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Response of winged bean genotypes (*Psophocarpus tetragonolobus*) to different levels of fertilizer

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Abstract
This study was designed in order to evaluate the growth and yield performance of some winged bean genotypes (*Psophocarpus tetragonolobus*) i.e. EC178335, IC026946, PWB 17-1, AKWB-1, Indira Winged bean -1, RMDWB-1 and PWB-11-2 and their responses to different levels of NPK fertilization. The seven mentioned genotypes were fertilized with four NPK levels i.e. control (no fertilizer), 75% RDF, RDF(20:40:20) and 125% RDF. Data showed that Amongst the growth parameters, significantly higher days to 50% flowering and days to pod setting was recorded with PWB17-1 and AKWB-1 respectively while lowest in EC178335 in both growth parameters however significantly higher days to 50% flowering was recorded with application of 125% RDF and lowest in control while days to pod setting and pod length was not significantly influenced due to fertilizer levels, significantly higher pod length was recorded with RMDWB-1. Amongst the yield attributes, number of pods per plant, number seeds per pod was significantly higher with genotype AKWB-1 while significantly higher 100 seed weight was recorded with genotype IC026946 however fertilizer levels was not significantly influenced the any yield attribute, significantly higher grain yield, gross returns, net returns and B:C ratio were found in genotype AKWB-1 and least was observed in the genotype Indira winged bean-1 and in fertilizer RDF(20:40:20) and 75% RDF as compared to control.

Keywords: winged bean, fertilizer, *Psophocarpus tetragonolobus*

Introduction

Chromosome 2n = 18 is found in the winged bean (*Psophocarpus tetragonolobus*), often called cigarillos, Goa bean, four-angled bean, four-cornered bean, princess bean, asparagus bean, and dragon bean, is an autogamous tropical legume crop with various uses (Mohanty *et al*., 2013) [1]. It is New Guinean in origin. It can be raised as a cover crop, a green vegetable, a tuber crop, a forage crop, and a grain legume. (Khalili *et al.*,2013; Lepcha *et al*., 2017) [1, 2].

It thrives in profusion in South and Southeast Asia's hot, humid equatorial regions. Although widely known, it is only lightly farmed in Papua New Guinea and Southeast Asia. It is grown on a modest scale by locals in some nations, including India, Papua New Guinea, Thailand, Indonesia, and Burma farmers. The versatility and disease resistance of winged bean are well known to consumers and farmers in southern Asia. Although it is currently underutilised, the winged bean has the potential to be a significant, multipurpose food crop in the tropics of Asia, Africa, and Latin America. (Wong *et al*., 2015; Lepcha *et al*., 2017) [3, 2].

The genus *Psophocarpus*, which is a member of the legume family Fabaceae, is where the species of winged bean is found. Psophocarpus species are perennial herbs that are grown as annuals. There are tuberous roots and pods with wings in *Psophocarpus* species. By twining their stems around a support, they can climb (Wong *et al*., 2017) [3]. Because of their high protein content, ability to fix nitrogen, and adaptability to a wide range of agroclimatic conditions, legume vegetables continue to hold a special place in both the food and agricultural industries. (Singh *et al*., 2016; Pandey *et al*., 2016; Nandan *et al.*, 2016) [4].

A popular protein-rich legume crop that encourages profuse nodulation and consequently high nitrogen fixation, winged beans are a good source of protein for tropical locations, according to nutritional status (Singh *et al*.,2016; Pandey *et al*., 2016) [4].

Winged beans are often eaten as green, soft pods that may be sliced or diced and contain a wealth of minerals and vitamins. The seeds can be used in ways similar to those of soybeans and have a protein value of between 30 and 37% while also having an oil content of between 15 and 18%. The addition to this winged bean was a plant dubbed "One Man Supermarket" since the leaves, pods, stem, seeds, blooms, and spongy roots could all be eaten fresh. (Lepcha *et al*., 2017; Singh *et al*., 2018) [2].

Fertilizers are crucial to the cultivation of pulse crops. Therefore, as farmers understand more about the importance of fertilisers in agricultural yield, the demand for fertilizers is rising rapidly. Huge amounts of manure can be used to grow large crops without the use of fertilisers, but this practise is not common because there isn't enough of it to meet the demand.

The use of small amount of nitrogenous fertilizers for establishing legumes is a common practice in western countries (Papanicolou *et al*; 1977, Cardoso *et al*., 1978 and Endo *et al*; 1988) [5, 6, 7]. In India also, split application of nitrogen in french bean (*Phaseolus vulgaris* L.) has been found to be useful (Singh and Rajput, 1987) [8]. Although it is generally understood that legume plants do not benefit from extra nitrogen, a small amount can be utilised to promote early growth until nodulation begins.

Numerous studies conducted in India and overseas had suggested that the winged bean crop needs phosphate and potassium. Indian soils do not lack potassium, although most of them have phosphorus issues.

Application of phosphatic fertilizer plays an important role in leguminous crops. Phosphorus is highly efficient in promoting root growth and ultimately the yield of leguminous crops (Perr and Bose, 1944). In India, the average yield of winged bean is low, which may be related to the inadequate availability of phosphorus. It directly affects many of the metabolic processes that plants go through. It serves as the "Master key" component in the development of crops. Iron and aluminium are detrimental to the availability and uptake of phosphorus by plants at low pH levels, while calcium is detrimental at high pH levels. To increase the amount of soil-available phosphorus, phosphoric fertilisers are added.

The efficient phosphorus solubilizing micro-organisms as inoculates are added in the root zone of crop plants for increasing the soluble forms of phosphatic compounds in soil and improve the fertilizer use efficiency (Somani *et al*. 1990) [10].

Winged bean (pod and grain type) better variants have been made available recently. The only way to fully use the yield potential of these genotypes is through improved crop management and optimal nutrition.

There have been reports of many genotypes and land races of winged bean with varying pod, seed, and tuber characteristics (Parthasarathy, 1993) [11]. Consequently, there is scope to utilise this crop's potential to produce vegetable tubers, seeds, and mature pods. This necessitates the development of geographically specific scientific studies, starting with genotype identification and standardisation of production techniques.

Method and material

A experiments were carried out during the *kharif* season of 2022-23 at the Research farm of Raj Mohini Devi College of Agriculture and Research Station, Ambikapur (C.G.) India to study the effect of different levels of NPK fertilizer and genoitypes on growth, yield attributes, yield,and economics of some winged bean.

The experiment included 28 treatments, which were the combination between seven winged bean genotypes and four levels of fertilizer as follows:

Genotypes of winged bean: EC178335, IC026946, PWB 17-1, AKWB-1, Indira Winged bean -1, RMDWB-1 and PWB-11-2.

Levels of fertilizer (NPK): control (no fertilizer), 75% RDF, RDF (20:40:20) and 125% RDF. At the time of sowing, Urea and IFFCO (12:32:16) were used to apply the treatment (control, 75% RDF, RDF (20:40:20) and 125% RDF) as basal dose.

The soil of experimental field was “Inceptisols” locally known as *“Chawar”*. The crop was sown on 13th July 2022. The investigation was carried out in factorial randomized block design with two factors genotype (seven genotypes) and fertilizer levels (four fertilizer) with twenty eight treatment combinations. Each experimental unit was replicated thrice with net plot size of 4 m × 2.4 m and spacing 60 cm × 30 cm (row × plant).

Data recorded

Plant stands at harvest: The plant stand at harvest was recorded separately during the pod pickings such that we can compare easily plant stand the crop establishment to the harvest.

Days to 50% flowering: The period from the date of sowing seeds to the date in which the 50% of established crop blooms, this period is calculated for every treatment in all the replications.

Days to pod setting: The period from the date of sowing seeds to the 1st appearance of the pod on the plant and this recording is taken for all the replications.

Pod length (cm): The length of the pod plays a major contribution in maximizing the yield, and the length is measured using a scale of measurement and the length of the 5 different pods is noted from every plots and there replications.

Number of pods per plant: To study formation of pods in winged bean crop, pods from five tagged plants in each net plot were collected and counted and the mean data was calculated and used for statical analysis.

Number of seeds per pod: Five pods from total pods of five randomly selected plants from each plot were taken. Total number of seeds of these pods was counted and their mean value was expressed as the number of seeds per pod.

100 seed weigh (g): 100 seeds from each treatment were counted and weighed separately such that the 100 seed weight is measured in grams.

Seed yield (q ha^{-1}): The pods collected were dried in sun such that the pods shatter due to heat and the seeds were collected. Next to that the seeds are weighed in gm per plot and converted to q/ha.

Economics of the treatment

Cost of cultivation (Rs ha^{-1}): The total cost of cultivation in a treatment is the total amount spent on growing the crop. The cost of cultivation (Rs ha^{-1}) for each treatment was determined by calculating the price of inputs, cultivation charges, labour and other costs.

Gross return (Rs ha^{-1}): Gross returns are the total monetary value of economic produce and by products obtained from the crop raised in the different treatments is calculated based on the local market prices.

Net return (Rs ha^{-1}): Net return is obtained by subtracting cultivation costs from gross returns. It is good indicator of suitability of a treatment since it represents the actual income.
Net profit (Rs ha^{-1}) = Gross income (Rs ha^{-1}) - Cost of cultivation (Rs ha^{-1})

Benefit: Cost ratio: The benefit cost ratio is the ratio of net profit to cultivation costs. The benefit: cost (B: C) ratio was calculated using the formula below.

$$\text{Benefit: Cost Ratio} = \frac{\text{Net income (Rs ha}^{-1})}{\text{Cost of cultivation (Rs ha}^{-1})}$$

Results

Effect of genotypes

Vegetative growth: At all growth stages, the genotypes had a significantly impact on growth parameters such as days to 50% flowering (57.25) and days to pod setting (80.50) was recorded lowest in genotype EC178335 while days to 50% flowering (75.08) and days to pod setting (93.66) was recorded highest by PWB17-1 and AKWB-1 respectively. Highest pod length (18 cm) was recorded by RMDWB-1 however this genotype was statically at par with the genotype AKWB-1 (17.33 cm) and PWB-11-2 (16.83 cm). Plant stand at harvest was not significantly influence due to different genotypes.

Yield attributes: All the yield attributes character was significantly influenced due to genotypes such as winged bean genotype AKWB-1 produced highest number of pods per plant (34.08) as well as highest number of seeds per pod (13) however this was statically at par with PWB-11-2 (12), genotype IC026946 produced higher 100 seed weight (34.16 g) however this genotype was statically at par with the EC178335 (31.25) and Indira winged bean-1 (31.25).

Yield: Winged bean seed yield varied significantly with different genotypes. Winged bean seed yield was significantly higher produced by genotype AKWB-1 (G_4) (18.43 q ha^{-1}) however this genotype was statically at par with the genotype IC026946 (G_2) (17.80 q ha^{-1}), lowest seed yield (14.973 q ha^{-1}) was produced by Indira winged bean-1 (G_5) and which was found at par with PWB-11-2 (G_7) (15.684 q ha^{-1}).

Economic: Economic study revealed that winged bean genotype AKWB-1 (G_4) was superior to other genotype evaluated. Higher gross returns (Rs 1,03,236 ha^{-1}), net returns (Rs 69,743 ha^{-1}), and benefit cost ratio (2.08) were reported with the genotype AKWB-1 however this genotype was statically at par with the genotype IC026946 (G_2) which gave gross returns (Rs 99,703 ha^{-1}), net returns (Rs 66,211 ha^{-1}) and benefit cost ratio (1.97).

Effect of fertilizer levels

Vegetative growth: Days to 50% flowering was increased linearly with an increase in level of fertilizer from control to 125% RDF. Significantly higher days to 50% flowering was recorded with 125% RDF and lowest days to 50% flowering was recorded with control. Days to pod setting and pod length was not significantly influenced due to fertilizer levels.

Yield attributes: All the yield attributes character and plant stand at harvest was not significantly influenced due to different fertilizer levels.

Yield: Seed yield of winged bean was increased linearly with an increase in level of fertilizer from control to RDF (20:40:20). Significantly higher seed yield of 19.48 q ha^{-1} was obtained with RDF (20:40:20) and it was at par with treatment F_2 (75% RDF).

Economic: The application of RDF (20:40:20) fertilizer (F_3) realized maximum gross return, net return and B:C ratio of 109112 Rs. ha^{-1}, 74,742 Rs. ha^{-1} and 2.17, respectively, it was at par with treatment F_2 (75% RDF) which gave gross return (Rs 105899 ha^{-1}), net return (Rs 72,406 ha^{-1}) and B:C ratio (2.16).

Table 1: Plant stand at harvest, days of 50% flowering and day to pod setting and pod length of winged bean as influenced by genotypes and fertilizer

Treatments	Growth parameters			
	Plant stand at harvest(K/ha)	Days of 50% flowering	Days to pod setting	Pod length (cm)
Genotypes				
EC178335	50.43	57.25	80.50	16.50
IC026946	50.34	61.41	80.75	16.08
PWB17-1	50.86	75.08	88.91	16.16
AKWB-1	50.87	68.16	93.66	17.33
Indira winged bean -1	50.43	66.83	88.33	16.41
RMDWB- 1	50.60	67.5	83.33	18.00
PWB-11-2	50.95	70.16	91.66	16.83
SEm±	0.62	0.74	0.95	0.45
C.D. (0.05)	NS	2.11	2.70	1.28
Fertilizer				
Control	50.49	63.19	86.00	16.33
75% RDF	50.64	65.33	86.52	16.66
RDF (20:40:20)	50.84	67.57	86.57	16.81
125% RDF	50.59	70.42	87.85	17.23
SEm±	0.47	0.56	0.71	0.34
C.D. (0.05)	NS	1.59	NS	NS
Interaction (G x F)				
C.D. (0.05)	NS	NS	NS	NS

Interaction effect

The interaction effect between genotype and fertilizer levels was found not significant with respect to days to 50% flowering, days to pod setting, pod length, number of pods per plant, number of seeds per pod, 100 seed weight, plant stand at harvest and seed yield.

Table 2: Yield attributing characters of winged bean as influenced by genotypes and fertilizer.

Treatments	Yield attributes		
	Number of pods per plant	number of seeds per pod	100 seed weight
Genotypes			
EC178335	27.58	11.58	31.25
IC026946	25.16	11.50	34.16
PWB17-1	30.50	11.41	26.75
AKWB-1	34.08	13.00	28.91
Indira winged bean-1	22.83	10.41	31.25
RMDWB-1	24.25	11.08	29.75
PWB-11-2	26.91	12.00	28.58
SEm±	0.51	0.35	1.24
C.D. (0.05)	1.45	1.01	3.55
Fertilizer			
Control	26.61	11.14	30.66
75% RDF	27.42	11.71	30.66
RDF (20:40:20)	27.85	12.04	29.57
125% RDF	27.42	11.38	29.47
SEm±	0.38	0.27	0.94
C.D. (0.05)	NS	NS	NS
Interaction (G x F)			
C.D. (0.05)	NS	NS	NS

Table 3: Seed yield of winged bean as influenced by genotypes and fertilizer

Treatments	Seed yield (quintal ha^{-1})
Genotype	
EC178335	17.07
IC026946	17.80
PWB17-1	17.04
AKWB-1	18.43
Indira winged bean -1	14.97
RMDWB- 1	16.30
PWB-11-2	15.68
SEm±	0.45
C.D. (0.05)	1.29
Fertilizer	
Control	11.19
75% RDF	18.91
RDF (20:40:20)	19.48
125% RDF	17.44
SEm±	0.34
C.D. (0.05)	0.97
Interaction (G x F)	
C.D. (0.05)	NS

Table 4: Economics of winged bean as influenced by genotypes and fertilizer.

Treatments	Economics			
	Gross return (Rs./ha)	Cost (Rs./ha)	Net return (Rs./ha)	B:C ratio
Genotype				
EC178335	95,632	33492	62,139	1.85
IC026946	99,703	33492	66,211	1.97
PWB17-1	95,442	33492	61,950	1.84
AKWB-1	1,03,236	33492	69,743	2.08
Indira winged bean -1	83,846	33492	50,353	1.50
RMDWB- 1	91,280	33492	57,787	1.72
PWB-11-2	87,831	33492	54,339	1.62
SEm±	2,546.37		2,546.37	0.07
C.D. (0.05)	7,239.74		7,239.77	0.22
Fertilizer				
Control	62,704	30860	31,844	1.03
75% RDF	105899	33493	72,406	2.16

RDF (20:40:20)	109112	34370	74,742	2.17
125% RDF	97,696	35246	62,450	1.77
SEm±	1,924.87		1,924.88	0.05
C.D. (0.05)	5,472.73		5,472.75	0.16
Interaction				
C.D. (0.05)	NS		NS	NS

Conclusion
In light of the results obtained from this investigation, it is concluded that for securing maximum seed yield production and getting higher net return, winged bean genotype AKWB-1 should be fertilized at RDF(20:40:20) in slightly acidic soils under northern hills zone Chhattisgarh condition.

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