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Research Article

French bean variety Ooty 3 : A high yielding variety suitable for Temperate zones of Tamil Nadu

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Abstract
Selection for earliness, high yield, quality pods, resistance to pests and diseases are the major aims in the French bean. Selection and identification of French bean variety suitable for cultivation are needed. Collections were made at the Nilgiris district and based on evaluation, French bean variety Ooty 3 (pole type) was selected as a pure line. Initially, sixteen different genotypes were collected from different locations and evaluated at Horticultural Research Station, Ooty. A single plant namely PvP5-1 was selected from Nilgiris local based on improvement in pod length, pod number, pod weight, pod circumference and yield per plant. The yield performance of Ooty 3 was superior over check in all the Multi-Location Trials, Adaptive Research Trial and large-scale evaluation trials. Due to its consistent superior performance, it was released as a French bean variety, Ooty 3 during 2018 duly approved by the Crop Scientist Meet, 2017 held at Tamil Nadu Agricultural University and Tamil Nadu State variety release committee to cater for the needs of Tamil Nadu farmers thereby increasing the yield level.

Keywords: French bean, Ooty 3, high yield, quality, Earliness

INTRODUCTION

The growing trend among the legume production has been increasing world-wide from 2010 to 2020 (FAOSTAT, 2020). Among the many economic genera of plants belonging to the legume family the common bean, French bean (*Phaseolus vulgaris L.*) is reported to be a native of South America, valued as a vegetable and seed for its nutrient and protein-rich pods (Carvalho *et al*., 2012). It is a highly self–pollinated legume having synonyms namely, snap bean, bush bean, kidney bean, navy bean, haricot bean and common bean. French beans are low in calories, contain vitamins A, B, C, calcium, phosphorus, iron, in addition to protein (20%) and fibre. Beans are great food for a fat-restricted diet as beans contain only 2-3% fat. Recent studies have shown that daily consumption of beans helps to reduce cholesterol. Since they are one of the richest sources of fibre, they can help to lower bad cholesterol levels. Worldwide French beans are cultivated in 1.5 million ha with a production of 24 million tonnes. In India, it is cultivated in an area of 10,029 ha under Irrigated and 1812 ha under rainfed with a total area of 21,841 ha with the production of 2277'000 MT (Horticultural Statistics, 2018). The major growing states in India are Tamil Nadu, Jammu and Kashmir, Punjab, Karnataka, Gujarat, Uttar Pradesh and Jharkhand (Reddy *et al*., 2021). French bean pods are generally classified as slender, straight, or slightly curved with a prominent beak. Likewise, seeds are elongated or kidney-shaped, has varied colours namely red, purple, white, black or mottled. The vegetable has great demand in cities and is grown both commercially and in home gardens. Its major cultivation area is confined to hills with temperate and sub-tropical conditions and harvested as green pods.

In Tamil Nadu State, the French bean is the fifth major crop among vegetables and accounts for up to 60% by the value of all vegetables. It is mostly cultivated by small and

marginal farmers for food and to get good remuneration. It has been grown both pure as well as the mixed crop from years together. Due to heavy demand for these beans in the market, the area under French beans is increasing every year. The current work has been formulated to evaluate the suitable high-yielding varieties of beans for Nilgiris which facilitates to supply in seed chain to the Tamil Nadu State Department of Horticulture. Earliness, high yield, good pod quality and resistance to pests and diseases, suitability to high, mid and lower elevations grown both in irrigated and rainfed conditions, are the main objectives for French bean improvement.

MATERIALS AND METHODS

Sixteen accessions of traditional French beans (Pole types) were collected from different elevations of Western Ghats, Nilgiris and evaluated at Horticultural Research Station, Ooty from 2010 to 2013. The experiment was conducted in a randomized block design with three replications. Observations were taken on eight growth and yield characters namely plant height (cm), the number of branches per plant, days taken of flowering, the number of pods per plant, days taken for pod setting, pod length (cm), pod diameter (cm), and pod weight per plant (g). A single plant was selected from Ooty 3 based on the pod length, pod numbers, pod weight, pod circumference, and yield/plant. The plant was self-fertilised during 2010 for three generations and named PvP5-1. The traits of interest used for selections are attractive fleshy long, straight pod without any curvature,availability during summer, high yielding, and resistance to powdery mildew and whitefly. The evaluation was done by conducting a performance trial at HRS, Ooty from 2010 – 2013 (8 trials). French bean Ooty 1 (Pole type) variety released from Horticultural Research Station, Ooty was taken as a check variety which has erect plant type which is most wanted. In contrast, the variety Ooty 2 released from the same institute is a bush type. The Multi-Location Trial at two locations were conducted at Horticultural Research Station, Thadiankudisai and Horticultural Research Station, Kodaikanal during 2013 and 2014. Adaptive Research Trials were conducted at different locations and elevations of all over Nilgiris and Erode Districts (Ooty Block -13 trials, Coonoor block – 11 trials, Kotagiri block -10 trials, and Gudalur – 11 trials). Totally 45 trials were conducted along with the check variety Ooty 1. The yield performance of Ooty 3 was superior over check in all the trials.

Table 1. Mean performance of growth and yield of different accessions of French Beans (Pole type) PvP5-1 over for four years (2010 – 13)

S. No.	Accessions	DFF	DPF	PH (cm)	NB	NP	GPL (cm)	GPD (cm)	GPW (g)	GPY (g)	PM (0-5) scale
1.	FBP -1	48.65	87.37	106.87	5.66	35.55	13.94	1.95	9.40	344.76	48.66
2.	FBP -2	54.78	93.58	91.88	4.98	30.05	15.98	2.69	11.15	288.67	18.20
3.	FBP -3	51.45	91.75	109.53	5.94	45.13	15.18	2.76	14.15	468.83	19.06
4.	FBP -4	50.64	88.22	117.12	5.61	37.07	11.81	2.53	8.71	273.51	29.23
5.	FBP- 5 (Ooty 3)	47.67	70.50	134.18	10.95	96.05	19.08	3.60	20.40	1651.28	6.95
6.	FBP -6	55.93	83.65	115.61	7.01	52.68	16.40	1.79	13.25	354.95	34.84
7.	FBP -7	57.58	83.53	84.95	5.05	44.45	13.10	1.49	8.75	454.20	27.46
8.	FBP -8	71.53	87.80	78.51	6.60	44.7	11.03	1.68	13.75	360.11	37.40
9.	FBP -9	62.30	82.30	79.39	7.63	38.29	13.73	1.61	15.20	461.23	41.84
10.	FBP 10	54.60	86.21	98.34	7.03	51.75	14.08	1.72	16.25	456.34	29.67
11.	FBP -11	57.07	82.07	97.95	4.11	42.31	11.90	1.61	10.03	485.39	26.02
12.	FBP -12	61.20	92.00	87.42	5.48	43.63	13.53	1.82	15.05	431.70	22.14
13.	FBP -13	56.96	90.07	108.59	4.13	48.35	12.06	1.54	14.68	448.60	16.12
14	FBP -14	55.55	81.53	111.11	4.28	46.55	13.13	1.20	16.70	611.70	12.14
15.	FBP -15	62.38	93.05	95.64	4.50	30.86	13.28	1.17	16.10	365.55	15.12
16.	FBP -16	57.68	82.98	84.68	5.23	41.73	13.90	1.43	16.00	574.01	11.10
Ooty 1 (Check)		62.32	80.00	97.98	6.83	74.18	14.25	2.34	15.18	1328.00	11.80
Mean		56.96	85.68	99.99	5.94	47.25	13.90	1.94	13.81	550.52	99.99
CD (0.05)		4.87	6.88	12.55	1.83	4.397	1.478	0.450	1.881	104.25	20.48
CV%		6.01	4.23	8.82	13.99	6.84	7.47	16.36	9.56	13.93	17.24

DFF- Days to first flowering; DPF- Days taken from planting to flowering; PH- Plant height ; NB- Number of branches/ plant ; NP- Number of pods/ plant ; GPL- Green pod length ; GPD- Green pod diameter; GPW- Green pod weight; GPY- Green pod yield ; PM- Powdery mildew score

The reaction to major pests and diseases was tested under artificial and field conditions at Horticultural Research Station Nilgiris, Thadiyankudisai and Kodaikanal. Scoring powdery mildew was followed as per Singh *et al*. (2018) was followed. The scores suggested by Taggar *et al*. (2013) were followed for whitefly screening. Value-added products and nutritional properties of French beans were tested along with Ooty 1 at Post harvest Technology Laboratory, Tamil Nadu Agricultural University, Coimbatore.

RESULTS AND DISCUSSION

In the pooled mean values of four years from 2010 to 2013, among the pole types evaluated, Ooty 3 recorded the maximum pod length (19.08 cm), pod number (96.05) per plant, pod weight, pod circumference and single plant yield. Among the pole bean types, Ooty 3 has recorded the maximum plant height (134.18), more number of branches (10.95), the number of compound leaves (36.68), days taken for flowering, (47.67), days taken for pod setting (59.50), number of pods (96.05), pod length (19.08 cm), pod diameter (3.60 cm) and pod weight (20.40 g), the highest pod yield of 1,651.28 g/plant (**Table 1**).

In the overall mean performance, Ooty 3 has manifested a yield advantage over the checks *viz*., Ooty 1 in different yield trials. It has recorded an overall mean pod yield of 36.20 tonnes per hectare in 48 trials in different locations which are 18.65 per cent higher than the check variety Ooty 1 (30.51 t/ha) (**Table 2**). In the trials conducted at Horticultural Research Station, Ooty from 2010 to 2013 yield trials, the variety, Ooty 3 recorded a mean green pod yield of 39.81 t/ha with 18.3 per cent increase over check variety, Ooty 1. More length of the pod was registered by Ooty 3 (19.8 cm as against 14.72 cm in Ooty 1), more number of pods (96.05 as against 85.5 pods in Ooty 1), more pod weight (20.4 g/ plant as against 15.18 g/plant in Ooty 1), more single plant yield (1654 g/plant as against 1328 g/plant in Ooty 1).

In the multi location trial, the variety, Ooty 3 recorded a mean green pod yield of 36.16 t/ha with 19.5 per cent and 15.73 per cent increase over the check variety, Ooty 1 during 2013-14 and 2014 – 15, respectively. Ooty 3 recorded more length of the pod (19.8 cm), more number of pods (95.52), increased pod weight (20.22 g/plant (**Table 3, Table 4 a and 4b**).

In adaptive research trials, the variety, Ooty 3 has out yielded the check variety Ooty 1 during 2015 – 16 (**Table 5**). In a large-scale demonstration it recorded a higher yield of 33.60 t/ ha at Thoothurmattam village (**Table 6**). The wider adaptability of Ooty 3 is exhibited

Table 2. Performance of French bean variety Ooty 3 at HRS, Ooty over years (2010 -2013)

Year	Length of green pod (cm)		Number of green pods / plant		Green pod weight (g)		Green pod yield (g)	
	Ooty 3	Ooty 1	Ooty 3	Ooty 1	Ooty 3	Ooty 1	Ooty 3	Ooty 1
2010 (Feb.)	18.2	13.2	91.1	72.2	20.2	15.3	1442	1294
2010 (Aug.)	21.6	14.4	99.9	78.4	22.0	15.6	1458	1301
2011 (Feb.)	18.4	14.0	89.6	70.5	19.8	15.0	1360	1350
2011 (Aug.)	19.4	14.8	93.4	71.1	20.4	15.8	1876	1376
2012 (Feb.)	16.6	15.2	91.2	77.0	19.6	14.1	1850	1346
2012 (Aug.)	19.4	15.8	104.8	79.2	20.8	14.8	1946	1348
2013 (Feb.)	18.5	12.4	92.6	74.0	20.1	15.0	1550	1288
2013 (Aug.)	20.5	14.2	105.8	72.6	20.3	15.8	1752	1324
Mean	19.08	14.72	96.05	85.50	20.4	15.18	1654	1328

Percentage of increase over Ooty 1 is 18.13 for green pod yield

Table 3. Performance of French bean variety Ooty 3 in Multi-Location Trial (2013-14)

S.No.	Name of the station	Length of green pod (cm)		Number of green pods / plant		Green pod yield (t/ha)	
		Ooty 3	Ooty 1	Ooty 3	Ooty 1	Ooty 3	Ooty 1
1.	HRS, Kodaikkanal	20.12	12.10	94.92	72.10	34.8	29.20
2.	HRS, Thadiyankudisai	19.20	13.02	94.12	68.12	37.52	31.30
	Mean	19.66	12.56	94.52	70.11	36.16	30.25

Percentage of increase over Ooty 1 is 19. 54 for green pod yield

Table 4a. Performance of French bean variety Ooty 3 in Multi-Location Trial (2014-15)

S. No.	Name of the Station	Length of green pod (cm)		Green pod length (cm)		Green pod yield (t/ha)	
		Ooty 3	Ooty 3	Ooty 3	Ooty 1	Ooty 3	Ooty 1
1.	HRS, Kodaikkanal	19.25	12.36	90.92	70.10	34.10	28.82
2.	HRS, Thadiyankudisai	21.20	12.20	100.12	70.02	36.22	30.40
	Mean	20.22	12.41	95.52	70.06	35.16	29.61

Percentage increase over check variety Ooty 1 is 15.73 for green pod yield

Table 4b. Average pooled mean of French bean Ooty 3 in Multi-Location Trial

S. No.	Name of the station	Length of green pod (cm)		Number of green pods / plant		Green pod yield (t/ha)	
		Ooty 3	Ooty 1	Ooty 3	Ooty 1	Ooty 3	Ooty 1
1.	HRS, Kodaikkanal	19.69	12.37	92.92	71.10	34.45	29.01
2.	HRS, Thadiyankudisai	20.2	12.61	97.12	69.07	36.87	30.85
	Mean	19.94	12.49	95.02	70.09	35.66	29.93

Percentage increase over check variety Ooty 1 is 19.14 for green pod yield

Table 5. Mean Performance of French bean variety, Ooty 3 in Adaptive Research Trials during 2015-16

Nilgiris (Block)	Length of green pod (cm)		Number of green pods / plant (g)		Green pod yield (t/ha)	
	Ooty 3	Ooty 1	Ooty 3	Ooty 1	Ooty 3	Ooty 1
Ooty	34.34	14.03	98.52	69.29	35.68	29.06
Coonoor	20.96	13.05	96.90	70.66	35.92	29.26
Kotagiri	20.72	13.01	96.53	68.09	35.54	28.79
Gudalur	20.04	13.06	95.97	68.65	35.73	29.25
Overall Mean	24.02	13.29	96.98	69.17	35.72	29.09

Percentage increase over check Variety Ooty 1 is 22.79 for green pod yield

Table 6. Performance of French bean variety Ooty 3 under large scale trial conducted at Thoothurmattam, Nilgiris (2015-16)

Name of the location	Length of green pod (cm)		Number of green pods / plant (g)		Green pod yield (t/ha)	
	Ooty 3	Ooty 1	Ooty 3	Ooty 1	Ooty 3	Ooty 1
Thoothurmattam, Nilgiris	20.40	14.80	95.12	70.10	33.60	29.33

Percentage increase over check Variety Ooty 1 is 14.59 for green pod yield

by its superior performance across the environments over the check variety (**Table 7**). Such high yield in french beans was also obtained by Reddy *et al*. (2021), Sheik *et al*. (2020), Basavaraja *et al*. (2019), Kargiotidou *et al*. (2019) and Pratap *et al*. (2021). Powdery mildew (*Erysiphe polygons DC)* is one of the most common serious diseases of common beans (Ferreira *et al*., 1999). French beans are susceptible to powdery mildew in temperate, tropical, and subtropical climates and cause 5 – 10 % yield loss (Trabanco *et al*., 2012). Considering the serious threat, French bean variety Ooty 3 was screened for powdery mildew under field and glasshouse conditions which revealed that the incidence of the above diseases was moderately resistant to powdery mildew (**Table 8 a and 8b**). Among insects, whitefly (*Bemisia tabaci*) is one of the most common serious pests in beans. The French bean variety, Ooty 3 to whitefly damage was screened under controlled and field conditions revealed that it is moderately resistant (**Table 9a and 9b**).

Table 7. Overall performance of French bean variety Ooty 3 for green pod yield

S.No.	Particulars	Number of trials	Length of green pod (cm)		Green pod yield (t /ha)	
			Ooty 3	Ooty 1	Ooty 3	Ooty 1
1.	HRS, Ooty	8	19.08	14.72	39.81	33.70
2.	MLT	4	19.94	12.49	35.66	29.93
3.	ART	45	24.02	13.29	35.72	29.09
4.	Large Scale Demonstration	1	20.2	14.80	33.60	29.33
	Mean	58	20.80	13.83	36.20	30.51

Over all percentage increase over check Variety Ooty 1 is 18.65 for green pod yield

Table 8a. Reaction of French bean variety, Ooty 3 to powdery mildew disease under field condition

Variety / Check	Percentage Disease Index	Grade	Reaction
Ooty 3	12.45	2	Moderately resistant
Ooty 1	47.50	3	Moderately Susceptible

Table 8b. Reaction of French bean variety Ooty 3 to powdery mildew disease under controlled condition

Variety / Check	Percentage Disease Index	Grade	Reaction
Ooty 3	10.25	2	Moderately resistant
Ooty 1	32.45	3	Moderately Susceptible

Table 9a. Reaction of French bean Ooty 3 to white fly under field condition

Variety / Check	Whitefly Resistance Index	Grade	Reaction
Ooty 3	1.25	1	Moderately resistant
Ooty 1	2.14	2	Moderately Susceptible

Table 9b. Reaction of French bean variety, Ooty 3 to white fly under controlled condition

Variety / Check	Whitefly Resistance Index	Grade	Reaction
Ooty 3	1.05	1	Moderately resistant
Ooty 1	1.55	2	Moderately Susceptible

As any vegetable is expected to have better nutritional properties, the French bean variety, Ooty 3 also possesses higher protein (1.51 %), more Vitamin C content (2.26 mg/100 g), high carotene (1.92 mg/100 g) besides more total antioxidant activity (2625 ug/g). The shelf life of the culture was found to be higher with 5 days under 28 ºC with 85 % relative humidity (**Table 10**). The variety, Ooty 3 is characterized by attractive fleshy long green and straight pods without any curvature, resistance to powdery mildew and whitefly besides photo insensitive as it is harvested even during summer making it available throughout the year with high yield. The descriptors of the variety Ooty 3 are furnished (**Table 11, Fig. 1**). The organoleptic evaluation of the cooked french beans of the variety Ooty 3 is highly acceptable in terms of its colour and appearance, texture, flavour and taste (**Table 12**). One rupee per kg of fresh beans is the advantage of Ooty 3 as evidenced by a higher benefit-cost ratio (Rs 3.65 per kg for Ooty 3 as against Rs.2.65 for Ooty 1 variety (**Table 13**). Hence, in all aspects, the French bean Ooty 3 variety is found to be superior thereby enhancing the economy of the farmer. Because of the consistent superior performance of the variety, Ooty 3 (as compared to the check Ooty 1) for its fleshy, less fibrous nature, very long and more pods, straight, smooth, attractive, light green colour with very

Table 10. Nutritive value of pods in French bean variety Ooty 3

S.No.	Parameters	Ooty 3	Ooty 1
1.	Moisture (%)	90.30	87.86
2.	Protein (%)	1.51	0.92
3.	Vitamin C (mg/100 g)	2.26	1.10
4.	Carotene (mg/100 g)	1.92	1.16
5.	Total Antioxidant activity (µg/g)	2625.0	1342.0
6.	Shelf life	5 days	3 days

Table.11. Descriptors for the French bean variety, Ooty 3

Traits	Description
Plant height (m)	Around 1.5 m, if left unpinched it grows around 2 - 2.5 m
Climbing habit	Trailing
Number of branches	10.95
Number of compound leaves	36.68
Days taken for flowering	47.67
Leaf morphology	Leaves alternate, green, trifoliolate, stipulate, petiolate, a marked pulvinus at base; leaflets ovate, entire; acuminate, 6–15 cm long, 3–11 cm wide
Leaf colour and upper surface	Light green
Inflorescence	Racemose, 7- 9 flowers
flower colour	Pink
Pod colour	Light green and shiny
Pod shape	Straight pods with slight curve at tip
Pod texture	Smooth and shiny
Seed shape	Kidney shaped
Seed size	Medium
Seed colour	Deep purple
Days to germination	5 to 7
Days to first flowering	40 to 48
Days to first harvest	65 to 75
Days to last harvest	90 to 100
Days to Seed to seed	110 to 120
Number of pods /plant	96.05
Green pod weight (g)	20.40
Green pod length (cm)	19.08
Green pod circumference (cm)	3.60
Green pod yield /plant	1651.28 g
Green pod yield (t/ha)	39.8 t/ha
No. of seeds/ pod	11 to 13
100 seed weight	36 g
Pedicel attachment	Firm

Table 12. Organoleptic scores of cooked French Bean variety Ooty 3

S. No.	Characters	Score	
		Ooty 3	Ooty 1
1.	Colour and Appearance	4.09	3.50
2.	Texture	4.54	4.10
3.	Flavour	4.45	3.90
4.	Taste	4.63	4.00

(Hedonic scale 1 to 5)

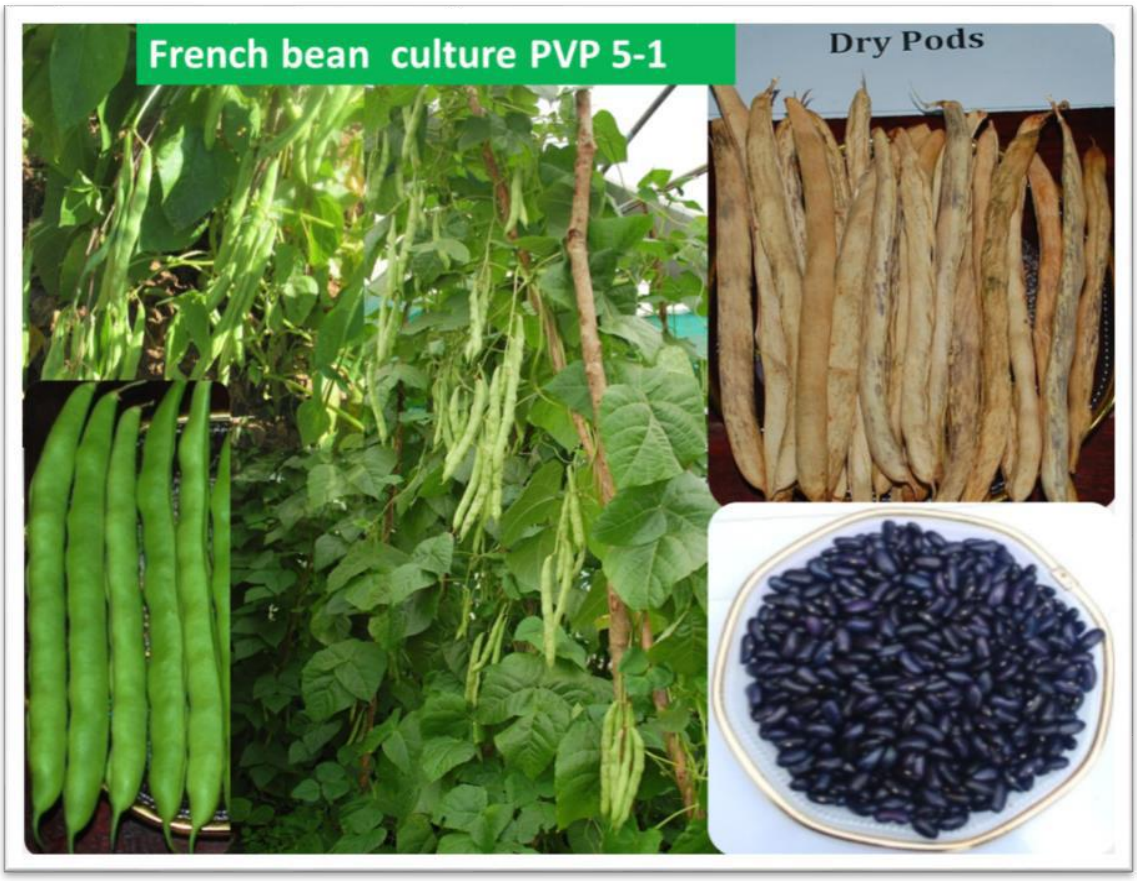

Fig. 1. French bean culture Ooty 3 plant, pods and seeds

Table 13. Economics of cultivation of French bean variety, Ooty 3

S. No.	Particulars	Ooty 3	Ooty 1
1.	Green pod yield (t/ha)	39.81	33.71
2.	Average price/Kg	Rs.20 – 25/-	Rs.20 - 25/-
3.	Income (per ha)	Rs.7,96,200/-	Rs.6,74,200/-
4.	Net income	Rs.6,25,200/-	Rs.4,54,200/-
5.	Benefit Cost Ratio	3.65	2.65

good cooking quality, high green pod yield, moderately tolerant to whitefly and powdery mildew. Also based on nutritional superiority and very high market preference, it was recommended for release as Ooty 3 in the 36th Crop Scientist Meet – Horticulture held at Tamil Nadu Agricultural University during 2017 and was released by the Tamil Nādu State variety release committee during 2018. This would fulfil the long-felt need of French bean variety to replace the existing variety.

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