

Original Research Article

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Evaluation of Soybean Lines for Edamame (*Glycine max* (L.) Merrill) as a Potential Vegetable for Telangana State of India

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ABSTRACT

Edamame (*Glycine max* (L.) Merrill) also called vegetable soybean is an import vegetable and well recognized for health and nutritional benefits in the world. Soybean cultivars with large seed size and high sucrose content are desirable in the production of vegetable soybean, which is the food bean harvested at R6 stage and just before turning to yellow colour. However, the farmers in the state cultivating regular soybean for the past two decades but there is no suitable or improved vegetable soybean cultivars in the state of Telangana, India. In this study, 7 breeding lines were evaluated in replicated field trials for vegetable soybean green pod yield, 100 green seed weight, agronomic traits, cooking quality by sensory attributes and nutritional composition in Agricultural Research station, Adilabad, Telangana state in 2018. For days to harvest at R6 stage VEG2 taken less days (62days), followed by VEG4 (63 days) and VEG7 taken 104 days to harvest at R6 stage. The trait green pod yield at harvest per plant has recorded maximum in case of genotype VEG 4 (7846 kg/ha) followed by VEG7 (7551 kg/ha). In case of 100 green seed weight, the highest mean was observed in VEG 2(75.0g) followed by VEG 4 (74.3g). The genotype VEG 4 is nutritionally equal to regular soybean and superior to other vegetables consumed in the state. Further it was well accepted as a vegetable curry by the panelists in terms of sensory attributes. Further this vegetable soybean may go as supplementary vegetable curry or food source for rural areas of Telangana for nutrition intervention programmes.

Keywords

Vegetable soybean,
Promising lines,
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Introduction

In India, soybean (*Glycine max*) is a major oil seed crop in terms of area, production and economic value. It is mostly grown for the

source of edible vegetable oil for human consumption, defatted soy protein products or soy protein extracts (concentrates or isolates) are an important ingredient for several processed foods and protein meal for animal

feeds (Xiaoyu *et al.*, 2011). In some kind of health foods, baby foods and bakery snacks, defatted soybean flour is an important industrial ingredient in making of premium category foods. Currently India is producing 13.15 million tonnes of soybean from an area of 11.67 Million hectares and the production share accounts 42% of country's total oil seeds production. The Telangana state in India is producing 0.25 million tonnes of soybean from an area of 0.24 million hectares (Directorate of Economics and Statistics-2017). However vegetable soybean (Gglycine max (L.) Merrill) is relatively new to India, although recently directorate of Soybean of ICAR developed NRC105 (INGR10056) vegetable genotype for the table purpose. Vegetable-type soybean, also called edamame and edamame is the Japanese name for a special type of immature soybean that is consumed as a vegetable or snack. It is also known as green soybean or edible soybean in North America and maodou in China (Guo-Liang Jiang *et al.*, 2018). Edamame is harvested at the R6 growth stage (Fehr *et al.*, 1971), when the pod cavity is completely filled and the seeds and pod shell are still green in colour and a soft texture (Huang *et al.*, 2014; Saldivar *et al.*, 2010). The regular soybean harvested after full maturity (R8 stage). The tender sweet green seeds have high nutritional values over other legume based vegetables and improved sensory attributes over mature soybean such as sweeter flavor and reduced levels of stachyose and raffinose, resulting in better digestibility (Song *et al.*, 2003). The fermented soymilk from vegetable soybeans showed to be a good food matrix to deliver probiotic bacteria, as well as a soy product with a lower content of non-digestible oligosaccharides (Carolina *et al.*, 2018). Similar to regular dried soybean, vegetable soybean is rich in good quality protein, has a high mineral content and has the potential to prevent some diseases, including cancer,

osteoporosis and menopausal symptoms due to its content in isoflavones (Sirisomboon *et al.*, 2007).

Protein Calorie Malnutrition (PCM)' is a major concern in Telangana state in India especially in infants, young children and nursing mothers in rural areas. About 33.1% children below 5 years under weight (weight for age), 33.3% children below 5 years under stunted (Height for age) and 67.5% children less than 5 years are suffering with anaemic problems (NFHS-4 data, 2015-16). Since, many parts of the state producing regular soybean and farmers have the skill set for production of soybean and other regular vegetables. Then the production of vegetable soybean is a good option of crop farming and it also addresses the malnutrition problems at rural areas of Telangana state. The cultivation of vegetable soybean by small-scale farmers and urban agriculture growers is a viable farming option by growing such a high-value niche crop. However, edamame products sold in markets across the United States are mainly imported from China and other Asian countries or regions and are mostly marketed frozen (Guo-Liang Jiang *et al.*, 2018).

Compared with dry soybean as oil seed crop the acreage of edamame grown in the India is much smaller scale and the crop is not yet introduced in the state of Telangana. However, vegetable soybean has better nutrition values than general-purpose soybean (Liu, 1999). In recent decades more and more people have become aware of the health and nutritional benefits of edamame (Messina 1999), and globalization has also provided a platform for international edamame trade. Consequently, there has been a steady increase in edamame market (Guo-Liang Jiang *et al.*, 2018). One of the important reasons for non production of vegetable soybean is that there is a lack of domestically developed or suitable improved edamame

cultivars in the India and also lack of affordable seed. Therefore, growing vegetable soybean faces challenges and/ or problems. From the point of plant breeding, the major problems include limited genetic resources, lodging, inferior plant structure or type, susceptibility to seed diseases, low yield potential, and shattering, which is important for vegetable soybean seed production.

In view of the above advantages, therefore, it is important to develop edamame cultivars adapted to Telangana state ecological and managerial conditions and to enhance the genetic resources for commercial vegetable soybean production and research. The objective of this study was to evaluate edamame seed breeding lines for vegetable soybean production in order to help identify and develop adapted superior vegetable soybean cultivars with desired nutritional and sensory attributes for the state of Telangana.

Materials and Methods

A total of 7 Vegetable soybean genotypes of VEG1 to VEG7 were grown in research farm of Agriculture Research Station, Professor Jayashankar Telangana State Agricultural University, Adilabad, Telangana State of India in *kharif* season of 2018. Most of the genotypes were advanced lines developed by ICAR-Indian Institute of Soybean Research, Indore, India, vegetable soybean/edamame program and derived from different crosses, among one released cultivar (VEG2) was used as check. In a randomized complete block design with three replications, in a black cotton soil with the plot size of 4.05 (sq. m.) having four row plots 3.0 meters long and 1.35 -meter row-spaced were planted at a rate of about 90 plants grown per meter. In accordance with local recommendations, 30kg/ha of nitrogen fertilizer, 60 kg/ha of phosphate (P₂O₅) and 40kg/ha of Potash (K₂O) applied to the soil. The crop

management was similar to general soybean production, with the insecticides Trizophos + Dichlorovos (2.0+1.0 ml/liter water), Emamectin benzoate (1.0g/ liter water), Coragen + Saff (0.3 ml + 2.0 g /liter water) and Novaluron (1 ml/liter water) applied to control Spodoptera, defoliators, Girdle beetle and Stem fly as needed. The insecticides were purchased from a local store of District Cooperative society and used under an experimental use permit.

The vegetable soybean was sown late in June and harvested at R6 stage or the “green bean” stage (Fehr *et al.*, 1971), in fortnight of September. Soybean vegetable samples of 1kg were collected to carry out cooking quality with the help of sensory evaluation and also nutritional composition of freshly harvested vegetable soybean. The traits investigated included plant height (centimetres from the bottom to the top of main stem), Days to harvest vegetable soybean at R6 stage, Green pod yield at harvest (kg·ha⁻¹), Yield of mature seeds (kg·ha⁻¹), the weight (grams) of fresh and dried 100-seeds.

Statistical analysis

Results were expressed as mean ± standard deviation. The difference between groups of each parameter was determined using the t-test and statistical significance was claimed at P < 0.05.

Cooking quality

Cooking of vegetable soybean

2 genotypes namely VEG 2 and VEG 4evaluated for cooking quality in pressure cooker with known amount of water and recorded time consumed to cook to the desired quality as against the control dolichos bean quality (Table 1).

Further, to evaluate the cooking quality and assessing taste profile of vegetable soybean, two regular carries and one cutlet were prepared from vegetable soybean matching to taste profile of South India as shown in Table 2. The sensory evaluation was conducted with dolichos bean curry as a control sample. The cutlet of green peas was used as control sample to explore vegetable soybean seeds are nutritious substitute food for green peas in cutlet.

Nutritional composition

The vegetable soybean seed sample which is superior in terms of genetic traits, cooking quality and acceptable sensory attributes was analyzed for moisture, protein (N* 6.25), ash, crude fibre and crude fat (AOAC, 1990). Carbohydrate was determined by difference. Selected mineral contents (calcium and Iron) and Vitamin-C were determined by using (AOAC, 2000) methods.

Sensory evaluation

The sensory assessments were conducted in a KVK, Adilabad laboratory. The panel of 25 members consisted of staff and graduate students of the College of Agriculture, PJTSAU, Jagtial. The panelists were naive to project objectives. Control (Dolichos bean (RND-1), samples (A, B and C) were used in the evaluation. Samples were coded using random three-digit numbers and served with the order of presentation counter-balanced. Panelists were provided with a glass of water and, instructed to rinse and swallow water between samples. They were given written instructions and asked to evaluate the products for Appearance, colour, taste, flavour, mouth feel and overall acceptability, using a 9- point hedonic scale (1 = dislike extremely to 9 = like extremely; Meilgaard *et al.*, 1999) .

Results and Discussion

Except harvesting at R6 stage, the vegetable soybean cultivation practices are similar to that of regular dried soybeans. In small farms edamame yield is usually harvested by hands. Pods are ready for harvest when they are close to full size and are bright green (between R6 and R7 growth stage), and pods have filled up to 80 – 90% of the pod width (Mentreddy *et al.*, 2002; Basavaraja *et al.*, 2005). It is highly recommended to pre-cool the soybean vegetable immediately after harvesting to reduce the field heat and preserving the freshness as long as possible (Kaiser, and Ernst, 2013). Edamame pods at harvest should have white pubescence; the hilum should be light brown or gray. Two or three seeds must be developed in the pod and pod length must be at least 5 cm and width 1.4 cm (Metredy *et al.*, 2002).

There is a wide variation observed between genotypes (Table 3) according to Germination (%), days to flowering, days to maturity, plant height, days to harvest at R6 stage, Green Pod (vegetable soybean) yield, 100 green seed weight at R6 stage, moisture content, yield of mature seeds. Though the check variety (VEG2) having bold seed size but the germination percentage was very low (33%) when compared to other genotypes and high germination was recorded by genotype VEG7, followed by VEG6 and VEG1. For days to 50% flowering, least genotype was recorded by VEG 4 (24) followed by VEG 2 (25) and high for VEG 7 (32). For days to maturity genotype VEG4 (88days) and VEG3 (93days) had taken less time to mature where as genotype VEG7 (104 days) taken more days to attain maturity. The genotype VEG3 showed high mean performance (93 days). For plant height highest mean performance was recorded for genotype VEG5 (61cm) followed by genotype VEG7 (60.6cm) and least for VEG 2 (33.0cm). For days to harvest

at R6 stage VEG2 taken less days (62days), followed by VEG4 (63 days) and VEG7 taken 104 days to harvest at R6 stage. The trait green pod yield at harvest per plant has recorded maximum in case of genotype VEG 4 (7846 kg/ha) followed by VEG7 (7551 kg/ha) and minimum for VEG 2 (1268kg/ha). Plant height and green pod yield exhibited greater estimates of broad sense heritability than other traits (Table 3). Mebrahtu and Mohamed (2006) reported a greater heritability for plant height and green pod yield as well. In case of 100 green seed weight, the highest mean was observed in VEG 2(75.0g) followed by VEG 4 (74.3g) while least for genotype VEG3 (23.8g). The low yield of mature seeds were recorded in VEG2 (541kg/ha) and highest yields were recorded VEG 4 (2815kg/ha). The moisture content in freshly harvested green pods of vegetable soybean was ranging from 59.83% to74.83% and highest moisture content

recorded in genotype VEG5. Fresh pod yields at harvest and yield of mature seeds were highly correlated, showing a coefficient of determination greater than 0.9 for both phenotypic and genotypic correlation (Table 3). This relationship is obvious because more pods means more seed yield, and thus one trait may be used as a selection indicator for the other in breeding. Plant height showed unremarkable or slight correlation with vegetable soybean yields and 100 green send weights. Similar results were the findings of Guo-Liang *et al.*, (2018) Shinde *et al.*, (2013) and Mahbub *et al.*, (2016). Based on the data results showed in table 3, preliminarily identified 2 promising lines that have desired traits. VEG2 and VEG4 lines exhibited greater acceptable appearance, maturity, green pod yield and 100-green seed weight than the averages of all genotypes evaluated and were superior to all cultivars.

Table.1 Cooking of vegetable soybean genotypes v/s Dolichos bean

Ingredients	Dolichos bean	VEG 2	VEG4
Quantity of Vegetable (g)	175	175	175
Water (ml)	310	310	310
Pressure cooking time (Minutes)	10	12	12

Table.2 Formulation of Vegetable soybean v/s dolichos bean curry

Ingredients	Dolichos bean	VEG 2	VEG 4
Pressure cooked vegetables (g)	175	175	175
Edible Oil (g)	15	15	15
Mustard (g)	0.5	0.5	0.5
Cumin (g)	0.5	0.5	0.5
Onion (g)	45	45	45
Ginger and Garlic paste (g)	5	4	5
Green chillies No.s	5	4	5
Salt (g)	6	5	6
Turmeric powder (g)	1	1	1
Red chilli (g)	4	3	4
Cooking time in minutes	10	10	10

Table.3 Genetic variability of vegetable soybean genotypes evaluated in *kharif* 2018

Entry Code	Germination (%)	Days to flower	Days to Maturity	Plant height (cm)	Days to picking at R6 stage	Green pod yield at harvest (kg/ha)	Pod appearance at Harvesting stage	100 green seed weight at harvest (g)	Moisture %	Yield of mature seeds (Kg/ha)
VEG 1	86	30	100	43.6	73	5829	Glabrous	32.5	60.93	2079
VEG2	33	25	90	33.0	62	1268	Glabrous	75.0	67.96	541
VEG3	71	28	93	49.1	67	2581	Glabrous	23.8	58.05	1111
VEG4	81	24	88	45.1	63	7846	Glabrous	74.3	63.80	2815
VEG 5	82	25	99	61.0	72	2825	Pubescence	44.2	74.83	1664
VEG6	87	31	101	39.9	71	3542	Glabrous	36.6	59.83	1871
VEG7	90	32	104	60.6	74	7551	Glabrous	26.7	61.10	2170
C. D. (5%)	3.74	2.47	3.65	8.31	3.33	714.76	-	4.38	7.74	465.75
C. V. (%)	2.7	4.8	2.1	9.7	2.6	8.8		5.4	6.7	14.7

Table.4 Sensory evaluation of vegetable soybean**

Samples	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
Control	8.6±0.21	8.5±0.23	8.1±0.31	8.9±0.32	8.8±0.36	8.9±0.28
VEG 2	8.3±0.17	8.7±0.19	8.0±0.30	7.7±0.11	8.4±0.23	8.0±0.13
VEG4	8.4±0.13	8.6±0.18	8.2±0.23	7.9±0.19	8.7±0.27	8.4±0.27

** All the values in Triplicate of analysis and presented as means ± standard error

Table.5 Nutrient composition of vegetable soybean (VEG4) V/s other vegetables for 100g*

S.No	Nutrients	Vegetable Soybean	Dolichos bean	French Bean (country)	Broad beans	Green Peas
1	Energy (kcal)	442.06	93.02	23.02	25.15	83.08
2	Moisture (%) (db)	6.68±0.6	64.74	89.14	84.2	
3	Protein (%)	41.54±0.8	19.83	2.49	3.85	5.42
4	Fat (%)	17.54±0.2	0.38	0.26	0.15	0.4
5	Total CHO's (%)	29.51±0.6	2.57	2.68	2.1	14.45
6	Dietary Fibre (%)	12.51±0.5	12.48	4.38	8.63	5.1
7	Minerals (%)	4.73±0.3		1.05	1.05	
8	Iron mg/100g	8.55±0.9		1.25	0.94	1.47
9	Calcium mg/100g	249.8±0.2		55.59	64.37	25
10	Ascorbic acid (mg/100g)	19.62±0.9		15.81	10.98	40
			Ref. Longvah et al.,2017			

Further VEG2 and VEG4 promising lines evaluated for sensory attributes after cooking against regular consuming vegetable dolichos bean used as a control sample. The higher pressure cooking time was recorded for vegetable soybean genotypes than the control sample (Table 2). Then the curries prepared were evaluated using 9 point hedonic scale. The mean scores of sensory evaluation showed in table 4 indicating that all the curries and cutlet prepared from vegetable soybean and dolichos bean samples prepared were within the acceptable range, while dolichos bean based curry (control sample) had significantly better appearance (8.6±0.0.21), color (8.5±0.23), flavour (8.1±0.31), texture (8.9±0.32), taste (8.8±0.36) and overall acceptability (8.9±0.28).

Statistically the curry sample prepared from promising genotype of VEG 4 vegetable soybean had better appearance (8.4±0.13), color (8.6±0.18), flavour (8.2±0.23), texture (7.9±0.19), taste (8.7±0.27) and overall acceptability (8.4±0.27) than compared to other promising lines.

The overall acceptability was mainly based on hardness, mouth feel and taste of curry and cutlet. Whole vegetable soybean curry was found harder due to toughness of husk of the soybean. Majority of the panellists recommended that the curry prepared from vegetable soybean seeds was more acceptable than the whole vegetable soybean like dolichos bean curry.

The cutlet prepared from vegetable soybean was very much accepted than the cutlet prepared from green peas. The genotype VEG 4 which is promising line and well accepted in terms of sensory attribute was chosen for nutritional analysis.

The nutrient contents of 100g of promising genotype VEG 4 (41.54±0.8 protein, and 442.06 kcal/100 g energy and 17.54±0.2 fat) fall in line with nutritional composition of regular dried soybean (Karr-Lilienthal *et al.*, 2005) (Table 5). However, vegetable soybean is superior in nutritional composition when compared to regular vegetables (Dolichos bean, French Bean (country) Broad beans and Green Peas) which are consumed regularly in the Telangana state of India.

In conclusion, the present study revealed that, the promising genotype VEG 4 of vegetable soybean is suitable to cultivate as regular vegetable in the Telangana state. It has the green pod yield potential of 7846 kg/ha and 100 green seed weight is 74.3g. The genotype VEG 4 is nutritionally equal to regular soybean and superior to other vegetables consumed in the state. Further it was well accepted as a vegetable curry by the pane lists in terms of sensory properties. Further this vegetable soybean may go as supplementary vegetable curry or food source for rural areas of Telangana for nutrition intervention programmes.

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