Exploration of Genetic Diversity and Variability in Winged Bean (*Psophocarpus tetragonolobus* L.) in the new alluvial zone of West Bengal

ABSTRACT

The winged bean (*Psophocarpus tetragonolobus* L.) is a multipurpose, underexploited leguminous crop of the tropics that is rich in proteins and minerals. The present study, entitled "Exploration of Genetic Diversity and Variability in Winged Bean (*Psophocarpus tetragonolobus* L.) in the new alluvial zone of West Bengal'' was conducted to assess the degree of variability, variation, genetic advance, for multiple quantitative traits in order to establish selection criteria for achieving high pod yield per plant in the winged bean. A total of 14 genotypes were included in the experimental material. The individuals were reared in a Randomized Block Design (RBD) with three replications throughout the kharif seasons of 2020–21 and 2021–2022. The trait with the highest GCV and PCV was the number of pods per plant, with values of 23.33 and 23.65, respectively. This was followed by the green pod yield per plant in kg, with GCV and PCV values of 22.78% and 22.91%, respectively. A high heritability estimate was recorded for the character of green pod yield per plant (98.8%), followed by total sugar (95.1%), protein content g/100 g (pod) (94.1%). Seed yield per plant (93.9%), vine length (cm) (93.6%), duration of the crop (days) (93.1%), shelling percentage (89.9%). A high genetic advance was observed. Vine length (81.40), followed by other characters like seed yield per plant (62.45), number of pods per plant (21.37), duration of the crops (14.65), shelling percentage (8.5), and days to first harvest (8.3) for quantitative parameters and protein content g/100g (pod) (4.61), followed by other characters like protein content g/100g (seed) (3.16), ascorbic acid (1.52), and total sugar (0.82%) for qualitative parameters.

Key words: *Genotypes, Pod Length, Pod Yield, Seed Yield, Winged Bean.*

INTRODUCTION

winged bean (*Psophocarpus tetragonolobus* (L.) DC.) belongs to the category of underutilized or orphan legumes found in tropical regions. It has demonstrated a robust twining habit, nitrogen fixation capability, and the presence of a tuberous root system (Eagleton 2020; Vatanparast *et al.* 2016). Thriving in the most prevalent agro-ecologies worldwide, particularly in hot and humid equatorial countries (Afridatul and Syukur 2021; Lepcha *et al.* 2017), this versatile plant holds promise for agricultural cultivation. It comes under Fabaceae with chromosome number 2n = 2x = 18, or 22. Genotype is the most important factor in any crop production programme and is the basic material to which all other technologies are applied. These genotypes also greatly vary in their performance under different agro-climatic conditions in the country, which often creates confusion among the farmers about their choice of variety. So, the selection of particular genotypes is also important for higher crop yield. Being an underutilised vegetable, the winged bean provides various food forms from a single plant and has more nutrition as compared to other vegetables. Thus, there is a scope for exploitation of the potential of this crop for the production of immature vegetable pods, seeds, and tubers. On this aspect, a number of experiments have so far been conducted in India, but in the plains of West Bengal, till now, no systematic approaches have been made to utilise the agro-ecological conditions of the states.

Keeping this view in perspective, the present experiment entitled "Exploration of Genetic Diversity and Variability in Winged Bean (*Psophocarpus tetragonolobus* L.) in the new alluvial zone of West Bengal" was conducted.

MATERIALS AND METHODS

The experiment entitled "Exploration of Genetic Diversity and Variability in Winged Bean (*Psophocarpus tetragonolobus* L.) in the new alluvial zone of West Bengal" was conducted in the main campus of Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia, West Bengal, during the periods of 2020–2021 and 2021–2022. The experimental site is located very close to the Tropic of

Cancer at 23.5° Northern latitude and 80° Eastern longitude, at an altitude of about 9.75 m above mean sea level, and enjoys a sub-tropical climate throughout the growing season. The predominant soil type of the experimental site is sandy loam with slide acidity and good water holding capacity. The experimental material included 14 genotypes of winged beans obtained from the Indian Institute of Vegetable Research, located in Varanasi, Uttar Pradesh. The experiment was conducted using a randomised block design, with 3 replications. The seeds of each genotype were planted in rows with spacing of 1 meter between the rows and 60 centimetres between the individual plants having an irrigation channel of 50 cm. N:P:K was applied in the form of urea, SSP and MOP, respectively @40:100:60. 1/3rd was applied at the time of sowing and remaining portion at the time of top dressing after 45 DAS. After emergence of seedling, staking the vines with 1.5 m bamboo pole is required for support. Harvesting was done at weekly interval after 120-130 DAS for vegetable purpose and for seed purpose respectively. The pods are harvested when the plants attained physiological maturity by turning pinkish brown to copper brown which are sun dried for 3 days and seeds are separated by gently beating with stick and dried to moisture content 3%.

Growth parameters like vine length, number of primary branches per plants; yield parameters like days to first flowering , days to 50% flowering , days to first green pod harvest, duration of crop , number of pods per plant, pod yield per plant (kg), pod length (cm), pod width (mm), seed yield and yield components i.e. number of seeds per pod , seed yield per plant (g), hundred seed weight/ seed index and shelling percentage (total seeds yield per plant (g)/ total dry pods per plant (g) x 100) were measured. Mean value of every parameter in each treatment was worked out.

RESULTS AND DISCUSSION

The results obtained in the present investigation entitled “Exploration of Genetic Diversity and Variability in Winged Bean (*Psophocarpus tetragonolobus* L.) in the new alluvial zone of West Bengal” are discussed here under the following headings:

Parameters of genetic variability

Genetic parameters of variation for yield and its components in winged beans are presented in

Table 1.

Quantitative parameters:

Vine length: The character vine length ranged from 574.85 cm (VRWB-4B) to 714.60 cm (VRWB-09), with a mean value of 626.07 cm.

No. of branches per plant: The character number of branches per plant varied between 7 and 13.33, with a mean value of 10.33. The highest number of branches per plant was recorded in genotype VRWB-09, whereas the lowest number of branches was found in genotype VRWB-13-6.

Days to first flowering: Days to first flowering ranged from 66 days in genotype VRWB-84 to 79 days in genotype VRWB-13-6, with a mean value of 74 days. Similar result also found by Hansda *et. al.,* 2023.

Days to 50% flowering: This character of days to 50% flowering varied between 74 days and 90 days, with a mean value of 82.05 days. The genotype that reached the 50% flowering stage earliest was VRWB-84, while the genotype reaching the 50% flowering stage at last was VRWB-12.

No. of pods per plant*:* The character number of pods per plant was found to range between 22.67 in genotype VRWB-13-6 and 60 in genotype VRWB-13-1, with an average value of 45.07 no. of pods per plant.

Pod width (cm): The pod width of these genotypes varied from 1.25 cm to 1.91 cm, with an average value of 1.60 cm. The highest pod width was found in genotype VRWB-26, while the lowest pod width was recorded in genotype VRWB-4B.

Pod length (cm): The character pod length was found to range between 16.95 cm in genotype VRWB-18 and 22.04 cm in genotype VRWB-13-6, with a mean value of 19.68 cm long.

Pod weight (gm): The pod weight of these 14 genotypes varied from 18.47 gm to 23.09 gm, with an average weight of 20.60 gm per pod. The highest-weighed pod was recorded in genotype VRWB-12, and the lowest-weighed pod was found in genotype VRWB-11-2.

Days to first harvest: The character days required for first harvesting ranged from 121.67 days in genotype VRWB-84 to 140.67 days in genotype VRWB-11, with an average value of 132.26 days.

Duration of the crops: The duration of the crops in days varied from 183.67 to 209.33, with a mean value of 196.93 days. The longest-duration crop was recorded in genotype VRWB-12, whereas the shortest-duration crop was found in genotype VRWB-13-6.

No. of seeds per pod: The character No. of seeds per pod ranged from 6.33 seeds per pod in genotype VRWB-09 to 11.00 seeds per pod in genotype VRWB-13-6, with an average of 8.95 seeds per pod.

100 seed weight/seed index (gm): The seed weight of 100 seeds ranged from 33.43 gm to 43.81 gm, with a mean value of 39.80 gm. 100 seeds weighing 33.43 gm and 43.81 gm were recorded in genotypes VRWB-18 and VRWB-26, respectively.

Seed yield per plant (gm): The character seed yield per plant varied from 104.91 gm being the lowest in genotype to VRWB-18214.89 gm being the highest in genotype VRWB-13-1 with a mean value of 157.31 gm.

Shelling percentage: The shelling percentage of these genotypes ranged from 33.46% to 50.22%, with an average of 38.23%. The highest shelling percentage of 50.22% was recorded in genotype VRWB-13, while the lowest shelling percentage of 33.46% was recorded in genotype VRWB-22.

Green pod yield per plant (kg): The character green pod yield per plant ranged from 0.49kg to 1.22 kg, with an average value of 0.92kg of green pod per plant. The highest yield was recorded in genotype VRWB-13-1, whereas the lowest green pod yield was found in genotype VRWB-13-6.

Qualitative parameters:

Protein content (gm)/100 gm seed: Protein content in 100 gm seed varied from 27.73 gm to 32.82 gm, with a mean value of 30.41 gm per 100 gm of seed. The highest protein content was found in genotype VRWB-26, whereas the lowest protein content was found in genotype VRWB-13-1.

Protein content (gm)/100 gm of pod: Protein content in a 100-gm pod was recorded to range between 18.98 gm (VRWB-13-1) and 27.15 gm (VRWB-18), with an average value of 21.43 gm per 100 gm of pod.

Chlorophyll a mg/100 gm: Chlorophyll a content in these genotypes varied from 1.24mg to 1.38mg per 100 gm, with a mean value of 1.31mg. The highest being recorded in genotype VRWB-18 and the lowest in genotype VRWB-11-2.

Chlorophyll b mg/100 g: Chlorophyll b content was recorded to range from 0.67mg, the lowest in genotype VRWB-22, to 0.82mg, the highest in genotype VRWB-21, with an average value of 0.75 mg/100 g.

Total chlorophyll mg/100 gm: The character of total chlorophyll varied from 1.98mg in genotype VRWB-11-2 to 2.20mg in genotype VRWB-21, with a mean value of 2.11 mg/100 gm.

Total sugar (%): The character total sugar was recorded to range from 2.04% in genotype VRWB-4B to 3.28% in genotype VRWB-09, with an average value of 2.57%.

Ascorbic acid (mg/100 g of fresh weight*):* Ascorbic acid content in these 14 genotypes varied from 15.48mg being the lowest in genotype VRWB-13 to 18.09mg being the highest in genotype VRWB-13-1, with an average value of 16.70mg ascorbic acid/100 g of fresh weight.

The study reveals significant variability in different traits However, minimal variation was observed in other traits such as seed quantity per pod, pod breadth, number of branches per plant, pod weight, protein content, chlorophyll levels, and overall sugar content.

Genotypic and Phenotypic Coefficients of Variation:

The computation of variance components, including the genotypic coefficient of variation (GCV) and the phenotypic coefficient of variation (PCV), was performed. The phenotypic coefficients of variation exhibited a slight increase compared to the equivalent genotypic coefficients of variation, suggesting a minimal impact of environmental factors on the manifestation of the observed traits. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) can be classified into three categories: low (less than 10%), moderate (10–20%), and high (greater than 20%).

For quantitative parameters, the character number of pods per plant had the highest GCV (23.33%) and PCV (23.5%), followed by green pod yield per plant, for which the GCV is 22.78% and the PCV is 22.91%, which suggests comparatively high genetic variation among the genotypes for these characters. A similar result was recorded by Prasanth K. *et al*. (2015) for the number of pods per plant.

Moderate GCV and PCV were observed for the number of branches per plant (16.78% and 19.43%), the number of seeds per pod (11.76% and 13.54%), the seed yield per plant (19.89% and 20.53%), and the shelling percentage (11.39% and 12.01%), respectively. Lowest GCV and PCV were recorded in Duration of the crops (3.74 % and 3.88), followed by other characters like Days to first harvest (3.54% and 4.11%), Days to first flowering (4.61and 6.52), Days to 50% flowering (4.82 and 6.57), Vine length (6.52 and 6.75). The rest of the traits exhibited low GCV and PCV estimates.

For qualitative parameters, the highest GCV and PCV were recorded for the character Total sugar (%) (15.97% and 16.38%), followed by characters like protein content g/100 g (Pod) (10.77% and 11.11%), which are categorised as moderate. Low GCV and PCV were found for characters like total chlorophyll mg/100 g (2.56% and 2.97%), chlorophyll a mg/100 g (2.91% and 3.30%), ascorbic acid (4.60% and 4.79%), protein content g/100 g (seed) (5.35% and 5.67%), and chlorophyll b mg/100 g (5.35% and 5.67%). The present findings clearly suggest the worth of these characters for the study of genetic variability in winged beans.

Genetic advance (GA):

Genetic advance is the improvement in performance of the selected lines over the original population. However, it is not necessarily true that high heritability would always exhibit high genetic advance. Johnson *et al.* (1955), for this reason, suggested that heritability in combination with genetic advance would be more reliable for predicting the effect of selection because genetic advance depends on the amount of genetic variability, the magnitude of the masking effect of genetic expression (environmental influence), and the intensity of selection. In the present investigation, genetic advances indicated few significant traits. The magnitude of genetic advance was categorised as high (> 20%), moderate (10%–20%), and low (< 10%). Genetic advance was moderately high to high (> 20%) for vine length (cm) (81.40%), seed yield/plant (gm) (62.45%), number of pods per plant (21.37%), and moderate for character duration of the crops (days) (14.65%), and low for characters like shelling percentage (8.50%), days to first harvest (8.30%), days to 50% flowering (5.99%), and 100 seed weight/seed index (5.15%) (Tables 3 and 4).

Conclusion:

From the present investigation it concluded that all the genotypes showed sufficient variability for nearly all traits, including crop duration, number of branches per plant, green pod yield per plant, 100 seed weight, and total sugar percentage. However, vine length, pod length (cm), pod weight (grams), number of seeds per pod, shelling %, chlorophyll, protein, and ascorbic acid content vary slightly. GCV (23.33) and PCV (23.65) were highest for pods per plant, followed by green pod yields (kg) (22.78% and 22.91%). The plant's branches (16.78% and 19.43%) had moderate GCV and PCV, followed by the total sugar percentage (15.97% and 16.38%) and seeds or pods (11.76% and 13.54%). Green pod production per plant (98.8%), total sugar% (95.1%), and protein content g/100 g (pod) (94.1%) were highly heritable. Seed yield per plant (93.9%), vine length (93.6%), crop duration (days) (93.1%), ascorbic acid (92.2%), shelling percentage (89.9%), and other characters showed a predominance of additive gene action, which could be used for selection to improve these traits.

The genetic advance was high. Vine length (81.40), followed by seed yield per plant (62.45), number of pods per plant (21.37), crop duration (14.65), shelling percentage (8.5), and days to first harvest (8.3) for quantitative parameters and protein content g/100g (pod) (4.61), seed (3.16), ascorbic acid (1.52), and total sugar (0.82%) for qualitative parameters.

Vine length, pod count, and seed yield per plant had significant heritability and genetic advance, indicating additive gene action for genetic improvement. Number of branches per plant, pod length (cm), pod weight (gm), days to first harvest, number of seeds/pods, 100 seed weight/seed index (gm), shelling percentage, protein content g/100gm (pod), protein content g/100gm (seed), ascorbic acid, and some other qualitative parameters showed high heritability with low genetic advance, indicating non-additive gene action and possible selection for such traits. Thus, direct selection for these features may help select high-genotype winged bean from available material.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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Table1: Performance of the winged bean genotypes for quantitative parameters

Genotypes	Vine length(cm)	No of branches/ plant	Days to first flowering	Days to 50% flowering	Days to first harvest	Duration of the crop	No. of pods/plant	Pod width (cm)	Pod length (cm)	Pod weight(gm)	Green pod yield /plant(kg)	No. of seeds /pods	100 seed weight (gm)	Seed yield/plant(gm)	Shelling percentage
VRWB-13-1	656.83	8	79	84	132.67	202.33	60	1.68	18.48	20.4	1.22	9.67	37.1	214.89	35.57
VRWB-84	652.27	9.67	66	74	121.67	193.67	53.67	1.6	19.33	21.18	1.13	9	38.6	186.42	36.35
VRWB-21	629.87	12	77.67	84	138	205.33	57.33	1.35	19.23	21.02	1.21	8.33	38.4	183.56	41.56
VRWB-09	714.6	13.33	72.67	83.33	131	203	57.33	1.84	18.89	18.77	1.08	6.33	37.55	136.07	41.84
VRWB-18	627.73	10.67	69.67	76	138.33	199	33.67	1.78	16.95	18.59	0.63	9.33	33.43	104.91	41.23
VRWB-13	652.34	12	73	82	131.33	203	47.33	1.32	18.44	19.34	0.92	9	39.14	166.36	50.22
VRWB-20	598.19	8	72.33	82.67	127.33	196	40	1.87	20.55	21.87	0.87	9.33	41.7	155.52	37.56
VRWB-12	627.18	11	77.67	90	136.33	209.33	40.33	1.43	20.52	23.09	0.93	9.33	42.81	160.98	36.67
VRWB-22	589.24	11.67	71.33	78.67	132	192.33	38.33	1.29	19.46	20.83	0.8	9	41.06	141.68	33.46
VRWB-11-2	674.97	12	71.67	78	128	191	42.33	1.44	18.34	18.47	0.78	8	39.64	134.08	33.91
VRWB-26	610.99	11	78	86.67	130.33	186.67	41.67	1.91	21.8	23.05	0.96	10.33	43.81	188.35	37.12
VRWB-4B	574.85	10.67	79	79	132.33	191.33	54.67	1.25	20.83	19.57	1.07	8.33	39.16	178.25	39.59
VRWB-11	576.05	9	83	83	140.67	200.33	41.67	1.75	20.66	20.48	0.85	8.33	41.5	143.91	34.77
VRWB-13-6	579.89	7	87.33	87.33	132	183.67	22.67	1.86	22.04	21.76	0.49	11	43.26	107.35	35.3
S.Em±	6.182	0.59	2.109	2.109	1.601	1.154	1.005	0.22	0.409	0.468	0.013	0.347	0.678	4.623	0.843
CD at 5%	17.97	1.72	6.13	6.13	4.65	3.35	2.92	0.64	1.19	1.36	0.04	1.01	1.97	13.44	2.45

Table2: Performance of the Winged bean genotypes for Qualitative parameters

Genotypes	Protein content g/100gm (seed)	Protein content g/100gm(Pod)	Chlorophyll a mg/100gm	Chlorophyll b mg/100gm	Total chlorophyll mg/100gm	Total sugar (%)	Ascorbic acid
VRWB-13-1	27.73	18.98	1.32	0.73	2.1	2.95	18.09
VRWB-84	28.75	19.95	1.34	0.74	2.14	2.86	16.16
VRWB-21	31.09	23.89	1.33	0.82	2.2	2.63	17.31
VRWB-09	32.04	24.45	1.29	0.76	2.09	3.28	16.88
VRWB-18	30.09	27.15	1.38	0.7	2.13	2.91	16.23
VRWB-13	32.14	19.75	1.31	0.78	2.14	2.06	15.48
VRWB-20	31.27	20.71	1.26	0.75	2.06	3.05	15.68
VRWB-12	28.32	20.16	1.32	0.77	2.13	2.76	16.8
VRWB-22	28.06	19.82	1.35	0.67	2.07	2.23	16.25
VRWB-11-2	29.75	20.45	1.24	0.68	1.98	2.3	15.77
VRWB-26	32.82	21.23	1.31	0.77	2.13	2.62	17.18
VRWB-4B	31.98	20.27	1.25	0.74	2.04	2.04	17.32
VRWB-11	30.78	23.12	1.34	0.78	2.17	2.08	17.45
VRWB-13-6	30.85	20.08	1.32	0.77	2.14	2.21	17.22
S.Em ±	0.33	0.333	0.012	0.012	0.018	0.054	0.129
CD at 5%	0.96	0.97	0.03	0.04	0.05	0.16	0.38

Table 3 : Genetic variability parameters for quantitative parameters

Characters	Mean	Range	PCV (%)	GCV (%)	Heritability (%) inb.s.	GA
Vine length(cm)	626.07	574.85-714.60	6.75	6.52	0.936	81.40
Number of branches plant	10.43	7.00-13.33	19.43	16.78	0.745	3.11
Days to first flowering	74.00	66.00-79.00	6.52	4.61	0.500	4.97
Days to 50% flowering	82.05	74.00- 90.00	6.57	4.82	0.540	5.99
Number of Pods per plant	45.07	22.67- 60.00	23.65	23.33	0.973	21.37
Pod width (cm)	1.60	1.25 - 1.91	24.79	6.69	0.073	0.06
Pod length (cm)	19.68	16.95- 22.04	7.90	7.03	0.792	2.54
Pod weight (gm)	20.60	18.47- 23.09	8.08	7.05	0.762	2.61
Days to first harvest	132.26	121.67-140.67	4.11	3.54	0.740	8.30
Duration of the crops (days)	196.93	183.67-209.33	3.88	3.74	0.931	14.65
Number of seeds/pods	8.95	6.33 -11.00	13.54	11.76	0.754	1.88
100 seed weight/seed index(gm)	39.80	33.43-43.81	7.45	6.84	0.843	5.15
Seed yield/plant (gm)	157.31	104.91-214.89	20.53	19.89	0.939	62.45
Shelling percentage	38.23	33.46-50.22	12.01	11.39	0.899	8.50
Green pod yields per plant(kg)	0.92	0.49-1.22	22.91	22.78	0.988	0.43

Table 4: Genetic variability parameters for qualitative parameters

Characters	Mean	Range	PCV(%)	GCV(%)	Heritability(%)inb.s	GA
Protein content g/100gm(seed)	30.41	27.73-32.82	5.67	5.35	0.890	3.16
Protein content g/100gm(Pod)	21.43	18.98-27.15	11.11	10.77	0.941	4.61
Chlorophyll a mg/100gm	1.31	1.24-1.38	3.30	2.91	0.780	0.07
Chlorophyll b mg/100gm	0.75	0.67-0.82	5.98	5.24	0.767	0.07
Total chlorophyll mg/100gm	2.11	1.98-2.20	2.97	2.56	0.744	0.10
Total sugar (%)	2.57	2.04-3.28	16.38	15.97	0.951	0.82
Ascorbic acid	16.70	15.48-18.09	4.79	4.60	0.922	1.52

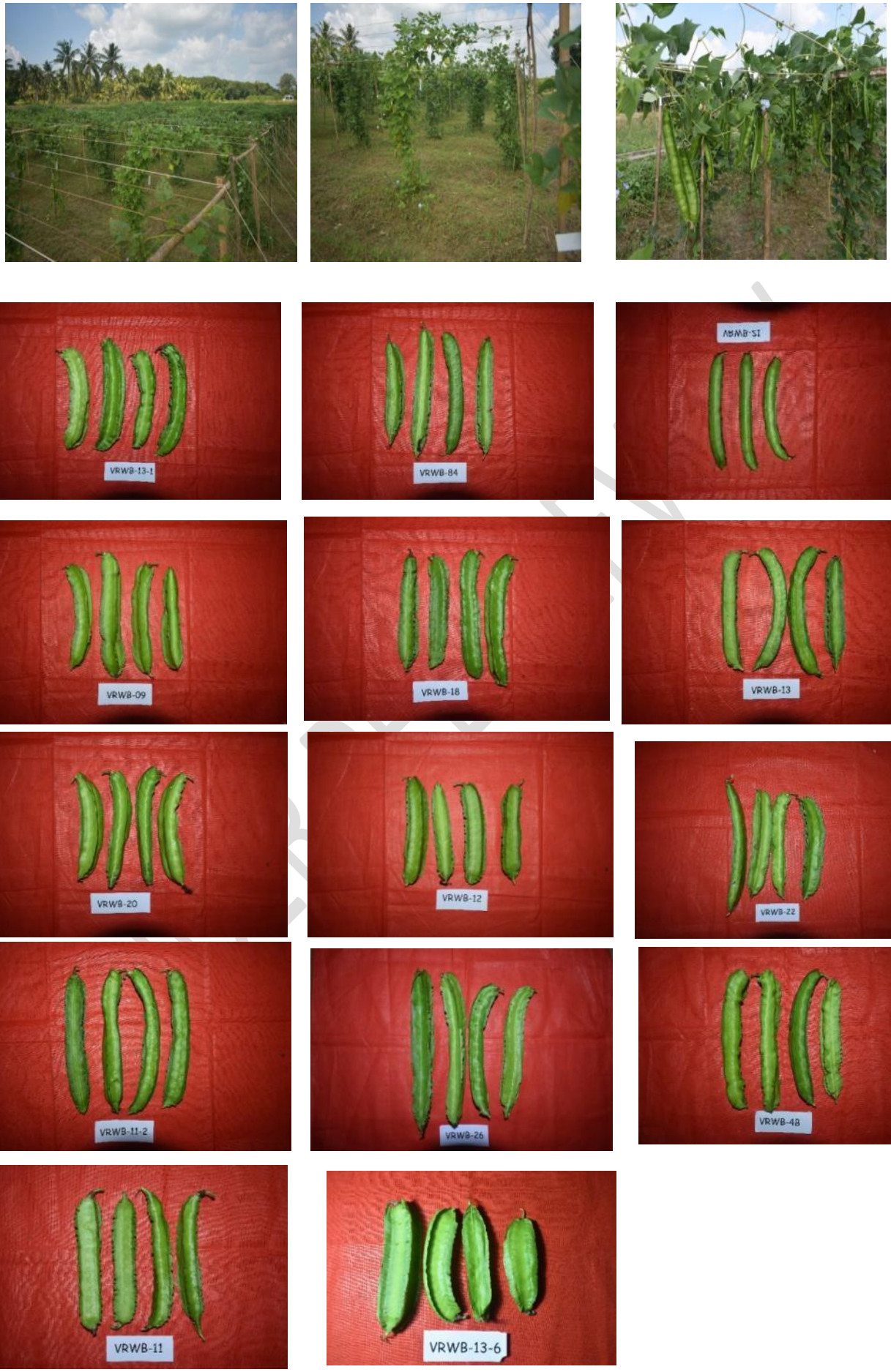

Plate 1: Different genotypes of Winged Bean pods Winged bean germplasms in research fields