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Growth and yields of winged bean (*Psophocarpus tetragonolobus* L.) genotypes in the new alluvial zone of West Bengal

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Abstract
Winged bean (*Psophocarpus tetragonolobus* (L.) DC.) is a versatile and underutilized leguminous crop primarily found in tropical regions. It boasts high protein and mineral content. This study focused on examining the ""Growth and Yields of Winged Bean *(Psophocarpus tetragonolobus L.*) Genotypes in the New Alluvial Zone of West Bengal". The present investigation was conducted at the Horticultural Research Station, Mondouri, Nadia under Department of Vegetable Science, Faculty of Horticulture at Bidhan Chandra Krishi Viswavidyalaya. The experiment employed a Randomized Block Design with three replications and duration spanning from July 2019 to February 2020. The treatments consist of 20 genotypes (*viz.*- VRWB-17, VRWB-23, VRWB-13-1, VRWB-84, VRWB-21, VRWB-09, VRWB-95, VRWB-18, VRWB-4A, VRWB-13, VRWB-83, VRWB-20, VRWB-12, VRWB-60, VRWB-22, VRWB-11-2, VRWB-26, VRWB-4B, VRWB-11, VRWB-13-6). Amongst the genotypes VRWB-09, VRWB-11-2, and VRWB-17 demonstrated superiority over others. Among the 20 genotypes evaluated, VRWB-84, VRWB-09, VRWB-22, and VRWB-18 exhibited early flowering (68.66, 69.33, 69.33, and 70.33 days, respectively), while VRWB-23 and VRWB-13-1 were categorized as late flowering (83.33 and 82 days, respectively). The highest number of pods, 151.66 per plant, was observed in genotype VRWB-09. Genotype VRWB-95 exhibited the highest pod weight of 31.98 g. The Genotype VRWB-11-2 achieved the highest green pod yield per plant of 3.56 kg and the number of seeds per pod varied among the genotypes, with the highest number observed in VRWB-13 (12.17), followed by VRWB-26 (12.00) and VRWB-18 (11.50). Furthermore, genotypes with a higher number of seeds per pod and greater bearing capacity per plant generally yielded higher seed production.

Keywords: Genotypes, pod length, seed yield, vine length and winged bean

Introduction
Psophocarpus tetragonolobus (L.) DC., commonly known as the winged bean, is a multipurpose underutilized tropical legume belonging to the family Leguminosae (Fabaceae). It has a diploid chromosome number of 2n=2x=18 or 22. It is grown in various countries, including India, Sri Lanka, Bangladesh, Burma, Indonesia, Malaysia, Thailand, the Philippines, and Papua New Guinea. In India, the winged bean is predominantly cultivated in the southern and north-eastern regions, such as Tripura, Manipur, Mizoram, and neighbouring areas, where the local population consumes it. However, despite its nutritional benefits and adaptability to diverse agro-climatic conditions, the winged bean needs more national recognition and commercial cultivation. Winged bean possesses unique characteristics, such as intertwining twining habits and complex plant architecture. The crop is considered much crucial because all the parts are edible and of high nutritious value since those are usually rich in protein, minerals, and vitamins (Chandel *et al.*, 1978) [2]. The crop offers a remarkable variety of food options from a single plant, providing different quantities of nutrition across its various plant parts. The protein content of winged bean seeds is higher than that of cowpea, pigeon pea, and lima beans, comparable to soybeans. Additionally, the leaves contain high levels of crude protein. However, the seeds and leaves also contain some anti-nutritional factors, which can be reduced through proper processing techniques. Apart from its nutritional significance, the winged bean is used as a cover crop in areas with high rainfall and severe soil erosion due to its dense branching pattern and perennial growth habit. Considering the growing global population, underutilized vegetables like the winged bean play a crucial role in ensuring nutritional security. Despite its local and regional importance, the winged bean has yet to gain national recognition and appreciation. Exploring the potential of this crop, especially in the plains of West Bengal, requires the evaluation of different genotypes for

green pod and seed yield characteristics. The present research aims to identify the best-performing genotypes of winged beans under the specific conditions of West Bengal.

Materials and Methods

The experimental material consisted of 20 genotypes of winged bean obtained from the Indian Institute of Vegetable Research in Varanasi, Uttar Pradesh, India. The research site was located at the Horticultural Research Station, Mondouri, Nadia under Department of Vegetable Science, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya near the Tropic of Cancer at 23.5° N latitude and 80° E longitude, with an altitude of approximately 9.75 m above sea level. The area experiences a sub-tropical climate throughout the growing season. The predominant soil type at the experimental site was the New Alluvial Zone of West Bengal, characterized by sandy loam soil with slightly acidic pH and good water holding capacity. The experiment followed a randomized block design with three replications, conducted from July 2019 to February 2020. Seeds of each genotype were sown in rows with a spacing of 1m between rows and 60 cm between plants. Several important traits were observed, including days to first flowering, days to 50% flowering, days to first harvest, crop duration, vine length during the final harvest, number of branches during the final harvest, number of pods per plant, pod length, pod girth, pod weight, number of seeds per pod, seed yield per plant, and seed index. Data were collected from five competitive plants within each replication of the genotype under study. Statistical analysis of the replicated data was performed using the OPSTAT software.

Results and Discussion

Growth Parameter

Vine Length: The vine length of the winged bean plants varied significantly among the 20 genotypes evaluated in the study, with mean values ranging from 568.17 cm to 715.50 cm (Table 1). The genotypes exhibited a considerable amount of variation in vine length. Among them, the genotype VRWB-95 demonstrated the highest vine length of 715.50 cm, surpassing the other genotypes. The varieties VRWB-09, VRWB-60, and VRWB-84 also displayed notable plant heights, measuring 672.33 cm, 670.67 cm, and 660.50 cm, respectively. These findings align with a similar result reported by Thongbam *et al*. in 2020 [9].

Number of Branches/Plant: The number of branches per plant for each genotype was analysed and the results are presented in Table 1. Among the genotypes, VRWB-11-2 exhibited the highest number of branches per plant (15.00), followed by VRWB-09 (14.50), which significantly differed from all other genotypes. Genotypes VRWB-21, VRWB-12, VRWB-13, VRWB-95, and VRWB-22 produced a mean number of branches ranging from 12.00 to 13.50, showing no significant differences among them. VRWB-17 and VRWB-4A displayed a similar number of branches per plant (11.83). On the other hand, VRWB-13-6 had the lowest number of branches per plant (6.50), which was statistically similar to VRWB-18 (7.50), VRWB-23 (7.66), and VRWB-20 (8.50). The genotypes with lower branch numbers may be attributed to their inherent genetic characteristics. Similar findings have been reported by Prasanth *et al*., in 2015 [6] and Thongbam *et al.*, in 2020 [9].

Days to First Flowering: Among the genotypes evaluated, the minimum days to first flowering were observed in VRWB-84, VRWB-09, and VRWB-22, with durations of 68.66 days, 69.33 days, and 69.33 days, respectively. VRWB-18 and VRWB-60 followed closely with durations of 70.33 days and 70.66 days, respectively (Table 1). The longest duration to first flowering was recorded in genotype VRWB-23 at 83.33 days, followed by VRWB-13-1 at 82.00 days. These findings are consistent with the research conducted by Kant *et al.,* in 2018 [3] and Lawal *et al.,* in 2019 [4].

Days to 50% Flowering: The genotypes VRWB-22, VRWB-84, VRWB-11-2, VRWB-17, and VRWB-18 exhibited the lowest durations of 75.33 days, 76.00 days, 78.00 days, 78.00 days, and 78.66 days, respectively, for 50% flowering. On the other hand, the genotypes VRWB-12 and VRWB-13-6 required the maximum duration of 90.66 days for 50% flowering (Table 1). Similar variations in flowering time were reported by Kant *et al.,* in 2018 [3] and Lawal *et al.* in 2019 [4].

Yield and Yield Attributes

Number of Pods per Plant

The number of pods per plant varied among the genotypes, ranging from 39.50 to 151.66 (Table 1). The highest number of pods, 151.66 per plant, was observed in genotype VRWB-09. Other genotypes such as VRWB-60, VRWB-21, and VRWB-17 also produced more than 100 pods per plant. Genotypes like VRWB-13, VRWB-4B, VRWB-13-1, VRWB-95, VRWB-83, and VRWB-4A had an average of 82.50 to 91.00 pods per plant (Fig 2). The lowest number of pods, 39.50, was recorded in genotype VRWB-13-6. The variation in pod number among the genotypes may be attributed to genetic variability or differences in climatic conditions during the growth period. Similar findings were reported by Prasant *et al*. in 2014 [5].

Pod Girth (mm): The pod girth of winged bean genotypes showed a wide range of variation. The widest pod girth, measuring 22.62 mm, was observed in genotypes VRWB-13-1 and VRWB-18. These genotypes were statistically similar to VRWB-95 (21.84 mm), VRWB-22 (21.81 mm), VRWB-83 (21.57 mm), and VRWB-09 (21.46 mm), but significantly different from all other genotypes (Table 1). The genotype VRWB-4B had the smallest pod girth of 15.08 mm, followed by VRWB-21 (16.44 mm), VRWB-13 (16.62 mm), and VRWB-23 (16.91 mm). The variations in pod girth can be attributed to inherent variability among different genotypes.

Pod Length (cm)

The pod length of winged bean genotypes exhibited significant variability. The longest pod length of 19.08 cm was observed in genotype VRWB-95, which was significantly different from all other genotypes. Genotype VRWB-11-2 had a pod length of 18.23 cm, followed by VRWB-22 and VRWB-17 with lengths of 18.16 cm and 18.07 cm, respectively. Genotype VRWB-13-6 had the shortest pod length of 12.19 cm, which was significantly different from most other genotypes except VRWB-11. Other genotypes did not show significant differences in pod length. The longest pod length in VRWB-95 could be attributed to its genetic characteristics and favourable environmental conditions during the study period. These findings align with the research by Kant *et al.* 2018 [3], Lawal *et al.* 2019 [4], and

Thongbam *et al.* 2020 [9].

Pod Weight (g): Genotype VRWB-95 exhibited the highest pod weight of 31.98 g. Other genotypes such as VRWB-22 and VRWB-17 also produced relatively higher pod weights. The variation in pod weight among genotypes can be attributed to their inherent characteristics. The lowest pod weight of 14.76 g was observed in genotype VRWB-11, followed by VRWB-60 with a pod weight of 15.36 g (Table 2). Significant differences in pod weight were observed among the other genotypes. The study revealed a wide range of variation in pod weight among winged bean genotypes. Similar findings were reported by Thongbam *et al.* 2020 [9].

Green Pod Yield/Plant: The Genotype VRWB-11-2 achieved the highest green pod yield per plant of 3.56 kg, followed by VRWB-95, VRWB-09, and VRWB-17 with yields of 2.86 kg, 2.75 kg, and 2.62 kg per plant, respectively (Table 2). These genotypes showed statistically significant differences compared to all other genotypes, but they were similar to each other. The variation in green pod yield among genotypes may be attributed to genetic variability within the genotypes themselves or variations in climatic conditions during the growing period. The lowest green pod yield of 0.62 kg per plant was observed in genotype VRWB-13-6, while VRWB-18, VRWB-20, and VRWB-23 produced yields of 0.72 kg, 0.90 kg, and 0.94 kg per plant, respectively (Fig. 1). These findings align with the results reported by Prasanth *et al.* 2015 [6].

Days to First Harvest: Significant differences were observed among all genotypes in terms of days required for first harvesting. The parameter "days to first harvest" exhibited a wide variation, ranging from 121.66 to 142.83 (Table 2). Genotype VRWB-84 had the shortest time to first harvest, taking only 121.66 days, followed by genotype VRWB-09 with a duration of 127.60 days. These two genotypes were found to be suitable for early harvesting. On the other hand, genotype VRWB-83 took the longest time, with 142.83 days for first harvest. The remaining genotypes had an average first harvest time ranging from 129 to 138 days.

Duration of the Crop: The duration of the crop varied among the genotypes, with mean values ranging from 171.75 days to 207.50 days. Similar results were also reported by Yulianah *et al*. 2020. The longest crop duration of 207.50 days was observed in genotype VRWB-21, followed by genotypes VRWB-95, VRWB-13-1, and VRWB-12, which had crop durations of 205.25, 205.00, and 204.00 days, respectively (Table 2). The shortest crop duration of 171.75 days was observed in genotype VRWB-23, followed by VRWB-13-6 and VRWB-26, with crop durations of 180.00 and 185.75 days, respectively. These durations differed significantly from the other genotypes. The variation in crop duration among the genotypes may be attributed to their specific inherited characteristics for the total lifespan.

Number of Seeds/Pod: The number of seeds per pod varied among the genotypes, with the highest number observed in VRWB-13 (12.17), followed by VRWB-26 (12.00) and VRWB-18 (11.50) (Table 2). The differences in the number of seeds per pod among the genotypes may be due to genetic factors or environmental influences during the growing period. The lowest number of seeds per pod, 6.50, was obtained from VRWB-84, followed by VRWB-4B (7.67) and VRWB-4A (7.83). These results align with the findings of Lawal *et al.* 2019 [4], Prasanth *et al.* 2016 [7], and Thongbam *et al*. 2020 [9].

Seed Yield/Plants (g): The variety had a significant effect on the number of seeds per plant. Genotype VRWB-09 had the highest number of seeds per plant, with a yield of 591.11 g (Table 2). Genotype VRWB-21 had the second-highest yield of 471.90 g, followed by VRWB-11-2 with 463.03 g. The variation in seed yield among the genotypes could be attributed to the number of seeds per pod and the size of the seeds. The lowest seed yield per plant was observed in VRWB-13-6, with a yield of 92.48 g, followed by VRWB-18 with 141.09 g. These two genotypes differed significantly from the other genotypes in terms of seed yield. These findings are consistent with the results reported by Thongbam *et al*. 2020 [9].

Test Weight (g): The weight of 100 seeds varied significantly among the genotypes. VRWB-21 had the highest weight of 46.62 g, followed by VRWB-13-1 with 42.62 g and VRWB-20 with 41.91 g (Table 2). This finding is consistent with the results reported by Prasanth *et al*. 2016 [7]. The lowest test weight of 30.82 g was observed in VRWB-11, and the second lowest weight was found in VRWB-4B with 33.35 g. The genotypes that produced higher 100 seed weights may be attributed to favourable plant growth and climatic conditions during flowering and seed formation, as well as genetically inherited characteristics of the genotypes.

Shelling Percentage (%): The genotype VRWB-83 exhibited the highest shelling percentage of 53.50, followed by VRWB-95 with a shelling percentage of 51.83. This finding is consistent with the results reported by Prasanth *et al*. 2016 [7]. Shelling percentage showed significant and positive correlations with the number of pods per plant and the number of seeds per pod. The lowest shelling percentages of 47.16 and 47.50 were observed in the VRWB-11 and VRWB-21 genotypes, respectively. The shelling percentages ranged from 47.16 to 53.50 among the genotypes (Table 2).

Table 1: Growth and yields attributes of winged bean genotypes under New Alluvial Zone of West Bengal.

Genotypes	Vine length (cm)	Number of branches per plant	Days to first flowering	Days to 50% flowering	Number of pods per plant	Pod girth (mm)	Pod length (cm)
VRWB-17	594.33	11.83	72.66	78.00	100.90	17.05	18.07
VRWB-23	610.67	7.66	83.33	88.00	65.66	16.91	17.30
VRWB-13-1	654.83	9.00	82.00	85.00	88.33	22.62	16.11
VRWB-84	660.50	10.33	68.66	76.00	67.33	18.47	17.71
VRWB-21	619.83	13.50	74.66	81.00	104.66	16.44	17.03
VRWB-09	715.50	14.50	69.33	79.66	151.66	21.46	16.03
VRWB-95	670.67	12.66	71.33	80.00	91.00	21.84	19.08
VRWB-18	634.67	7.50	70.33	78.66	36.83	22.62	16.00
VRWB-4A	568.17	11.83	75.66	82.66	90.33	18.31	14.41
VRWB-13	653.83	12.83	72.66	80.33	82.50	16.62	16.43
VRWB-83	663.33	10.16	74.00	83.00	90.66	21.57	14.99
VRWB-20	594.00	8.50	71.00	81.33	41.16	17.94	15.34
VRWB-12	638.00	13.16	80.33	90.66	132.00	18.64	13.40
VRWB-60	615.83	11.16	70.66	78.66	114.00	18.09	14.38
VRWB-22	589.67	12.00	69.33	75.33	66.16	21.81	18.16
VRWB-11-2	672.33	15.00	71.66	78.00	135.66	16.49	18.23
VRWB-26	620.17	10.83	79.66	89.00	66.83	18.37	16.95
VRWB-4B	568.50	11.33	71.66	79.33	87.50	15.08	16.16
VRWB-11	573.50	8.33	79.33	86.33	76.66	18.70	13.11
VRWB-13-6	574.50	6.50	80.33	90.00	39.50	17.77	12.19
C.D	40.25	0.82	3.82	4.34	13.81	N/A	2.53
SE(m)	14.01	0.28	1.33	1.51	4.80	1.753	0.88

Table 2: Growth and yields attributes of winged bean genotypes under New Alluvial Zone of West Bengal.

Genotypes	Pod weight (g)	Green pod yields per plant (kg)	Days to first harvest	Duration of the crops (days)	Number of seeds/pods	Seed yields /plant	100 seeds weight /seed index (g)	Shelling percentage
VRWB-17	23.89	2.86	138.33	202.25	11.16	391.19	35.50	49.66
VRWB-23	17.58	0.94	139.83	171.75	8.00	265.94	36.14	50.83
VRWB-13-1	17.30	1.56	135.58	205.00	9.83	349.96	41.74	49.50
VRWB-84	21.01	1.38	121.66	192.75	6.50	160.22	38.24	49.50
VRWB-21	19.52	2.05	137.25	207.50	10.50	356.54	38.84	47.50
VRWB-09	27.31	2.75	127.60	197.75	12.60	591.11	46.62	53.50
VRWB-95	24.35	3.56	134.58	205.25	12.00	471.90	42.62	51.83
VRWB-18	21.34	0.72	138.58	197.25	9.50	141.09	36.02	48.33
VRWB-4A	21.04	1.86	130.16	196.50	7.83	241.62	35.87	49.50
VRWB-13	20.01	1.60	134.16	199.50	12.17	351.77	36.82	49.33
VRWB-83	18.39	1.78	142.83	198.00	11.16	351.81	38.82	48.33
VRWB-20	21.80	0.90	129.83	192.50	9.00	188.73	35.11	48.50
VRWB-12	19.27	2.44	137.16	204.00	10.83	358.28	35.36	49.00
VRWB-60	15.36	1.84	132.08	190.25	11.50	412.16	41.91	49.00
VRWB-22	17.60	1.70	130.00	189.00	9.50	277.28	39.62	50.00
VRWB-11-2	24.72	2.62	129.33	192.25	10.83	463.03	39.62	48.50
VRWB-26	21.79	1.23	130.91	185.75	10.50	311.25	39.85	49.16
VRWB-4B	21.92	2.02	130.00	186.16	7.66	213.39	33.35	49.83
VRWB-11	14.76	1.10	140.08	196.00	9.83	230.96	30.82	47.16
VRWB-13-6	16.66	0.62	134.25	180.00	7.16	92.48	35.08	49.66
C.D	N/A	0.68	5.47	9.91	1.63	92.20	2.31	N/A
SE(m)	2.42	0.23	1.90	3.44	0.56	32.08	0.80	1.81

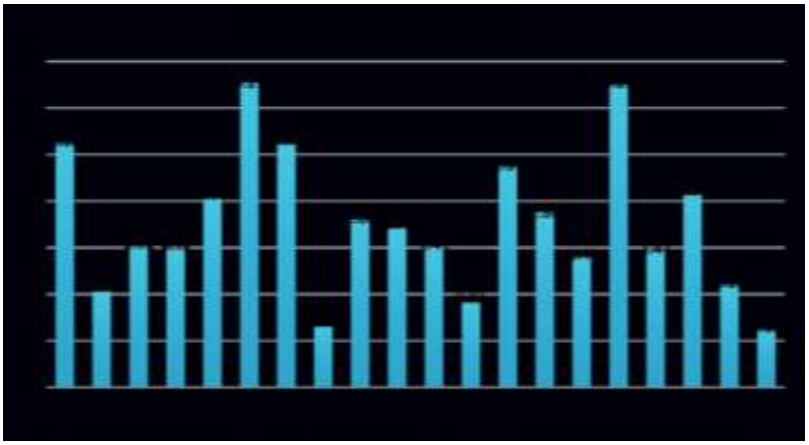

Fig 1: Graph showing variation of green pod yields/plants of winged bean genotypes under New Alluvial Zone of West Bengal.

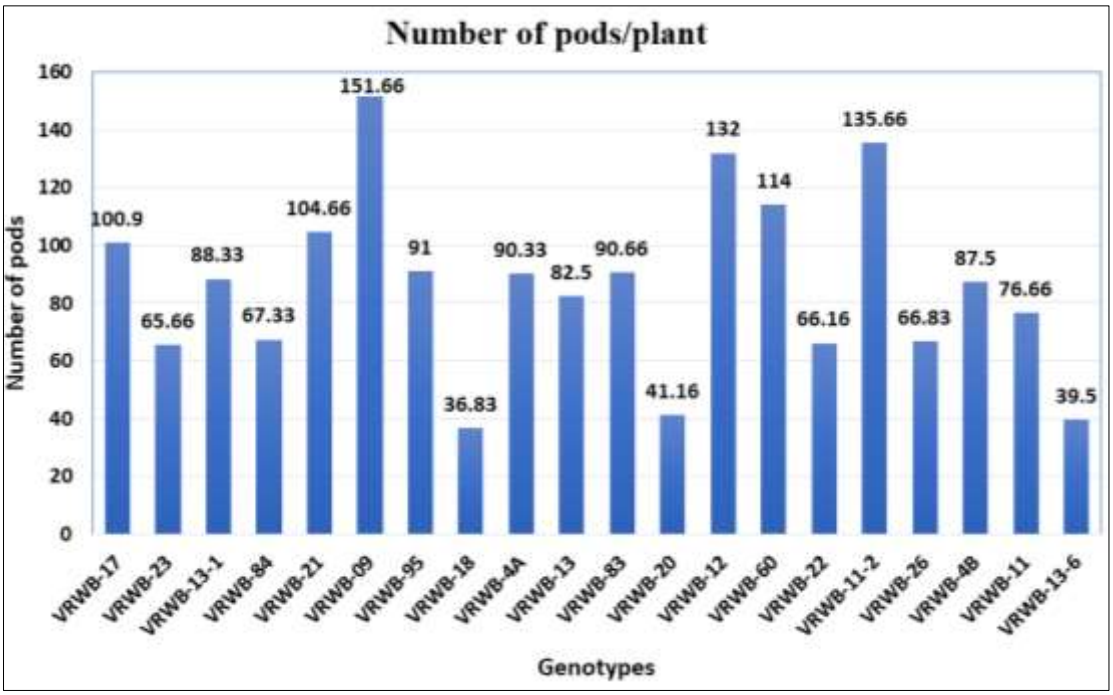

Fig 2: Graph showing variation of number of pods/plants of winged bean genotypes under New Alluvial Zone of West Bengal.

Plates 1: Mature pods of 20 genotypes and notable genotypes in the new alluvial zone of West Bengal

Plates 2: Notable genotypes among the 20 genotypes of winged bean in the new alluvial zone of West Bengal

Conclusion

From the overall point of view of the result and discussion, it was concluded that genotype with higher vine length with the highest number of branches have higher pod yields per plant. The genotype like VRWB-09, VRWB-11-2 and VRWB-17 displayed superior performance compared to the others genotypes. Conversely, VRWB-13-6 exhibited poor performance in terms of pod girth, length, and pod yields per plant. Among the 20 genotypes studied, VRWB-84, VRWB-09, VRWB-22, VRWB-18, and VRWB-60 were identified as early flowering, while VRWB-23 and VRWB-13-1 were categorized as late flowering genotypes. It was observed that genotypes with a greater number of seeds per pod and higher bearing capacity per plant generally resulted in higher seed yield. Notably, VRWB-09, VRWB-11-2, and VRWB-12 demonstrated promising results in this regard. Based on the findings of this investigation, it is recommended that genotypes such as VRWB-09, VRWB-11-2, and VRWB-12 be considered as promising options for achieving better pod and seed yields under the prevailing conditions in West Bengal.

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