AATCC Review

09 March 2025: Received
30 April 2025: Revised
07 May 2025: Accepted
10 June 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Yield attributes and Yield of french bean as influenced by tillage and organic nutrient management in finger millet – french bean cropping system

Sulochna[1*], Md. Parwaiz Alam[2], Sheela Barla[3] and Satish Kumar Pandey[4]

[1]*Department of Agronomy, Agriculture College Garhwa, Jharkhand, 822114, India*
[2]*Department of Agronomy, BAU, Ranchi, Jharkhand, 834006, India*
[3]*Department of Agronomy, TMAC, Godda, Jharkhand, 814133, India*

ABSTRACT

A field experiment was conducted at the Research Farm of Birsa Agricultural University, Kanke, Ranchi, Jharkhand, during 2020-21 and 2021-22. The experimental soil textural class was sandy loam with pH 5.56, EC 0.03 dS/m, and OC (5.91 g/kg). The soil was low in available nitrogen (218.63 kg/ha), medium in available phosphorus (15.75 kg/ha), and available potassium (178.32 kg/ha). The experiment was laid out in a split-plot design with three replications. The experiment consisted of four main plot treatments viz., conventional tillage–conventional tillage (CT–CT), conventional tillage–zero tillage (CT–ZT), zero tillage–conventional tillage (ZT–CT) and zero tillage–zero tillage (ZT-ZT) and subplot has four treatments with different sources of organic nutrient management viz., 100% N through FYM, 100% N through VC, 50% N through FYM + 50% N through VC and 75% N through FYM + 25% N through VC. The pooled data revealed that significantly highest value of pod length (11.60 cm), number of pods/plant (10.34), pod fresh weight (4.91 g), number of seeds/pod (6.84), 100 seed weight (40.56 g), green pod yield (82.87 q/ha) and haulm yield (102.04 q/ha) were observed in conventional tillage-conventional tillage. Among organic sources, pod length (11.62 cm), number of pods/plant (10.62), pod fresh weight (5.00 g), number of seeds/pod (6.88), 100 seed weight (40.69 g), green pod yield (88.91 q/ha) and haulm yield (104.28 q/ha) were observed maximum in 100% N through VC.

Keywords: *French bean, yield attributes, yield.*

Introduction

French bean *(Phaseolus vulgaris* L.) is one of the most important leguminous vegetable crops in the world. Its primary centre of origin is regarded as South Mexico and Central America, reported by Vavilov (1951). It is known as the common bean, kidney bean, Navy bean, Snap bean, and Pinto bean. It is an important grain legume. It is also known as Haricos in French, Judeas in Spanish, and Rajamash in Hindi. In India, the fresh pods used as vegetables are called French beans, and the dried pods for pulse are called Rajamah. The more fleshy, tender pods of round podded types with less string are preferred for vegetables as compared to flat pods. French bean is grown extensively because of their short duration and nutritional value. They are a rich source of protein and closely comparable to meat. Edible protein is 94% of the pods and per 100 g of edible protein contains: moisture 91.4 g, protein 1.7 g, fat 0.1 g, carbohydrate 4.5 g, fiber 1.8 g, minerals 0.5 g, vitamin A 221 I.U., thiamine 0.08 mg, vitamin C 14 mg, calcium 50 mg, phosphorus 28 mg, iron 1.70 mg, potassium 120 mg, sulphur 37 mg, sodium 4.3 mg copper 0.21 mg (Prasad, 2005).

French bean is an annual and herbaceous plant grown throughout the world for its edible beans, using both for the tender vegetables and shelled green beans and dry beans, which are referred to as beans. In India, vegetables occupy about an area of 9,068 lakh ha, and with the production of about 1,59,511 lakh tonnes, among which beans occupy an area of about 125 lakhs ha and with production of about 1292 lakh tonnes. This vegetable (French bean) is largely grown in Andhra Pradesh, Maharashtra, Karnataka, Odisha, Uttarakhand, Tamil Nadu, Jharkhand, etc. (Anusuya *et al*., 2016). In India, French bean is grown in an area of 228 thousand ha, along with production of 2277 thousand tonnes and productivity of 9.98 tonnes/ha. In case of Jharkhand, it is cultivated over an area of 12.91 thousand ha with production of 191.18 thousand tonnes and productivity of 14.81 tonnes/ha (Horticultural Statistics at a Glance, 2018).

Finger millet-french bean cropping system may be suitable in the Jharkhand region. So, there is scope to obtain higher yield levels by manipulating different managements in a fields like adopting appropriate tillage practices. Tillage operations are one of the production factors. Tillage (zero tillage) practices are gradually gaining importance as effective mitigation options under changing climatic conditions (Das *et al.,* 2014). Proper tillage has a favourable effect on soil properties and crop performance. The role of tillage (zero tillage) practices in conserving soil moisture, with the subsequent effect on crop yields, has also been observed in various parts of the country (Atkinsons *et al*., 2007). Tillage practices greatly enhance the labour cost in production systems, resulting in lower economic returns. However, tillage practice (zero tillage) is effective for reducing water loss from shallow depth soils and improves soil moisture regime as soil porosity, soil infiltration, and soil structure are greatly affected by tillage (Fan *et al*., 2013).

Corresponding Author:* ***Sulochna*

DOI: https://doi.org/10.21276/AATCCReview.2025.13.03.185

On the other hand, increasing awareness of the deleterious effects of chemical fertilizers and pesticides in agriculture has led to adopt organic crop production as an alternative method for cultivation. The use of organics in crop production is gaining much popularity. Organic sources like FYM and vermicompost, *etc.* supply not only organic matter but also increase the fertility status of the soil (Chung *et al.,* 2000; Keupper and Gegner, 2004). In recent years, declining organic carbon (0.20-0.35 per cent), and a deficit in many essential nutrients in soils have been a major worry among scientists and policy-makers. Till now, most of the research on the organic production of French bean has mainly concentrated on the use of FYM, compost, green manure, oil cakes, etc. (Ananda and Murthy, 2017). Devsenapathy (2008) also reported a decrease in organic carbon content in soil from 1.2 per cent in the 1970s to 0.60 per cent in 2000 and declining further.

Keeping these points in view, the present investigation was undertaken to know the effect of "Yield attributes and Yield of French bean as influenced by tillage and organic nutrient management in finger millet-French bean cropping system."

Materials and Methods

The experiment entitled, "Yield attributes and Yield of french bean as influenced by tillage and organic nutrient management in finger millet – french bean cropping system" was conducted in Agronomical Research Farm of the Birsa Agricultural University, Kanke, Ranchi (23° 17' N latitude, 85°10' E longitude and 625.22 m above mean sea level), Jharkhand during 2020-21 and 2021-22. The experiment was laid out in a split-plot design with three replications. The experiment consisted of four main plot treatments, *viz*., conventional tillage–conventional tillage (CT-CT), conventional tillage-zero tillage (CT-ZT), zero tillage conventional tillage (ZT-CT), and zero tillage-zero tillage (ZT-ZT), and the subplot had four treatments with different sources of organic nutrient management, *viz*., 100% N through FYM, 100% N through vermicompost, 50% N through FYM + 50% N through vermicompost, and 75% N through FYM + 25% N through vermicompost. Finger millet and French bean (for vegetable purposes) varieties taken for cultivation were BBM 10 and Swarna Priya, respectively. Seed rates for finger millet and French bean were 10 and 80 kg/ha, respectively. Recommended dose of nitrogen (RDN) for finger millet and French bean was 40 and 140 kg/ha, respectively. The source of organic nutrients was FYM and vermicompost. Sowing of finger millet was done on 26th June 2020 and 18thJune 2021, with row-to-row spacing of 30 cm and plant-to-plant spacing of 10 cm. Spacing was maintained after thinning. Fifteen days prior to the sowing of green French beans, the organic nutrients were manually incorporated into the soil. Green French bean was sown on 13th Nov 2020 and 06th Nov 2021 with row-to-row spacing of 40 cm and plant-to-plant spacing of 10 cm. Both crops were sown in an east-west direction in both years. The texture of soil (0-15 cm of depth) was sandy loam. Mechanical analysis was done by Hydrometer method, bulk density by core sampler method, permanent wilting point and field capacity by pressure plate method, pH and EC by pH and EC meter, organic carbon by Walkley & Black method, available nitrogen by Alkaline permanganate method, available phosphorus by Bray's P_1 method, available potassium by Flame photometer method and microbial count by Pour plate techniques. The soils were acidic, medium in organic carbon, low in available nitrogen, medium in available phosphorous, and potassium. The maximum and minimum temperatures ranged from 26.8 to 36.8 °C and from 4.0 to 24.1 °C, respectively, during 2020-21. During the second season (2021-22), it ranged from 21.0 to 34.2 °C and from 3.6 to 25.2 °C, respectively. Rainfall varied from 0 to 185.8 mm and from 0 to 229.4 mm in the first and second seasons, respectively. Agricultural operations and practices were applied as recommended for the crop. The finger millet crop was harvested on 28th Oct 2020 in the first year and on 19th Oct 2021 in the second year. While in the case of French bean, it was harvested on 18th Feb 2021 and on 9th Feb 2022 in the first and second year, respectively. Data on soil parameters were recorded as per normal procedure.

Result

Yield attributes

Yield attributes of French bean were significantly influenced by tillage and organic nutrient management, and also their interaction failed to produce any significant variation.

Pod length (cm)

Pod length in green French bean (Table 1) was recorded significantly maximum (11.60 cm) in CT-CT, followed by CT-ZT (11.35 cm), but comparable to ZT-CT (10.20 cm) and ZT-ZT (10.04 cm). In case of organic nutrient management, 100% N through VC recorded highest (11.62 cm) pod length in comparison to 50% N through FYM + 50% N through VC (10.41 cm) and 100% N through FYM (9.95 cm) which was at par with 50% N through FYM + 50% N through VC (11.21 cm) Interaction between tillage and organic nutrient management showed no significant difference on pod length of French bean.

Number of pods/plant

Number of pods/plant (Table 2) in green French bean was recorded maximum (10.34) in CT-CT, which was at par with CT-ZT (10.13) but significantly superior over ZT-CT (10.01) and ZT-ZT (9.76). In case of organic nutrient management 100% N through VC reported with maximum (10.62) number of pods/plant which was being at par with 50% N through FYM + 50% N through VC (10.22) and 75% N through FYM + 25% N through VC (10.03) but significantly superior over 100% N through FYM (9.37).

Fresh weight (g)

An experimentation of data (Table 3) revealed that fresh weight of the French bean pod was highest (4.91 g) in CT-CT, followed by CT-ZT (4.83 g), but comparable to ZT-CT (4.70 g) and ZT-ZT (4.51 g). Whereas, organic source such as 100% N through VC gave maximum (5.00 g) value of fresh weight of French bean pod in comparison to 100% N through FYM (4.39 g) but remain at par with 50% N through FYM + 50% N through VC (4.89 g) and 75% N through FYM + 25% N through VC (4.66 g).

Number of seeds/pod

Number of seeds/pod (Table 4) of French bean was registered maximum in CT-CT (6.84), which was significantly at par with CT-ZT (6.53), but significantly superior over ZT-CT (6.14) and ZT-ZT (5.97). Whereas, organic nutrient management gave highest (6.88) number of seeds/pod of French bean in 100% N through VC being at par with 50% N through FYM + 50% N through VC (6.48) and 75% N through FYM + 25% N through VC (6.26) while statistically superior to 100% N through FYM (5.86).

100 seed weight (g)

Close examination of pooled data (Table 5) revealed that tillage

and organic nutrient management had no significant difference on hundred-seed weight. Hundred seed weight of French bean was found to be maximum (40.56 g) in CT-CT. Minimum value was observed in ZT-ZT (36.96 g). Sub-plot treatment like organic nutrient management was highest with the application of 100% N through VC (40.69 g), while the lowest value of hundred seed weight (36.79 g) was found with 100% N through FYM.

Yield

Green pod yield (q/ha)

A critical study of the pooled data related to green pod yield (Table 6) showed the critical difference due to tillage and organic nutrient management. Main plot treatment, i.e., CT-CT recorded maximum (82.87 q/ha) green pod yield, followed by CT-ZT (80.98 q/ha), but comparable to ZT-CT (79.17 q/ha) and ZT-ZT (74.72 q/ha). Sub plot treatment such as 100% N through VC recorded higher (88.91 q/ha) green pod yield than 100% N through FYM (67.14 q/ha) and 75% N through FYM + 25% N through VC (78.92 q/ha) while remain at par with 50% N through FYM + 50% N through VC (82.76 q/ha).

Haulm yield (q/ha)

Significantly higher haulm yield (Table 6) was observed in CT-CT (102.04 q/ha), followed by CT-ZT (101.36 q/ha), and showed its superiority to ZT-CT (99.18 q/ha) and ZT-ZT (93.79 q/ha). Among various treatment in sub plot, the treatment 100% N through VC recorded maximum (104.28 q/ha) haulm yield which was remain at par with 50% N through FYM + 50% N through VC (101.30 q/ha) and 75% N through FYM + 25% N through VC (100.14 q/ha) whereas, significantly superior over 100% N through FYM (90.66 q/ha).

Harvest index (%)

Scanning of the pooled data presented in Table 6 revealed that the harvest index of French bean was neither significantly influenced by tillage and organic nutrient management nor by their interaction. The highest harvest index (44.71%) was recorded with the CT-CT in combination with the application of 100% N through VC (45.99%). Treatment combination ZT-ZT and 100% N through FYM produced the lowest harvest index (44.14% and 42.48%, respectively) among all treatment combinations.

Discussion

Yield attributing characters (Table 1-5) like pod length, number of pods/plant, pod fresh weight, number of seeds/pod, 100 seed weight and yield of green french bean (Table 6) were recorded significantly higher in CT-CT which was at par with CT-ZT and statistically superior over rest of the treatments. The lowest values were noted in ZT-ZT tillage practice. This might be due to conventional tillage practices modifying soil structure by changing its physical properties, such as soil bulk density, soil penetration resistance, and soil moisture content. Annual disturbance and pulverizing caused by conventional tillage produce a finer and looser soil structure as compared to conservation and no-tillage method, which leaves the soil intact (Rashid and Keshavarzpour 2007). This difference results in a change of number, shape, continuity, and size distribution of the pore network, which controls the ability of soil to store and transmit air and water (Khan *et al*. 2001). Howeler *et al*., (1993), also revealed that, surface soil compaction can increase with no-till, which may inhibit root growth as well as prevent adequate drainage and soil aeration, which could reduce crop yield under no-till compared to conventional tillage practices.

On the other hand, yield attributing characters and yield of green French bean (Figure 1) showed remarkable improvement by adopting different organic nutrient management. 100% N through VC was most efficient organic nutrient management that gave significantly maximum yield attributes and yield of green French bean which were remain at par with 50% N through FYM + 50% N through VC and 75% N through FYM + 25% N through VC while significantly superior over 100% N through FYM. Interaction between tillage and organic nutrient management was observed to be non-significant. 100% N through FYM gave the statistically minimum values. This might be due to the superiority of vermicompost over farmyard manure might be due to its nutritional richness, quick mineralization, and more availability of nitrogen and other plant nutrients (Mujahid and Gupta, 2010) that lead to improved yield attributes and yield of green French bean in 100% N through VC. These results are in line with Abou El-Hassan *et al*., (2017) and Mohanty *et al*., (2017).

Conclusion

Based on the results obtained from the present investigation, conventional tillage–conventional tillage significantly enhanced pod length, number of pods per plant, pod fresh weight, number of seeds per pod, 100-seed weight, green pod yield, and haulm yield of French bean. Among the different organic nutrient sources, 100% N through vermicompost (VC) proved to be the most effective in achieving higher productivity of French bean.

Acknowledgement

Authors sincerely acknowledge the Birsa Agricultural University, Ranchi, Jharkhand, for providing all the facilities for this field and laboratory studies and for pursuing Ph. D. related research work of the first author.

Conflict of interest statement

The author's study affirms that there were no financial or commercial ties that might be viewed as having a potential conflict of interest.

Competing interests

Authors have declared that no competing interests exist.

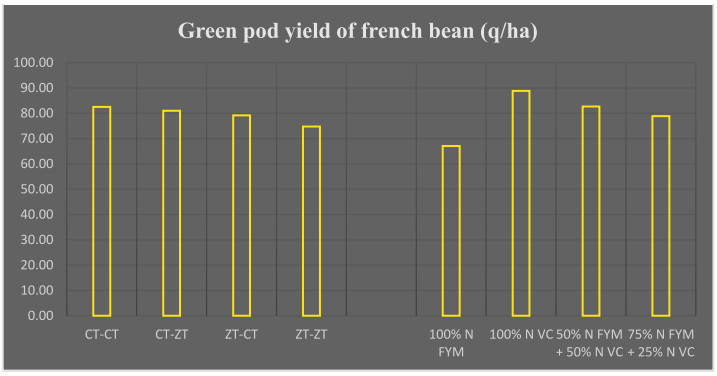

Fig 1: Green pod yield of French bean (q/ha)

Table-1: Pod length (cm) of french bean as influenced by tillage and organic nutrient management in finger millet – french bean cropping system

Main Plot: Tillage Practice (A)	Pod Length (cm)		
	2020-21	2021-22	Pooled
CT-CT	11.54	11.66	11.60
CT-ZT	11.29	11.42	11.35
ZT-CT	10.12	10.27	10.20
ZT-ZT	9.99	10.10	10.04
SEm±	0.30	0.28	0.25
CD (P=0.05)	1.26	1.18	1.06
Sub Plot: Organic Nutrient Management (B)			
100% N through FYM	9.89	10.01	9.95
100% N through Vermicompost	11.56	11.68	11.62
50% N FYM + 50% N Vermicompost	11.14	11.28	11.21
75% N FYM + 25% N Vermicompost	10.35	10.47	10.41
SEm±	0.36	0.36	0.34
CD (P=0.05)	1.23	1.21	1.14
CV %	11.76	11.42	10.80
Interaction (A x B)			
SEm±	0.70	0.68	0.64
CD (P=0.05)	NS	NS	NS

Table-2: Number of pods/plant of french bean as influenced by tillage and organic nutrient management in finger millet – french bean cropping system

Main Plot: Tillage Practice (A)	Number of Pods / Plant		
	2020-21	2021-22	Pooled
CT-CT	10.30	10.38	10.34
CT-ZT	10.09	10.17	10.13
ZT-CT	9.95	10.07	10.01
ZT-ZT	9.70	9.82	9.76
SEm±	0.08	0.07	0.07
CD (P=0.05)	0.32	0.29	0.30
Sub Plot: Organic Nutrient Management (B)			
100% N through FYM	9.32	9.42	9.37
100% N through Vermicompost	10.57	10.67	10.62
50% N FYM + 50% N Vermicompost	10.17	10.27	10.22
75% N FYM + 25% N Vermicompost	9.98	10.08	10.03
SEm±	0.21	0.21	0.21
CD (P=0.05)	0.70	0.72	0.71
CV %	7.17	7.26	7.21
Interaction (A x B)			
SEm±	0.37	0.37	0.37
CD (P=0.05)	NS	NS	NS

Table-3: Fresh weight (g) of french bean pod as influenced by tillage and organic nutrient management in finger millet – french bean cropping system

Main Plot: Tillage Practice (A)	Pod Fresh Weight (g)		
	2020-21	2021-22	Pooled
CT-CT	4.87	4.94	4.91
CT-ZT	4.79	4.88	4.83
ZT-CT	4.66	4.74	4.70
ZT-ZT	4.46	4.55	4.51
SEm±	0.04	0.05	0.04
CD (P=0.05)	0.17	0.19	0.18
Sub Plot: Organic Nutrient Management (B)			
100% N through FYM	4.38	4.41	4.39
100% N through Vermicompost	4.96	5.05	5.00
50% N FYM + 50% N Vermicompost	4.83	4.95	4.89
75% N FYM + 25% N Vermicompost	4.61	4.71	4.66
SEm±	0.11	0.11	0.11
CD (P=0.05)	0.38	0.36	0.37
CV %	8.27	7.81	8.04
Interaction (A x B)			
SEm±	0.20	0.19	0.20
CD (P=0.05)	NS	NS	NS

Table-4: Number of seeds/pod of french bean as influenced by tillage and organic nutrient management in finger millet – french bean cropping system

Main Plot: Tillage Practice (A)	Number of Seeds / Pod		
	2020-21	2021-22	Pooled
CT-CT	6.79	6.89	6.84
CT-ZT	6.47	6.58	6.53
ZT-CT	6.09	6.20	6.14
ZT-ZT	5.91	6.02	5.97
SEm±	0.16	0.15	0.15
CD (P=0.05)	0.65	0.64	0.65
Sub Plot: Organic Nutrient Management (B)			
100% N through FYM	5.80	5.92	5.86
100% N through Vermicompost	6.83	6.92	6.88
50% N FYM + 50% N Vermicompost	6.42	6.53	6.48
75% N FYM + 25% N Vermicompost	6.20	6.31	6.26
SEm±	0.19	0.18	0.18
CD (P=0.05)	0.63	0.62	0.63
CV %	10.26	9.87	10.06
Interaction (A x B)			
SEm±	0.36	0.35	0.36
CD (P=0.05)	NS	NS	NS

Table-5: Hundred seed weight of french bean as influenced by tillage and organic nutrient management in finger millet – french bean cropping system

Main Plot: Tillage Practice (A)	100 Seed Weight (g)		
	2020-21	2021-22	Pooled
CT-CT	40.49	40.63	40.56
CT-ZT	39.40	39.54	39.47
ZT-CT	37.31	37.45	37.38
ZT-ZT	36.88	37.04	36.96
SEm±	0.98	0.88	0.92
CD (P=0.05)	NS	NS	NS
Sub Plot: Organic Nutrient Management (B)			
100% N through FYM	36.71	36.87	36.79
100% N through Vermicompost	40.63	40.76	40.69
50% N FYM + 50% N Vermicompost	38.89	39.03	38.96
75% N FYM + 25% N Vermicompost	37.85	37.99	37.92
SEm±	1.20	1.16	1.16
CD (P=0.05)	NS	NS	NS
CV %	10.80	10.36	10.41
Interaction (A x B)			
SEm±	2.30	2.19	2.21
CD (P=0.05)	NS	NS	NS

Table-6: Green pod yield, haulm yield and harvest index of french bean as influenced by tillage and organic nutrient management in finger millet – french bean cropping system

Main Plot: Tillage Practice (A)	Green Pod Yield (q/ha)			Haulm Yield (q/ha)			Harvest Index (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
CT-CT	82.50	83.23	82.87	101.53	102.55	102.04	44.71	44.71	44.71
CT-ZT	80.52	81.44	80.98	101.03	101.69	101.36	44.38	44.42	44.40
ZT-CT	78.70	79.63	79.17	98.84	99.53	99.18	44.34	44.41	44.37
ZT-ZT	73.81	75.63	74.72	93.09	94.50	93.79	43.98	44.31	44.14
SEm±	0.71	0.69	0.69	0.51	0.56	0.42	0.24	0.24	0.22
CD (P=0.05)	2.97	2.88	2.91	2.14	2.35	1.74	NS	NS	NS
Sub Plot: Organic Nutrient Management (B)									
100% N through FYM	66.69	67.60	67.14	90.13	91.19	90.66	42.45	42.51	42.48
100% N through Vermicompost	88.27	89.54	88.91	103.81	104.74	104.28	45.93	46.05	45.99
50% N FYM + 50% N Vermicompost	82.26	83.26	82.76	100.85	101.76	101.30	44.96	45.06	45.01
75% N FYM + 25% N Vermicompost	78.31	79.54	78.92	99.70	100.58	100.14	44.06	44.23	44.15
SEm±	2.16	2.10	2.13	2.80	3.00	2.59	1.07	1.05	1.01
CD (P=0.05)	7.30	7.09	7.19	9.48	10.13	8.76	NS	NS	NS
CV %	9.49	9.09	9.28	9.84	10.42	9.05	8.38	8.19	7.90
Interaction (A x B)									
SEm±	3.81	3.70	3.75	4.88	5.22	4.50	1.87	1.84	1.77
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

References

1. Ananada, M. R. and Murthy, K. N. K. (2017). Response of finger millet under organic nutrient management in groundnut (*Arachis hypogea* L.) – finger millet (*Eleusine coracana* L.) cropping system. *International Journal of Pure and Applied Bioscience* 5(5): 200-206.

2. Anusuya, S. Muthamilan, A. Revathy, N. and Ananthan, M. (2016). Prevalence, symptomatology, pathogenicity and nutitional requirements of *Fusarium oxysporum* f.sp. *phaseolus* ausing Fusarium yellow of French bean in Thandikudi. *International Journal of Plant Science* 11(2): 161-166.

3. Atkinson, H. S., Sparkes, D. L., Mooney, S. J. (2007). Using selected soil physical properties of seedbeds to predict crop establishment. *Soil and tillage Research* 97: 218-228.

4. Chung, R. C. H., Wang, Y., Wang, R. S., Wang, C. W., Wang, Y. T. and Wang. (2000). Influence of organic matter and inorganic fertilizer on the growth and nitrogen accumulation of corn plants. *Taiwan Journal Plant Nutrition* 23(3): 297-311.

5. Das, A., Lal, R., Patel, D. P. and Idapuganti. (2014). Effect of tillage and biomass on soil quality and productivity of lowland rice cultivation by small scale farmers in North Eastern India. *Soil and Tillage Research* 143: 50-58.

6. Devsenapathy (2008). Organic farming, In: CAS A Training on Commercial Agriculture, conducted by TNAU during Jan-Feb.

7. El-Hassan, S. A., Elwanis, M. Abd and El-Shinawy, M. Z. (2017). Application of Compost and Vermicompost as Substitutes for Mineral Fertilizers to Produce Green Beans. *Egyptian Journal of Horticulture* 44(2): 155-163.

8. Fan, R., Zhang, X. P., Yang, X. and Liang, A. (2013). Effect of tillage management on infilteration and preferential flow in a black soil, Northeast China. *Chinese Geographical Science* 23(3): 312-320.

9. Horticultural Statistics at a Glance (2018). Government of India, Ministry of Agricultural & Farmers welfare, Department of Agricultural, Cooperation & farmers Welfare, Horticulture statistic Division.

10. Howeler, R.H., Ezumah, H. C. and Midmore, D. J. (1993). Tillage systems for root and tuber crops in the tropics. *Soil Tillage Research* 27: 211-240.

11. Khan, F. U. H., Tahir, A. R. and Yuler, J. I. (2001). Intrinsic implication of different tillage practices on soil penetration resistance and crop growth. *International Journal of Agriculture and Biology* 3(1): 23-26.

12. Kuepper G., L. and Gegner (2004). Organic crop production overview. ATTRA of National Centre for Appropriate Technology.

13. Mohanty, S., Sahu, S., Pradhan, S. R., Mangaraj, S. and Nahak, S. (2017). Integrated nutrient management for seed production in french bean (*Phaseolus vulagris* L.). *International Journal of Current Microbiology and Applied Science* 6(10): 3295-3303.

14. Prasad, N. (2005). Studies on occurrence and management of virus disease of French bean in Ranchi. M. Sc. (Ag.). Thesis, Birsa Agricultural University, Kanke, Ranchi.

15. Rashidi, M. and Keshavarzpour, F. (2007). Effect of different tillage method on grain yield and yield components of maize (*Zea mays* L.). *International Journal of Agriculture and Biology* 9(2): 274-277.

16. Vavilov, N. I. (1951). Origin, variation, immunity and breeding of cultivated plants. *Chronica Botanica* 13: 364-366.