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Research Paper

Identification of suitable cultivars for organically grown maize (*Zea mays*)–French bean (*Phaseolus vulgaris* L.) cropping system of Eastern Himalayas

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ABSTRACT

An experiment was conducted at Umiam, Meghalaya, to assess the performance of different cultivars of maize (*Zea mays* L.) followed by no-till French bean (*Phaseolus vulgaris* L.) in cropping system mode under organic production system. During 2015, 2016 and 2017. The experiment was conducted with 10 cultivars of maize (8 composite cultivars and 2 local lines) followed by 10 cultivars of French bean (8 improved cultivars and 2 local varieties). Among all the maize cultivars evaluated over the years, maximum and minimum values of cob length, cob weight, green cob yield and kernel yield were noticed in variety 'RCM 1-61' and 'Local white' respectively. Significantly higher chlorophyll index at 60 days after sowing (DAS) was recorded in 'RCM 1-61' followed by 'RCM 1-3' and minimum in 'RCM 1-1' followed by 'Hemant'. Moreover, 'RCM 1-3' and 'RCM 1-2' varieties of maize recorded significantly higher crude protein content, whereas 'RCM 1-3' followed by 'Local Yellow' recorded higher crude fibre against the other varieties of maize. The average highest yield of French bean in terms of green pod was recorded in 'Naga local' (8.91 t/ha) followed by 'RCM FB 18' (7.93 t/ha), 'RCM FB 19' (5.74 t/ha) and 'RCM FB 80' (5.73 t/ha). The maximum maize-equivalent yield (17.1 t/ha) and system productivity (6.3 t/ha) was observed for 'RCM 1-61' (maize cultivar)–'Naga local' (French bean) followed by 'RCM 75' (maize)–'RCM FB 18' (French bean) sequence. The highest net returns (₹2,24,059/ha) also recorded from the 'RCM 1-61' (maize cultivar)–Naga local (French bean) cropping sequence. The soil organic carbon concentration was also enhanced after 3 years owing to adoption of maize–French bean cropping sequence and the highest value (21.8 g/kg) was recorded in 'RCM 1-61' (maize cultivar)–'Naga local' (French bean) sequence. The present study reveals the scope of successful cultivation of French bean in no-till maize fallow under organic rainfed production system.

Keywords: *French bean, Maize fallow, No-till, Organic management, Yield attributes*

The system of organic food production is gaining its momentum worldwide, as it is considered to be one of the best options for protecting and sustaining the soil health as well as production of healthy food (Das *et al.,* 2010). In general, soils under continuous organic production system are reported to have higher levels of total soil organic carbon (SOC), total nitrogen (N), soluble phosphorus (P) and entrenched with higher microbial activity (Mader *et al.,* 2002). In light of the growing demand for organic food products around the world, including in India, the North-Eastern Region (NER) in the sub-Himalayas has a lot of potential for organic food production because it has good amount of plant biomass and livestock-excreta-based organic manure, biodiversity, indigenous knowledge and favourable climatic conditions that makes it suitable for cultivating wide range of crop species (Saha *et al*., 2012). Maize is a major coarse cereal (Sharma *et al*., 2019) and eventually recognized as the second predominant rainy season crop in the hilly ecosystem of NER of India (Ngangom *et al*., 2017). Because of its unique adaptability to wide range of climatic conditions including varied altitudes ranging from low (up to 800 m), medium (800–1,300 m) to high (above 1,300 m) and ease of growing as rainfed mono or mixed crop in both the upland and *jhum* land, it is a crop of choice for cultivation in marginal soils of NER

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(Choudhary *et al*., 2018). The area under maize cultivation in the region is estimated to be about 0.23 million ha, with productivity of 1.82 t/ha (DAC&FW, 2019). It is observed that, a large part of the arable area after harvesting of maize remain uncultivated and wasted in the NER. This creates window of opportunity for introduction of French bean in the maize–fallows. Moreover, French bean well known for its nutrient richness and profitability which is mostly grown and consumed in the form of tender pods and shelled green beans having a high demand in the market (Layek *et al.,* 2016a). French bean is also widely known for its short duration, less incidence of pest and diseases unlike other pulses and high premium price in the market. These special characters bolster its suitability and conduciveness for cultivation under organic production system and also provide an added advantage for increasing the yield and cropping intensity among the resource-poor growers in the region. In the recent years, especially no-till systems have proven to be excellent alternatives for sustainable production systems in tropical regions (Kumar *et al*., 2017).

On view of the findings, planting French bean in maize fallows under "no-till" conditions and using standard technologies can aid improve farm income, cropping intensity, and system productivity in the region. This unique crop can also act as tenable cover crop to protect the soil from erosion and physical degradation like aggregate destruction, top soil compaction and surface sealing (Baets *et al*., 2011). However, it is need of the hour/necessary to evaluate and identify suitable cultivars of maize as well as French bean under no-till practices that can enhance the success and profitability of maize–vegetable cropping system, with special reference to hilly conditions and organic management system of NER of India. Identification of suitable cultivars will not only help the farmers to enhance their farm income but can also bring substantial area under vegetable production in the region. Therefore, present research was carried out in cropping system to: (*i*) study the possibility of growing second crop French bean after maize with residual soil moisture and (*ii*) identify suitable varieties of maize and French bean under organic management practices in cropping-system mode.

MATERIALS AND METHODS

Experimental Site

The field experiment was conducted for 3 consecutive years of 2015, 2016 and 2017 at lowland Agronomy organic farm, ICAR Research Complex for NEH Region, Umiam, Meghalaya (25°30'N and 9°51'E, with an elevation of 950 m above mean sea-level). The average maximum and minimum temperature during the cropping season was 29.0%C and 19.8%C respectively whereas the mean relative humidity in the morning and evening was 89.10% and 79.8% respectively (Fig. 1). The long-term average annual rainfall of the site is 2,450 mm. More than 90% of the rainfall was received during the months of March–October and very less was rainfall received during the months of November–February. (Fig. 1). The soil of the experimental site was sandy loam, with high organic C (2.3%), low available N (150.3 kg/ha), medium available P (16.8 kg/ha) and moderately high available K (250.36 kg/ha) and acidic in soil reaction (pH=5.2).

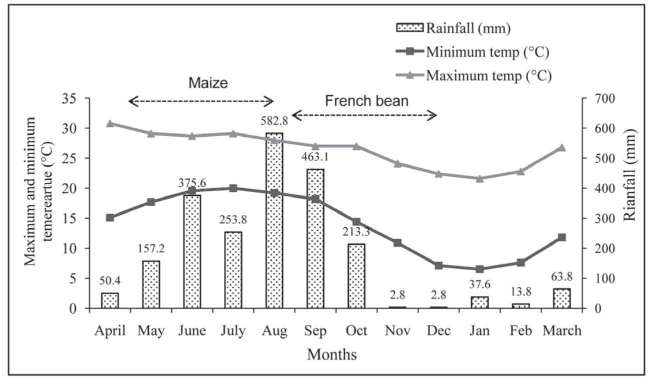


Fig. 1. Average monthly weather parameters (pooled mean of 2015, 2016 & 2017) of experimental site, Umiam, Meghalaya

The experiment was laid out in randomized block design with 3 replications with 10 cultivars of maize followed by 10 cultivars of French bean in cropping sequence mode during 2015, 2016 and 2017. Among the 10 maize cultivars evaluated, 8 were composites viz., 'RCM 1-1', 'RCM 1-2', 'RCM 1-3', 'RCM-75', 'RCM-76', 'Vijay Composite', 'Hemant' and 'RCM 1-61' and 2 local lines 'Local white', 'Local Yellow'. The experiment for French bean, consisted of 8 improved varieties viz., 'RCM FB 18', 'RCM FB19', 'RCM FB 37', 'RCM FB 61', 'RCM FB 62', 'RCM FB 80', 'Nagaland Local 1' and 'Nagaland Local 3') and 2 Local varieties (Maram' and 'Naga Local'.

Ten maize–French bean cropping sequences, consisting of T_1, 'RCM 1-1' – 'RCM FB 61'; T_2, 'RCM 1-2' – 'RCM FB 19'; T_3, 'RCM 1-3' – 'RCM FB 37'; T_4, 'RCM 75' – 'RCM FB 18'; T_5, 'RCM 76' – 'RCM FB 62'; T_6-, 'Vijay Composite' – 'RCM FB 80'; T_7-, 'Hemant' – 'Nagaland Local 1'; T_8-, 'RCM 1-61' – Naga Local'; T_9-, 'Local Yellow' – 'Maram'; T_{10}-, 'Local white' – 'Nagaland Local 3' were grown in the experiment.

Maize was sown under conventional tillage with the onset of monsoon showers in April, with spacing of 50 cm × 25 cm. Twelve (12) tonnes of well-decomposed farmyard manure (FYM) (0.5% N, 0.2% P and 0.5% K approx.) was applied per hectare on the basis of equivalent nitrogen (N) dose, to meet the requirement of 60 : 60 : 40 kg N, P_2O_5 and K_2O/ha. Phosphorus (P) requirement was supplemented through rockphosphate, as the soils of this region are severe to moderately acidic and P availability is rated as very low. After harvesting of maize cobs, the stalks were cut leaving 1.0 m stalk standing in the field (Fig. 2a–2f). The left-over standing stalks of maize provided the initial support for vining the French bean crop grown after maize. The top portion of the maize stalks were kept near the bunds and were used as mulch between French bean lines after germination to conserve soil moisture (Fig. 2a–2f). Two V-shaped narrow furrows were made using furrow opener in between 2 rows of standing maize stalk at a row-to-row spacing of 30 cm (by keeping 15 cm spacing between the French bean and maize stalk) with minimal disturbance of the soil. A recommended dose of well-decomposed FYM @10 t/ha + rockphosphate @ 150 kg/ha + lime @ 400 kg /ha were applied in the furrows and thoroughly mixed. French bean seeds were sown in the furrows between 2 rows in maize at 8–10 cm spacing and immediately covered with 2 : 1 soil : FYM mixture. Two hand-weeding at 20–25 days after sowing (DAS) and 40–45 DAS were done for controlling of weeds in French bean. The green pods were hand-picked-from 50 DAS onwards with 8–10 days intervals, and generally 3–4 pickings were done.

Five maize plants were selected at random from each experiment plot, tagged, and the plant height was measured using a scale from the base of the stem to the tip of the tallest tassel branch.The chlorophyll index of maize leaves was measured at 30 and 60 DAS using SPAD meter (SPAD 502 Plus, Konica Minolta Inc, Japan), to determine the

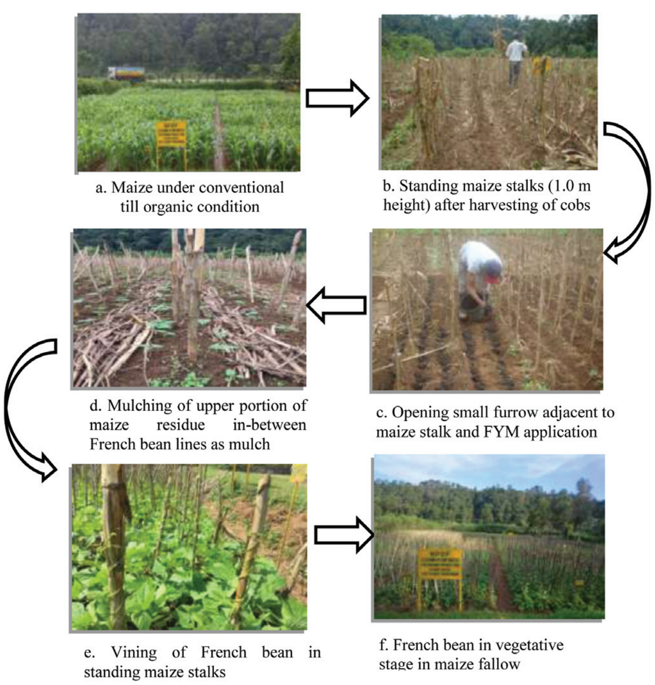


Fig. 2a-2f. Cultivation of French bean in no-till maize fallow under organic production system

relative differences in chlorophyll density. The yield and yield attributes of different cultivars of maize were recorded at harvesting. Maize fodder properties (from silking to milking), viz. crude protein, crude fibre, extract ether (E.E), ash content, and nitrogen-free extract (NFE) using standard protocols, and the results were expressed as a percentage. At harvesting, plant height, pod length, pod weight, pod yield, seed yield, and stover yield of French bean were all determined.

The harvest index (HI) was determined as per

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100...$$

.. Ruttanaprasert *et al.,* 2016

Composite soil samples at 0–15 cm depth were collected from the plots of experimental before sowing and after harvesting of French bean after completion of 3 years of the cropping sequence. The collected soil samples were air-dried under shade, grinded and passed through the 2-mm sieve. The soil *p*H was determined in a 1 : 2.5 soil : water suspension, soil organic carbon (SOC) by Walkley and Black method (1934), available N by alkaline potassium permanganate method, available P_2O_5 by Bray's method and available K_2O by ammonium acetate-extraction method.

Yields of French bean grown in sequence was converted to maize equivalent yield (MEY) taking into account of the prevailing market price of the maize and French bean (seed yield) using the following formula (De Wit, 1960).

MEY (e.g., Maize – French bean system)

$$= \text{Maize yield} + \frac{\text{Yield of French bean}}{\text{Market price of Maize}} \times \text{Market price of French bean}$$

System productivity of the maize–French bean cropping sequences were calculated by adding the yield of maize (grain yield) and French bean (seed yield) grown in sequence.

Economic studies

For the maize-French bean sequences, the value of the products (maize and French bean seeds/ grains) in terms of money was calculated based on prevailing market price and was recorded on unit area basis. The gross returns from the maize and French bean calculated for different varieties grown in sequences were added to give a gross return for the 10 maize–French bean sequences and expressed in ₹/ha. Net return was worked out by subtracting the cost of cultivation from the corresponding gross return and expressed in ₹/ha.

The data for all the parameters recorded in the experiment were analysed statistically using the technique of

ANOVA and their significance was tested by "F" test (Gomez and Gomez, 1984). Standard error of means (SEm±) and critical difference (CD) values at 5% probability (P=0.05) were calculated for all the parameter studied to evaluate differences between treatment means.

RESULTS AND DISCUSSION

Growth parameters and fodder quality of maize

Among the tested cultivars of maize, average plant height (pooled data of 2015, 2016 and 2017) was the maximum in 'RCM 75' (252.6 cm), followed by 'RCM 1-3', and 'Hemant', the minimum in 'RCM 1-61' (223.7 cm), followed by 'Local yellow' (Table 1). Considerable variation in chlorophyll content was also noticed across the growth stages and the maize cultivars. Significantly higher chlorophyll index at 60 DAS was recorded in improved variety 'RCM 1-61' (48.7), followed by 'RCM 1-3' (47.4), and the minimum in 'RCM 1-1', (43.4) followed by 'Hemant'. The ability to increase in plant height and chlorophyll content in 'RCM 75', 'RCM 1-3', 'RCM 1-61' and 'Hemant' can be attributed to inherent varietal characters (Layek *et al*., 2016b) and supply of sufficient quantities of nutrients especially nitrogen for optimum growth and performance (Das *et al*., 2019). 'RCM 1-3' and 'RCM 1-2' had significantly higher crude protein content than the other 8 lines/ composites in terms of fodder quality (Table 1). However, 'RCM 1-3' had the highest crude fibre content, followed by 'Local Yellow'. But, 'RCM 1-1' recorded the lowest crude fibre among tested varieties. In respect to extract ether, 'Vijay Composite' and 'RCM 1-3' recorded significantly higher values than the other varieties. The fodder quality is specific to the cultivars/ varieties grown and controlled by an interaction of several factors like soil type, manure composition, moisture availability etc. (Parray *et al*., 2007). 'RCM 75' showed significantly higher value of ash, whereas nitrogen-free extract (NFE) was the highest in 'Local White' and the lowest value was the recorded in 'RCM 1-3'. The high quality of the fodder can be linked to the cultivar's optimal growth along with the slow release of nutrients from organic manures, resulting in free nutrients available for uptake throughout the growth stages (Das *et al*., 2016).

Yield and yield attributes of maize

Yield and yield attributes of different varieties of maize were significantly different under organic production system and pooled data of 2015, 2016 and 2017, (Table 2). In general, higher cob length, cob weight/cob, green cob yield and kernel yield were noticed in 'RCM 1-61', whereas 'Local white' recorded the lowest among all the varieties. The maximum cob length was recorded with 'RCM 1-61' (14.7 cm), followed by 'RCM 75' and 'Local yellow'. Similar trends were observed for cob weight, green cob yield and kernel yield. 'Local white' exhibited the shortest cob length, cob weight/cob, green cob yield and kernel yield. The highest green cob yield and grain yield in maize were recorded in 'DA 61A' (5.91 and 3.64 t/ha respectively), followed by 'RCM 75' as compared to the other cultivars. There is a favourable link between yield-contributing characters like cob length and cob weight and maize green cob yield and grain yield (Layek *et al.,* 2016b) and varieties/ cultivars that produce higher cob length and cob weight. Also recorded higher green cob yield and grain yield. The highest stover yield was observed for 'RCM 1-3' (8.38 t/ha), followed by 'RCM 76'. Among the different varieties, the lowest stover yield was recorded in 'Vijay

Table 1. Growth parameters and fodder quality of maize grown under organic production system (mean of 2015, 2016 and 2017)

Maize–French bean cropping system	Plant height at harvesting (cm)	Chlorophyll index (CI)		Crude protein (%)	Fodder quality			
		30 DAS	60 DAS		Crude fibre (%)	E.E. (%)	Ash(%)	NFE(%)
'RCM 1-1' – 'RCM FB 61'	246.7	36.5	43.4	10.9	24.6	1.3	12.5	50.9
'RCM 1-2' – 'RCM FB 19'	233.9	37.5	45.6	12.5	24.8	1.4	11.4	50.7
'RCM 1-3' – 'RCM FB 37'	249.0	41.6	47.4	12.6	29.4	1.6	11.2	46.7
'RCM 75 – 'RCM FB 18'	252.6	39.8	46.2	11.7	26.7	1.3	14.3	47.3
'RCM 76' – 'RCM FB 62'	243.7	39.0	45.2	11.6	26.6	1.3	10.2	51.5
'Vijay Composite' – 'RCM FB 80'	234.9	36.9	45.5	10.8	25.4	1.7	11.7	51.5
'Hemant' – 'Nagaland Local 1'	247.0	36.0	44.0	12.1	25.4	1.5	10.9	50.8
'RCM 1-61' – 'Naga Local'	223.7	42.3	48.7	10.6	26.4	1.5	11.3	51.6
Local yellow – Maram'	224.8	37.7	44.6	11.0	28.5	1.3	9.9	50.2
Local white - Nagaland Local 3	234.9	39.3	45.1	11.6	24.8	1.5	10.3	53.1
SEm±	3.4	1.2	1.0	0.29	0.57	0.06	0.37	0.59
CD (P=0.05)	10.1	3.5	3.0	0.84	1.70	0.18	1.09	1.75

E.E., Extract ether; NFE, nitrogen-free extract, DAS, days after sowing

Composite' (6.30 t/ha). Significantly, highest harvest index was recorded for 'RCM 1-61' (32.1%) followed by 'RCM 1-2' and 'RCM 76'. The harvest index is the ratio between grain yield or kernel to biological yield (grain yield + stover yield) and the maize cultivars which increased grain yield with similar total biological yield found to increase harvest index. Superior performance of maize cultivars like 'RCM 1-61', 'RCM 75' in term of green cob yield and grain yield may be owing to better growth, chlorophyll content and their positive influence on the yield parameters like cob length, cob weight, seeds/cob etc. than the other varieties. Our results confirm the findings of Layek *et al.* (2016b). However, 'DA 61A' performed better in terms of yield and yield attributes than the other varieties under organic management.

Yield attributes and yield of French bean

The average plant height of French bean grown in maize-fallow under no-till conditions with organic management was found to be significantly higher in 'Naga Local' (237.6 cm) than the other varieties, which was followed by 'RCM FB18' and 'RCM FB80' (Table 3). French bean cultivar 'Maram' showed the lowest plant height (47.7), followed by 'Nagaland Local 3' and 'RCM FB 61'. Plant height is governed by mostly genetic makeup of the plants and the variation in plant height of the French bean cultivars are associated with their varietal characteristics. Among different French bean varieties, pod length of 'Naga Local' (16.3 cm) was the highest, followed by 'RCM FB 18', 'RCM FB 80'and 'RCM FB 19', while the lowest pod length was observed in cultivar 'Maram' (13.1 cm), followed by 'Nagaland Local 1'. The longer pod length had a positive correlation with the total green pod yield in French bean and the cultivar having longer pod length with similar number of pods/ plant may enhance the green pod yield. The average pod weight was found to be highest in 'Naga Local' (11.4 g/pod), followed by 'RCM FB 18' and 'RCM FB 19', while the lowest average pod weight was recorded in 'Maram' (3.9 g/pod), followed by 'Nagaland Local 1' and 'Nagaland Local 3'. The average

Table 2. Yield and yield attributes of maize cultivars grown under organic production system (mean of 2015, 2016 and 2017)

Maize-French bean cropping system	Cob length (cm)	Cob weight (g/cob)	Green cob yield (t/ha)	Kernel/grain yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
'RCM 1-1' – 'RCM FB 61'	13.4	210.8	5.43	3.38	7.49	31.1
'RCM 1-2' – 'RCM FB 19'	12.9	202.1	4.92	3.59	7.70	31.8
'RCM 1-3 – 'RCM FB 37'	13.5	212.7	5.61	3.50	8.38	29.5
'RCM 75' – 'RCM FB 18'	14.0	219.8	5.74	3.55	8.02	30.7
'RCM 76' – 'RCM FB 62'	13.9	212.0	5.67	3.54	7.81	31.2
'Vijay composite' – 'RCM FB 80'	13.4	197.1	4.42	2.83	6.30	31.0
'Hemant' – 'Nagaland local 1'	12.8	191.3	4.93	3.31	7.98	29.3
'RCM 1-61' – 'Naga Local'	14.7	224.1	5.91	3.64	7.69	32.1
'Local yellow' – 'Maram'	14.0	179.8	4.33	2.96	7.50	28.3
'Local white' – 'Nagaland local 3'	11.6	165.0	4.15	3.01	7.85	27.7
SEm±	0.30	1.85	0.26	0.19	0.38	0.71
CD (P=0.05)	0.87	5.36	0.75	0.55	1.10	2.05

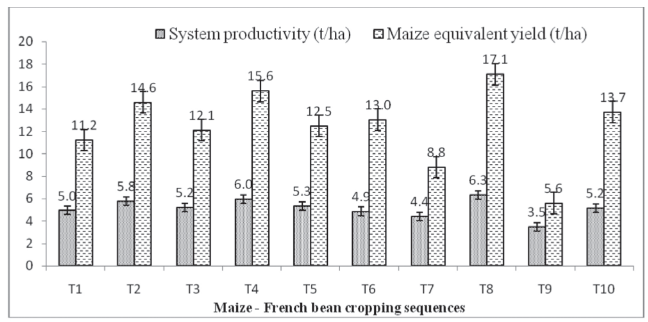
Table 3. Yield attributes and yield of French bean grown under no-till maize-fallows (mean of 2015, 2016 and 2017)

Maize–French bean cropping system	Plant height at harvesting (cm)	Pod length (cm)	Average pod weight (g/pod)	Green pod yield (t/ha)	Seed yield (t/ha)
'RCM 1-1' – 'RCM FB 61'	157.8	14.1	6.4	3.59	1.57
'RCM 1-2' – 'RCM FB 19'	189.1	15.1	7.5	5.73	2.20
'RCM 1-3' – 'RCM FB 37'	220.0	14.8	7.2	5.54	1.72
'RCM 75' – 'RCM FB 18'	224.6	16.0	10.2	7.93	2.41
'RCM 76' – 'RCM FB 62'	216.9	13.5	6.5	5.62	1.79
'Vijay Composite' – 'RCM FB 80'	223.6	15.1	7.2	5.74	2.04
'Hemant' – 'Nagaland local 1'	197.8	13.4	4.4	2.21	1.10
'RCM 1-61' – 'Naga local'	237.6	16.3	11.4	8.91	2.69
'Local yellow' – 'Maram'	47.7	13.1	3.9	1.13	0.53
'Local white' – 'Nagaland local 3'	148.4	14.7	5.9	5.18	2.14
SEm±	5.61	0.41	0.26	0.14	0.11
CD (P=0.05)	16.67	1.22	0.79	0.42	0.30

highest yield in terms of green pod was recorded in 'Naga Local' (9.0 t/ha), followed by 'RCM FB 18', 'RCM FB 19' and 'RCM FB 80', while the lowest green pod yield was recorded in 'Maram' (1.1 t/ha). The results are in conformity with the findings of Patel *et al*. (2015). In the North Eastern Hills Region, there is very little risk of yield loss from switching to organic farming for French bean cultivation because the majority of farmers follow traditional agricultural practices that include no inorganic synthetic fertilizer and only a small amount of cattle or pig manure. The maximum seed yield was also recorded in 'Naga Local' (2.6 t/ha), followed by 'RCM FB 18' and the lowest seed yield of 0.5 t/ha in 'Maram'. In general, 'Naga Local' recorded significantly higher pod length, average pod weight, green pod yield and seed yield, whereas 'Maram' recorded the lowest among different French bean varieties grown under no-till conditions in maize-fallow with organic management. This variation in plant growth, yield and yield parameters under no-till condition may be attributed to variation in genetic potential of the cultivars (Layek*et al*., 2014). For selection of cultivars for achieving high yield, due weightage should be given to those yield attributing characters of crops like pod length and average pod weight in French bean (Tickoo *et al*. 2005).

System productivity and maize equivalent yield of the cropping sequence

Selections of crops and cultivars in a cropping sequence should be suitably planned for enhancing the system productivity and efficient use of time and resource base (Anderson, 2005). The highest system productivity (6.33 t/ha/year) was recorded by T_8, cropping system (maize cultivar 'RCM 1-61' followed by French bean cultivar 'Naga Local'), followed by T_4, sequence (maize variety 'RCM 75' followed by French bean variety RCM FB 18) (Fig. 3). The lowest system productivity was recorded in cropping system T_9, (local yellow of maize, followed by Maram of French bean). The better performances of the cropping sequences T_8, and T_4, for higher system productivity was owing to higher grain and seed yield of maize cultivars (cv. 'RCM 1-61' and 'RCM 75') and French bean cultivars ('Naga Local' and 'RCM FB 18') French bean varieties. The maximum maize-equivalent yield (MEY) was also observed for maize cultivar 'RCM 1-61'–'Naga Local' (French bean), followed by maize cultivar RCM 75 - French bean cultivar RCM FB 18 (Fig.3). Higher yield along with good market price for French bean was one of the major causes for getting high MEY in the sequence (Ijoyah *et al*., 2012). So, these varieties of maize (viz. 'RCM 1-61', 'RCM 75') and French bean ('Naga Local', 'RCM FB 18') fit perfectly within the cropping system and should be promoted for high system productivity.



Vertical bar (both way) represents CD (P=0.05)

T1- RCM 1-1 - RCM FB 61 T6- Vijay composite - RCM FB 80
T2- RCM 1-2 - RCM FB 19 T7- Hemant - Nagaland local 1
T3- RCM 1-3 - RCM FB 37 T8- RCM 1-61 – Naga local
T4- RCM 75 - RCM FB 18 T9- Local yellow - Maram
T5- RCM 76 - RCM FB 62 T10- Local white – Nagaland local 3

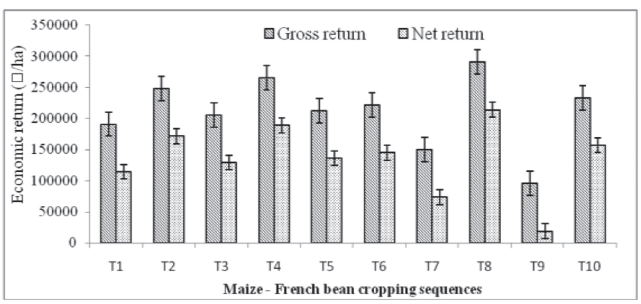
Fig. 3. System productivity and maize equivalent yield (pooled mean) as influenced by different varietal based maize-French bean cropping sequences

Table 4. Soil physical and chemical properties (at 0–15 cm soil depth) after three years maize–French bean cropping system under organic production system (year 2017)

Maize–French bean cropping system	Soil *p*H	Soil organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
'RCM 1-1' – 'RCM FB 61'	5.04	2.11	210.8	18.4	200.9
'RCM 1-2' – 'RCM FB 19'	5.10	2.11	213.9	19.3	203.2
'RCM 1-3' – 'RCM FB 37'	4.98	2.16	214.7	20.2	204.4
'RCM 75' – 'RCM FB 18'	4.99	2.17	203.2	19.2	197.5
'RCM 76' – 'RCM FB 62'	5.13	2.14	203.5	18.4	197.8
'Vijay Composite' – 'RCM FB 80'	5.09	2.13	206.2	18.9	195.5
'Hemant' – 'Nagaland local 1'	4.96	2.11	201.1	18.1	196.5
'RCM 1-61' – 'Naga local'	5.04	2.18	199.8	19.3	189.8
'Local yellow' – 'Maram'	5.14	2.10	217.3	18.9	202.9
'Local white' – 'Nagaland local 3'	4.98	2.12	213.3	20.2	198.8
SEm±	0.04	0.02	2.73	0.86	4.00
CD (P=0.05)	NS	0.07	7.99	2.51	NS

Economics of cropping sequence

The highest gross return (₹290,530/ha) and net return (₹214,059/ha) was recorded from the maize (‘RCM 1-61’)–French bean (‘Naga Local’) cropping sequence, followed by maize (‘RCM 75’)–French bean (‘RCM FB 18’) sequence (₹265,200/ha and 188,729/ha, respectively) (Fig. 4). So, by cultivating second crop French bean in succession after maize using residual soil moisture under conservation agricultural practices, there is a tremendous opportunity to increase the revenue of the farming community. Farmers’ revenue will increase even more if they receive a premium price for their organic goods. The lowest gross and returns of only ₹95,370/ha and ₹18,899/ha were recorded from the sequence of maize (Local yellow), followed by French bean (‘Maram’). Since there is significant variation in the gross and net returns across the cultivars of maize and French bean grown in sequence, selection of suitable cultivars is very pertinent for profitable organic production system.



Vertical bar (both way) represents CD (P=0.05)

T1- RCM 1-1 - RCM FB 61 T6- Vijay composite - RCM FB 80
T2- RCM 1-2 - RCM FB 19 T7- Hemant - Nagaland local 1
T3- RCM 1-3 - RCM FB 37 T8- RCM 1-61 – Naga local
T4- RCM 75 - RCM FB 18 T9- Local yellow - Maram
T5- RCM 76 - RCM FB 62 T10- Local white – Nagaland local 3

Fig. 4. Economic returns from different varietal based maize-French bean cropping sequences (pooled mean of 2015, 2016 & 2017)

Effect of cropping systems on soil properties

The soil *p*H, soil organic carbon (SOC) and availability of major plant nutrients like available N, P and K in soil after completion of 3 years of maize–French bean sequence from all the plots were measured and given in Table 4. The soil *p*H was not influenced by the cultivars of maize or French bean grown in sequence. As the respective dose of nutrients (FYM, rock phosphate etc.) and lime was same for all the cultivars of maize and French bean and there was no addition of inputs in the system the soil pH did not change significantly over the treatments. The SOC is considered as an important index of soil health (Jakhar *et al*., 2018) and was significantly influenced by various cultivars of maize and French bean in sequence. However, the highest SOC (21.8 g/kg) was recorded under the sequence of maize (‘DA 61-A’)–French bean (‘Naga Local’) sequence, which was followed by the sequence of ‘RCM 75’ (maize)–‘RCM FB 18’ (French bean). Retention of maize biomass (both stalk and upper portion as mulch) in soil might play a major role in enhancing the SOC in the system (Romheld and Kirkby, 2010). Production of higher biomass of maize and French bean especially high root biomass under the varieties of DA 61A, RCM FB 75, RCM 76 (for maize) and Naga local, RCM FB 18 (for French bean) may also enhanced SOC under these cultivars when grown in sequence. The highest available N in soil was recorded in cropping system consisting of ‘Local yellow’ (maize cultivar)–‘Maram’ (French bean cultivar) (217.3 kg/ha) and the lowest in ‘RCM 75’ (maize cultivar)–French bean ‘Nagaland Local 1’ (French bean cultivar) (199.8 kg/ha). Due to a delay in nodule formation on the root-system and insufficient nodule mass, the French bean fixes very little nitrogen in soil compared to the other legumes, and higher N uptake by the cropping sequence resulted in reduced soil-available N after crop harvesting (Yadav *et al.,* 2010). However, the available P and K status in soil was not significantly influenced by the varieties of maize and French bean grown in sequence.

Thus, North-Eastern Hills (NEH) region of India has a great scope for cultivation of French bean in maize–fallow under no-till system. It was concluded that, maize cultivars like ‘RCM 1-61’, ‘RCM 75’, and ‘RCM 1-3’ are the most promising and cost-effective in terms of green cob yield and kernel yield, whereas ‘Naga Local’, ‘RCM FB 18’ and ‘RCM FB 19’ are promising high-yielding French bean cultivars that can be grown in maize-fallow under no-till conditions in organic production systems of NEH region of India and similar ecosystems elsewhere.

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