5	Green	14.6	1.0	6	White	2	2	2
Torrent	Violet	37	44	65	9	5	Green	15.0	9.0	6	White	2	2	4
Landmark	Yellow White	42	50	74	9	5	Green	13.5	1.0	4	White	2	3	2

[1]Pod borer, bean rust and leaf miner rating scale: 1-Highly resistant; 2- Moderately resistant; 3-Resistant;4-Susceptible; 5-Very susceptible

In 2009, after completing the requirements for multi-location field testing of another set of pole snap bean and bush snap bean entries, one new potential variety of pole snap bean, the "Tublay" and two selections of bush snap beans, "Sablan" and "Bokod" were recommended to NSIC. They were officially approved as new varieties for regional commercialization and awarded Certificates of Registration as NSIC 2009 PSnBn3 and NSIC 2009 BSnBn1 and NSIC 2009 BSnBn2, respectively on November 25, 2009 by NSIC. Consequently, they were also named after the names of the three Benguet municipalities producing snap bean, 'Tublay", "Sablan" and "Bokod", and based on their prominent characteristics (Tandang *et al.* 2008 and 2009). In 2015, another selection of bush snap bean "Hab 19" was nominated to NSIC for registration as commercial variety for CAR. It was finally approved in November 2015 as NSIC 2015 BsnBn3 with the name, "Cali" after the name of the location where CIAT International Center for Tropical Agriculture is, in Cali, Colombia where the original accession was obtained.

Based on the results of the multi-location field trials conducted over the years, the characteristics of new improved varieties of pole snap bean together with the check variety "Alno," the commercial traditional variety, are summarized in Table 5. Similarly, the characteristics of three new improved bush snap bean varieties with Bush Blue Lake 274 (BBL274) as check variety, are summarized in Table 6.

Table 5. The characteristics of new varieties of pole snap bean in comparison with "Alno," the check variety

Characteristics	New Varieties			Check Variety
	"Kapangan"	"Mabunga"	"Tublay"	"Alno"
a. Yield (t/ha)	11.56	9.78	11.47	8.97
b. Number of flowers/cluster	7	7	9	9
c. Number of pods/cluster	6	6	5	5
d. Days to flowering (DAP)	48	49	45	48
e. Days to first harvest	56	58	55	55
f. Days to last harvest	82	84	80	77
g. Pod color	Dark Green	Violet	Green	Light Green
h. Pod length(cm)	17.10	17.80	15.40	15.00
i. Pod width(cm)	1.10	0.90	1.10	1.10
j. Seed color	White	Light Brown	Black	Black
k. Number of seeds/pod	8	7	9	8
l. Reaction to bean rust*	MR	MR	MR	S
m. Reaction to pod borer*	MR	MR	MR	R
n. General acceptability	Highly Acceptable	Moderately Acceptable	HighlyAcceptable	HighlyAcceptable
o. ROI (%)	91	78	89	60

*Reaction: S- Susceptible R- Resistant MR -Moderately Resistant

Table 6. Characteristics of three new varieties of bush snap bean in comparison with BBL 274 as the check variety

Characteristics	New Varieties			Check Variety
	‘‘Sablan”	“Bokod”	“Cali”	BBL274
Yield (t/ha)	8.57	9.29	8.46	9.27
Number of flower clusters/plant	7	9	9	9
Number of pods/cluster	6	5	5	5
Days to flowering (DAP)	42	42	42	42
Days to first harvest	50	50	52	50
Days to last harvest	76	74	76	74
Pod color	Green	Green	Green	Light Green
Pod length (cm)	13.3	13.4	13.6	14.6
Pod width (cm)	0.9	0.9	0.9	1.0
Seed color	Black	Black	Black	White
Number of seeds/pod	6	6	5	6
Reaction to bean rust*	MR	MR	MR	MR
Reaction to pod borer*	MR	R	MR	MR
Reaction to weevil*	MR	MR	MR	S
General acceptability	Highly Acceptable	Highly Acceptable	Highly Acceptable	Moderately Acceptable
ROI (%)	84	98	86	98

*S- Susceptible R- Resistant MR -Moderately resistant

The total yield of eight potential pole snap bean entries in different locations in the Northern Philippine highlands from 2009-2014 is presented on Table 7. On the average, “Alno”, the traditional commercial variety, recorded the least yield. It was out-yielded by the seven entries included in the multi-location testing. “Kapangan”, “Mabunga” and ‘‘Tublay” still recorded the highest yield across locations over years of testing. “Itogon”, a selection from an introduced germplasm and the three locally-bred and selected improved lines such as “Kibungan”, “Tuba” and “Wangal” also out-yielded “Alno”. Their average yield performance and other horticultural characteristics compared to “Alno”, are summarized in Table 8.

Table 7. Total yield per plot (kg/5m$_2$) of eight potential pole snap bean entries in multi-location trials in 2009-2014

Entries	2009-2010		2010-2011		2010-2011	2011-2012		2012-2013	2013-2014	Average
	Betag, LaTrinidad	Mangkayan, Benguet	Betag, La Trinidad	Balili, La Trinidad	Kibungan, Benguet	Palina Kibungan	Betag, LaTrinidad	Betag, La Trinidad	Betag, La Trinidad	
Kapangan	11.40	9.08$_{bc}$	-	-	17.00$_{bc}$	11.78$_{bc}$	23.66$_{bc}$	21.40$_{ab}$	26.59$_{a}$	17.27
Mabunga	-	10.06$_{abc}$	23.10	16.62$_{a}$	-	-	25.46$_{bc}$	20.35$_{bcd}$	26.85$_{a}$	20.40
Alno (check)	9.44	5.06$_{cd}$	14.64	-	18.75$_{a}$	12.96$_{a}$	21.28$_{bc}$	11.65$_{g}$	16.19$_{cdef}$	13.74
Kibungan	11.82	12.24$_{ab}$	19.22	-	-	-	17.48$_{e}$	14.94$_{efg}$	17.07$_{cdef}$	15.46
Tublay	12.82	4.71$_{bc}$	20.74	10.54$_{c}$	17.73$_{b}$	12.24$_{b}$	26.76$_{bc}$	17.3$_{cdef}$	24.91$_{ab}$	16.41
Tuba	10.24	-	19.06	-	-	-	25.70$_{bc}$	17.25$_{cdef}$	17.29$_{cdef}$	17.90
Itogon	12.00	13.22$_{a}$	18.96	12.38$_{b}$	15.71$_{c}$	11.42$_{c}$	20.78$_{bc}$	18.36$_{bcde}$	15.07$_{def}$	15.32
Wangal	12.54	11.80$_{ab}$	19.06	12.42$_{b}$	-	-	21.16$_{bc}$	19.55$_{bcd}$	20.38$_{abcde}$	16.70
CV (%)	18.86	5.16	3.37	4.14	12.64	11.28	19.12	-	-	

Within a column, means followed by similar letters are not significantly different at 5%level using DMRT

Table 8. Characteristics of four new varieties of pole snap bean in comparison with "Alno," the check variety

Characteristics	New Variety "Itogon"	New Variety "Kibungan"	New Variety "Tuba"	New Variety "Wangal"	Check Variety "Alno"
Yield (t/ha)	15.08	14.40	15.47	14.50 (34.01%)	10.82
Number of flowers/ cluster	7	7	5	5	7
Number of pods/cluster	6	6	5	5	5
Days to flower(DAP)	43	45	45	48	48
Days to first harvest	50	52	51	54	55
Days to last harvest	89	78	84	85	77
Pod color	Green	Dark Green	Dark Green	Dark Green	Light Green
Pod length(cm)	14.03	15.30	15.00	15.60	14.82
Pod width(cm)	1.20	1.10	1.10	1.20	1.18
Seed color	Black	Dark Brown	Black	White	Black
Number of seeds/pod	8	7	6	6	8
Reaction to bean rust*	MR	HR	HR	HR	S
Reaction to pod borer*	MR	R	R	R	R
General Acceptability	Highly Acceptable	Highly Acceptable	Highly Acceptable	Highly Acceptable	Highly Acceptable
ROI (%)	179.60	170.08	180.70	168.85	100.60

*S- Susceptible R- Resistant MR -Moderately Resistant HR- Highly Resistant

VARIETY DESCRIPTION

A. Pole Snap Bean Varieties

"Kapangan" (NSIC 2008 PSnBn1) is a selection from introduced accession N2643 from the National Seed Storage Laboratory of the United States Department of Agriculture in Fort Collins, Colorado. It is high-yielding, producing 11.56 t ha-1 marketable fresh pods, with 28.87% yield advantage over the check variety, "Alno", a traditional commercial variety (Table 5). It has longer dark green pods than "Alno", measuring 17.10 cm and 1.10 cm width and has better quality that it can be harvested in 56 days after planting (Figure 2). It has better resistance to bean rust and pod borer than "Alno". It is highly acceptable to consumers.

Figure 2. The plants and pods of pole snap bean NSIC 2008 PSnBn 1 "Kapangan"

"Mabunga" (NSIC 2008 PSnBn2) is also a selection from introduced accession from the Asian Vegetable Research and Development Center (AVRDC) in Tainan, Taiwan now known as World Vegetable Center. It is highly prolific with an average fresh pod yield of 9.78t ha-1 (Table 5). It has longer pods than "Alno", measuring 17.80 cm and a width of 0.90 cm. Its violet pod color is indicative of better quality due to the presence of more anti-oxidants (Figure 3). It has better resistance to bean rust and pod borer than "Alno".

Figure 3. The plants and pods of pole snap bean NSIC 2008 PSnBn2 "Mabunga"

"Tublay" (NSIC 2009 PSnBn3) is a highly prolific selection from introduced accession from the International Center for Tropical Agriculture (CIAT) in Cali, Colombia. It has an average marketable snap bean yield of 11.47 t ha-1, with 27.87% yield advantage over the check variety, Alno. It has moderate resistance to bean rust and pod borer, better than "Alno" (Table5). Its normal straight green pod is 15.40 cm long and 1.10 cm wide green (Figure 4). It matures in 45 days, three days earlier than "Alno" and has also longer harvesting period. It is highly acceptable to the snap bean growers and consumers.

Figure 4. The plants and pods of pole snap bean NSIC 2009 PSnBn 3 "Tublay"

"ITOGON" (NSIC 2014 PSBn4) is also a highly prolific selection from an introduction from the International Center for Tropical Agricultural (CIAT). It has an average yield of 15.08t/ha, with 39.37% yield advantage and 79% ROI over the

Figure 5. The plants and pods of pole snap bean NSIC 2009 PSnBn4 "Itogon"

check variety, "Alno". It has slightly shorter and greener round pods than "Alno" that could be harvested in 50 days after emergence, five days earlier than "Alno" and with longer harvesting period. "Itogon" has better resistance to bean rust and pod borer than "Alno". It is highly acceptable to consumers. "Itogon" is adapted in mid- and high elevation areas during dry season.

"Kibungan" (NSIC 2009 PSnBn5) is a progeny of a cross between "Alno" and "Blue Lake" from 1996 hybridization activities. It is the first locally-bred variety recommended for registration and commercialization in Benguet. It has an average fresh pod yield of 14.40 t/ha, with 33% advantage over the check variety "Alno" and ROI of 170%. "Kibungan" is adapted to high elevation areas during the dry season. It has dark green pods that can be harvested at 52 DAE. It is longer, smoother-textured and has shinier pods than "Alno". It is highly resistant to bean rust and to pod borer.

Figure 6. Pole snap bean NSIC 2009 PSnBn5 "Kibungan" plants and pods

"Tuba" (NSIC 2014 PSnBn6) is a highly prolific selection from a cross between 'Blue Lake' and 'Alno.' It has an average fresh pod yield of 15.14 t/ha, an almost 40% lead from the check variety 'Alno,' and 181% ROI. It is adapted to medium to high elevation areas during the dry season. Tuba is highly resistant to bean rust and to pod borer. It matures four days earlier than 'Alno' at 51 DAE. It has a one week longer harvesting period and has better pod texture and greener color than "Alno". "Tuba" is highly acceptable to both snap bean growers and consumers.

"Wangal" (NSIC 2014 PSnBn7) is a selection from a cross between 'Alno' and 'Blue Lake'. It has an average fresh pod yield of 14.50t/ha, a 34.01% yield advantage over 'Alno', the check variety, and has an ROI of 168.85%. "Wangal" is highly resistant to bean rust and is adapted both to mid and high elevation areas during the dry season. It has darker green pods that are longer and more snappy than the check variety. It is harvestable at 54 DAE almost similar to 'Alno' but has longer harvesting period.

Figure 7. Plants and pods of pole snap bean NSIC 2009 PSnBn6 "Tuba"

Figure 8. Plants and pods of pole snap bean NSIC 2009 PSnBn7 "Wangal"

B. Bush Snap Bean

"Sablan" (NSIC 2009 BSnBn1) is a selection from an introduced accession from the International Center for Tropical Agriculture (CIAT) in Columbia. It has better quality and high resistance to weevil than the check variety, "BBL 274". It has an average marketable fresh pod yield of 8.57 t ha-1(Table 6). It has shorter and tastier green pod than "BBL 274" and measures 13.3 cm long and 0.90 cm wide (Figure 5). It has comparable moderate resistance to bean rust and pod borer with "BBL 274" and could be profitably grown in the highlands and lowlands. It is more

resistant to lodging and stem breakage and has moderate resistance to bean weevil.

Figure 9. Plants and pods of bush snap bean NSIC 2009 BSnBn1, "Sablan"

"Bokod" (NSIC 2009 BSnBn2) is a selection from an introduced accession also from the CIAT. It has smoother, snappier and darker green pods and with higher resistance to bean weevil than the check variety, 'BBL 274'. Bokod has an average yield of 9.29t ha-1 (Table 6). It has shorter, and tastier straight green pods than 'BBL 274' measuring 13.4 cm long and 0.90 cm wide (Figure 5). It is very much liked by farmers and consumers because it has comparable moderate resistance to bean rust with 'BBL 274'. It could be profitably grown both in the highlands and lowlands, and has resistance to pod borer and stem breakage or lodging than BBL 274 whose stems easily break or lodge.

Figure 10. Plants and pods of bush snap bean NSIC 2009 BSnBn2 ,"Bokod"

"Cali" (NSIC 2015 BSnBn3) is a selection from an introduced accession from CIAT with an average fresh pod yield of 8.46t/ha. It has better pod quality and high resistance to weevil than the check variety, BBL 274 but comparable with "Bokod" and "Sablan". It has shorter and tastier green pod than 'BBL 274'. It has comparable moderate resistance to bean rust with all check varieties and better resistance to pod borer than 'BBL 274'. It could be grown both in the highlands and lowlands. It is more resistant to lodging and stem breakage and weevil than 'BBL 274'.

Figure 11. Plants and pods of bush snap beans Hab 19, officially registered as NSIC 2015 BSnBn 3 "Cali"

Dissemination of NSIC-Approved varieties

The new NSIC-approved varieties of pole and bush snap beans were published in regional dailies like Sun Star and the Baguio Midland Courier, BSU's "Shamag" and in ISI Scientific Journals like the Philippine Journal of Crop Science (PJCS), Volume 35 Supplemental No.1 in March 2010, Volume 35 No 3 in December 2010 and Volume 36 Supplemental No.1 in May 2011 and Volume 36 No.1 in April 2011. They were also published in the form of poster presentations during the 40th Scientific Conference of the Crop Science Society of the Philippines (CSSP) in Davao City on March 15-20, 2010, and during the 2015 Federation of Crop Science Society of the Philippines (FCSSP) Scientific Conference held in Clark, Pampanga on May 12-16, 2015 and during the 4th National Conference of the Restoration Ecology Society of the Philippines on May 6-9, 2015 in Baguio City. They were also disseminated in Farmers' Forum, local and national trade fairs and as exhibits held during the yearly University Foundation Day Celebration, Hands-on Training on Varietal Characterization and Evaluation of Vegetable, Legume and Root Crops (VELERO) and in class lectures at the Department of Agronomy, College of Agriculture, BSU course offerings specifically agronomy major subjects including Agriculture 11 and TLE 102 and others. Seeds from NSIC-approved improved varieties of snap beans were also given free to Benguet Local Government Unit (LGU) through its Governor Hon. Nestor Fongwan and the Provincial Agriculturist including the Municipality of Tublay through its

Municipal Agriculture Officer and farmers who attended the forum at BSU as well as walk-in visitors and buyers. They were also shared as test materials for thesis and laboratory exercises of students of the College of Agriculture particularly in the Departments of Agronomy, Horticulture, Plant Pathology, Entomology and Soil Science and to scientists and researchers in BSU's research centers and other State Colleges and Universities including UP Los Baños. They were also distributed to different cooperating stations conducting the National Cooperative Test for Vegetable crops like in Ilagan, Isabela in Region 2, Bicol Integrated Agricultural Research Center in Region V, Visayas State University in Region VIII, and Mariano Marcos State University in Region I, Ifugao State University in CAR, collaborating agencies nationwide and others.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Seven new improved varieties of pole snap bean, and three new improved bush snap bean varieties were nominated to the vegetable technical working group (VCTWG) of NSIC which, in turn recommended the potential varieties' approval to the NSIC for registration as new improved varieties for commercialization. They were finally and officially approved and registered by the DA-NSIC as new improved varieties for regional commercialization in the Cordillera Administrative Region (CAR) based on their yield potential, early flowering and maturity and other distinct horticultural characters. They are NSIC 2008 PSnBn1 "Kapangan," NSIC 2008 PSnBn2 "Mabunga," and NSIC 2009 PSnBn3 "Tublay," NSIC 2014 PsnBn4 "Itogon", NSIC 2014 PSnBn5 "Kibungan", NSIC2014 PSnBn6 "Tuba", and NSIC 2014 PSnBn7 "Wangal" pole snap bean varieties and; bush snap bean varieties such as NSIC 2009 BSnBn1 "Sablan," NSIC 2009 BSnB 2 "Bokod" and NSIC 2015 BSnBn 3 "Cali". Their breeder and basic seeds are maintained and supplied to the growers by the BSU-IPB Highland Crops Research Station based at Benguet State University in La Trinidad, Benguet.

Recommendations

The new improved varieties of bush and pole snap bean could now be commercially produced in the northern Philippine highland. These NSIC-approved improved varieties of bush and pole snap beans are best adapted in cool elevated areas in the highlands throughout the year but they could also be commercially grown in the low- and mid-elevation areas provided they are planted during cooler months from November to March cropping season. Further testing of the new improved varieties of snap bean must be undertaken in other locations nationwide to make them as officially approved varieties for national commercialization. These new improved locally developed varieties could be used as test materials in different research and production activities involving snap beans. Production of breeder and foundation seeds must be done and certified seeds must be multiplied by appropriate or concerned agencies to make the new improved varieties more available to target clientele or beneficiaries. These new approved varieties of bush and pole snap beans together with other promising varieties selected and identified in the breeding program must be evaluated under different production systems and climatic conditions.

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