EFFECT OF ORGANIC NUTRIENT SOURCES ON GROWTH, YIELD AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.)

Thesis

by

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(F-2016-50-M)

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CERTIFICATE - I

This is to certify that the thesis entitled **"Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)",** submitted in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (AGRICULTURE)** in the discipline of **SOIL SCIENCE** to Dr Yashwant Singh Parmar University of Horticulture & Forestry, Nauni- 173230, Solan (HP) India is a bonafide record of research work carried out by **Mr Akshay Rana (F-2016-50-M)** son of Mr Rakesh Rana under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation has been fully acknowledged.

Place: Nauni, Solan
Dated:

(Dr Uday Sharma)
Chairman
Advisory Committee

CERTIFICATE-II

This is to certify that the thesis **"Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)"**, submitted by **Mr. Akshay Rana (F-2016-50-M)** son of Mr Rakesh Rana to Dr Yashwant Singh Parmar University of Horticulture & Forestry, Nauni-173230, Solan (HP) India in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (AGRICULTURE)** in the discipline of **SOIL SCIENCE** has been approved by the Advisory Committee after a viva voce examination of the student in collaboration with an external examiner.

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Needless to say, all omissions and errors are mine.

`

Place : Nauni, Solan
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CONTENTS

ABBREVIATIONS USED

%	:	per cent
ANOVA	:	Analysis of variance
@	:	at the rate
^{0} B	:	degree Brix
$^{\circ}$C	:	Degree Celsius
CD	:	Critical difference
cfu	:	colony forming units
cm	:	centimetre
cv.	:	Cultivar
DTPA	:	Diethylene triamine penta acetic acid
dSm^{-1}	:	deci Siemens per meter
EC	:	Electrical conductivity
et al.	:	*et* ("and") *alii* (" others")
etc.	:	et cetera
FYM	:	farm yard manure
g	:	gram
h	:	hour
ha	:	hectare
i.e.	:	that is
INM	:	Integrated nutrient management
kg	:	Kilogram
L	:	Litre
L.	:	Linnaeus
mg	:	milligrams
m	:	metre
ml	:	millimeter
mm	:	millimetre
MT	:	metric tonnes
NS	:	Non significant
NH_4^+	:	Ammonium cation
PM	:	poultry manure
PNP	:	p-nitro phenol
OC	:	Organic carbon
pH	:	*Puissance de Hydrogen*
ppm	:	parts per million
PSB	:	phosphate solubilising bacteria
q	:	quintal
RBD	:	Randomized Block Design
RDF	:	Recommended Doses of Fertilizers
RDN	:	Recommended Doses of Nutrients
T	:	Treatment
t	:	tonnes
TPF	:	triphenyl formazan
TSS	:	total soluble solids
USDA	:	United States Department of Agriculture
viz.	:	videlicet
VM	:	vermicompost

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Chapter - 1

INTRODUCTION

Vegetables are considered essential for well-balanced diets since they supply vitamins, minerals, dietary fibre, and phytochemicals. In the daily diet vegetables have been strongly associated with improvement of gastrointestinal health, good vision, and reduced risk of heart disease, stroke, chronic diseases such as diabetes, and some forms of cancer. Some phytochemicals of vegetables are strong antioxidants and are thought to reduce the risk of chronic disease by protecting against free radical damage, by modifying metabolic activation and detoxification of carcinogens, or even by influencing processes that alter the course of tumor cells (Dias, 2012). India is the second largest producer of vegetable crops in the world. However, vegetable production in the country is much less than the optimum per capita requirement, if balanced diet is to be provided to every individual. The present production of vegetables of about 90.8 million tonnes is to be raised to 250 million tonnes by 2024-2025 (Kokate *et al.* 2012). There are different ways and means to achieve this target, e.g. bringing additional area under vegetable crops, using hybrid seeds and use of improved agro-techniques. In India, vegetables are grown in an area of 9.575 million ha with the productivity of 17.7 MT ha^{-1}, which constitutes about 14% of the total world production of vegetables. Among various states in India, West Bengal, Uttar Pradesh, Bihar, Madhya Pradesh, Odisha, Gujarat and Karnataka are the major vegetable growing states (Sahni and Kumari, 2017). Himachal is known for production of vegetables worth crores of rupees in specialized niches. The area, production and productivity of vegetables in the state has increased from 38,700 ha area, with annual production of 4,76,000 MT and productivity of 12.3 MT ha^{-1} in 1991-92 to 86,600 ha area, with annual production of 16,35,900 MT and productivity of 18.9 t ha^{-1} during 2013-2014 (Anonymous 2014 a).

French bean (*Phaseolus vulgaris* L.) is an important leguminous vegetable. French bean has evolved in the highlands of middle America from a wild vine over a period of 7000- 8000 years. Vavilov (1951) reported Mexico and Central America as the primary, and Peruvian-Ecuadorion-Bolivian region of South America, as the secondary centres of origin of French bean. French bean, is a nutritious vegetable and 100g of its edible pods contain energy (26Kcals), proteins (2g), calcium (50mg), phosphorus (28mg), iron (1mg), carotene (132mg), thiamine (0.08mg), riboflavin (0.06mg), fibre (2g) and vitamin C (24.0mg). It is a short

duration crop mainly grown in kharif season. But, if irrigation facilities are available, it can be grown in rabi and summer seasons as well. It is a tender, warm season vegetable that cannot tolerate frost. Its seeds do not germinate below 15°C and plants drop blossoms in hot or rainy weather. A mean air temperature of 20°-25°C is optimum for its growth and high pod yield. The favourable soil temperature is 18-24°C.

Plant nutrients are the essential components of sustainable agriculture. Undoubtedly, for optimum plant growth and production, the essential nutrients must be readily available in sufficient and balanced quantities. However, suitable and balanced combination of macro and micro nutrients are not only essential for plant growth and production, but also good for the environment (Chen, 2006). Moreover, quality and yield potential of plants can be enhanced by maintaining an adequate level of nutrients by soil or foliar application. Macronutrients play an important role in growth and development process of the plant; for example, phosphorus encourages root development and also provides energy by forming ATP (Shaheen *et al*. 2007). Similarly, micronutrients are also essential for the plants. For example, zinc is essential for normal plant growth and development as carbohydrates, protein metabolism and sexual fertilization depend on zinc (Cakmak *et al*. 1989). French bean is grown over a wide range of well-drained, alluvial friable soils, but it cannot withstand extreme acidic and alkaline soils. Clay soils impede the emergence of seed leading to uneven or poor stand. The optimum soil pH required for french beans is 5.5-6.8. For optimum nitrogen fixation, good soil aeration is required. Soil fertility is the main factor of achieving higher yields. Adding well decomposed farmyard manure (FYM) at the time of land preparation will enrich the soil fertility. Soil micronutrient deficiency should be taken care based on the result of soil test.

French bean is a precious and highly relished pulse crop which responds well to fertilization. It is especially characterized by lack of nodules, though it is legume, due to absence of NOD gene regulator (Pathak and Khurana, 1993) and is inefficient in nitrogen fixation (Kushwaha, 1994). Hence, it responds well to high nitrogen fertilization up to 120 kg per ha (Rana and Singh 1998). Fertilizers play an important role in crop production. But, now a days the inorganic fertilizers are producing very hazardous effect on soil properties as well as some times enter the food chain causing harm to human beings. The food chain begins in the farms (agriculture and orchards) and ends on the dining table. Basically, everything absorbed by the plants from the soil and water resources becomes part of the food chain. These inputs includes elements and substances from agrochemicals (pesticides, herbicides,

fungicides, growth promoting hormones and preservatives etc.), air pollutants (sulphur dioxide and nitrogen oxides) known for acid rain; shelf-life extenders, and even elements that become soluble in cooking wares and food containers.

In green revolution, intensive use of synthetic agrochemicals, such as fertilizers and pesticides with adoption of nutrient responsive high yielding varieties of crops has boosted the production to a great extent. Of late, concern has been raised time and again over its adverse effects on degradation of soil health, environment and food quality. There is an urgent need to minimize the environmental degradation as much as possible and restore the productivity of degraded soils. In such situation, a renewable and lasting alternative, that is, organic farming has to emerge for successful agricultural revolution. A self sustaining system of agriculture like organic farming may offer solution to many problems in Indian Agriculture. Keeping in view the above facts, it has necessitated the concept of organic farming as modern technology, methodology and philosophy which rely on conservation of natural resources, eco-friendly production technology and integrated crop management practices etc. for sustainability in crop production.

The organic farming is considered as a system of farming without the use of artificial fertilizers (soluble salts) with a view to have nutrient inputs and pesticides originated from organic or bio-sources. The Organic farming is now well established as an alternative agriculture, which has been proposed as a solution to the problems associated with inputs of chemical fertilizers and pesticides as explained above. Since 1991, about 50 countries across the world have introduced mandatory system for regulating the production and trade of organic products and also made rules and regulations and standards of quality control parameters for organic produce found to be sustainable, economically viable, environmentally safe, socially acceptable and easy to adopt with little training in the subject. India is uniquely in favour of organic production of different agricultural and horticultural crops. The different agro-climatic conditions suitable for production of several potential organic products include available farm land which are not much exposed to chemical farming, and farmers have been practicing traditional farming since time immemorial particularly in Hill States like Himachal Pradesh, Jammu and Kashmir, Uttarakhand and Northern States etc. In view of the above, the mountain regions of our country that happened to be the hotspots of biodiversity, with varied flora and fauna are the appropriate locations to adopt the alternative production systems, like organic farming technology. Moreover, most of the mountain regions and the hills of Himachal Pradesh are particularly suitable for this

system and have vast potential for organic production of fruits, vegetables, pulses, cereals, oilseeds and medicinal plants etc. in addition to the quality milk production etc. Organic farming envisages a comprehensive management approach to improve soil health and ecosystem of an area in particular and region in general. Organic foods are generally considered healthier than conventionally grown products. The demand for organic products is gradually increasing. Organic manures not only increase the yield but also improve physical, chemical and biological properties of soil that improve fertility, productivity, water holding capacity of soil.

In recent past, the use of indigenous sources like farmyard manure, vermicompost, poultry manure etc. have become inevitable in package of practices of crops. FYM, vermicompost, poultry manure and liquid organic nutrient suppliers like panchgavya and jeevamruta are good source of organic manure containing most of the essential macro and micro nutrients, hence, can prove effective in sustainable farming system. Use of FYM increase soil organic matter content and had greater residual effects (Kumaran *et al.* 1998). FYM application improves soil structure, enhances water holding capacity, soil microbial activity and available soil nutrients to plants (Ayyub *et al*. 2011). Similarly, vermicompost is a rich source of nutrients, vitamins, enzymes, antibiotics, plant growth hormones and a number of beneficial microorganisms. The use of vermicompost has long been considered as an effective means of improving the structure and fertility of the soil (Haj *et al.,* 2011).

Because of nutritional importance of French beans, cultivation under organic condition is a positive step for quality food production. In this cultivation, each organic source of nutrient (i.e. farmyard manure, vermicompost, poultry manure) individually and in integration, is important for nutritional management , for achieving higher productivity, good quality of food and soil health. Consequently, the present research project entitled **"Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)" ,** was planned to be conducted at the Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry with the following objectives:

i) To study the effect of different organic management practices on physico- chemical and microbiological properties of soil.

ii) To study the efficacy of different organic management practices on yield and quality of French bean.

Chapter - 2

REVIEW OF LITERATURE

Organic farming is gaining importance in Indian agriculture on account of sustainability and quality of crops being produced. The bulky/concentrated organic manures (farmyard manure, green manures, composts, vermicompost, poultry manure, non-edible cakes etc.) and liquid manures (beejamrit, jeevamrit, panchagavya, amrit pani, vermiwash etc.) are commonly being used to provide nutrient elements to crop plants. The crop protection from different pests and diseases are being taken care by using botanicals and different formulations prepared from natural vegetation. The organic farming system of agriculture is viewed as a good alternative to chemical agriculture to improve soil health and to increase farmers' income.

The work carried out on the use of bulky/concentrated organic manures and liquid manures along with use of botanicals/ bio formulations have been reviewed under the following headings:

2.1 Effect of bulky/ concentrated manures on the growth, yield and quality of crop:

- **2.1.1 Effect of FYM on the growth, yield and quality**
- **2.1.2 Effect of VC on the growth, yield and quality**
- **2.1.3 Effect of PM on the growth, yield and quality**
- **2.1.4 Effect of FYM, VC and CF on the growth, yield and quality**
- **2.1.5 Effect of FYM, PM, Biofertilizers and CF on the growth, yield and quality**

2.2 Effect of Liquid organic inputs alone or in combination on growth, yield and quality of crop:

- **2.2.1 Effect of Panchgavya on the growth, yield and quality**
- **2.2.2 Effect of Jeevamrit on the growth, yield and quality**
- **2.2.3 Effect of Panchgavya and Jeevamrit on the growth, yield and quality**

2.1 EFFECT OF BULKY/ CONCENTRATED MANURES ON THE GROWTH, YIELD AND QUALITY OF CROP:

2.1.1 Effect of FYM on the growth, yield and quality

Gana and Busari (2001) reported that with incorporation of farm yard manure (@10 t ha^{-1}) in sugar cane intercropped with legume resulted in better crop vigour, stalk height, tiller number/ plot and yield in comparison to inorganic fertilizer alone.

The application of farm yard manure (5t/ha) along with recommended dose of fertilizers were at par with vermicompost (4t/ha) along with rock phosphate to produce germination, seedling vigour index and field emergence, plant growth, seed yield and quality of soybean, besides a considerable improvement in properties of soil (Maheshbabu *et al*., 2008).

Application of farm yard manure 20 t ha^{-1} in okra enhanced growth (height of plant and fruits per plant), quality (crude fibre and moisture) and yield in comparison to other treatments comprising of poultry manure and vermicompost, neemcake and RDF alone and in combination (Premsekhar and Rajshree, 2009).

Suge *et al*. (2011) reported that application of 100% recommended rates of fertilizers and FYM reported maximum number of fruits, plant height and fresh weight, length and diameter of fruits in brinjal as compared to application of compost alone and tithonia alone and in combination with chemical fertilizers.

Long term application of farm yard manure along with recommended dose of fertilizers resulted reduction in bulk density and improvement in organic carbon, available NPK, grain and straw yield of wheat in comparison to application of wheat straw, green manure with inorganic fertilizers (Kumar *et al*., 2012).

Ojha *et al*. (2014) studied residual effect of different levels of farm yard manure in broccoli-mung bean cropping sequence and reported that FYM @ 21 t/ha significantly increased broccoli sprout yield and not only biomass but, also influenced soil properties like pH, EC, organic carbon. Further the, mung bean yield at residual level of FYM 10.5 t/ha at par with those of 7 t/ha and 14 t/ha.

Application of organics accounted better supply of nutrients accredited to improve physical and biological properties of soil which ultimately results in increased crop growth and yield. The incorporation of farm yard manure alone and along with foliar application of sea weed extract @2 per cent and panchagavya @ 2 per cent in onion led to increase in plant height, higher leaf breadth, bulb length, girth, number of bublets, weight, yield per plot; however, the effects were statistically at par with incorporation of vermicompost along with foliar application of same bio-stimulants (Sundharaiya *et al*., 2016).

Kumar *et al*. (2017) also reported that the supplementation of 50 per cent recommended dose of fertilizers with farm yard manure and *Azotobacter* (seed treatment) in mustard significantly increased the growth parameters (plant height, number of primary and secondary branches, root-shoot length number of siliqua per plant), quality parameters (number of seeds per siliqua, seed weight, seed vigour index) in comparison to chemical fertilizer application alone and with combinations studied.

2.1.2 Effect of VC on the growth, yield and quality

Edwards *et al*. (2004) reported that the addition of vermicompost to soil-less bedding plant media increases the germination, growth, flowering and fruiting of wide range of vegetables and ornamentals.

Vijaya and Seethalakshmi (2011) reported that incorporation of vermicompost @ 5 t/ha alone or in combination with farm yard manure or 50 per cent RDF increased growth, yield and quality of eggplants and available nitrogen and phosphorus levels.

The substitution of vermicompost at 0, 20, 40, 60, 80 and 100 per cent (v/v) in potting media for peat in different varieties of tomato has significantly enhanced emergence and elongation of seedlings; biomass allocation; morphological parameters (circumference, dry matter content, peel firmness) and chemical fruit parameters (C, N, P, K, Ca, Mg content, ascorbic acid, glucose, fructose) (Zaller, 2007).

Joshi and Pal (2010) reported that with the application of vermicompost @ 0, 15, 30, 45 per cent with soil in tomato recorded significant increase in growth parameters (stem diameter, plant height, leaf number, plant biomass), yield per plant and quality parameters (ascorbic acid, titrable acidity, soluble solids, insoluble solids and pH) in comparison to control. They also reported that germination percentage was highest in vermicompost 15 per cent treatment which decreases with increase in level of vermicompost.

Theunissen *et al*. (2010) reported that vermicompost contains high percentage of humic acid, essential plant nutrients and high water holding capacity, porosity, aeration, drainage and microbial activity which accounts to good effect on plant nutrition, photosynthesis, chlorophyll content, growth and yield of plants and enhances synthesis of phenolic compounds which also tend to improve plant and soil quality and damper pest and diseases.

Application of vermicompost reduces life cycle of crops therefore shorten harvesting time and enhances quality of fruit (Sinha *et al*., 2010). Brinjal yield and fruit quality (fruit per plant, fruit length etc.) was reported to increase by the addition of vermicompost @6 t/ha alone and also with interaction with nitrogen fertilizer @75 kg/ha (Moraditochaee *et al.*, 2011).

Mamta *et al.* (2012) reported that the application of vermicompost in brinjal enhances plant characterstics such as height of plant, number of leaves, width of leaves, number of fruits to each plant, fruit weight and physico-chemical soil properties *viz*., moisture content, humus content, organic carbon content, phosphate, nitrate and potassium contents.

Dhanalakshmi *et al*. 2014 reported that the application of vermicompost @ 50 and 75 per cent has influenced germination period, germination percentage, root and shoot length, number of branches of okra, brinjal, tomato and chilli and nutrient status of soil significantly in comparison to control and other tried level of vermicompost.

Application of vermicompost with rice hulls ash and coconut husk in 1:1:1 ratio reported to enhance germination rate, plant height, leaf area, plant biomass and P, K, Ca, Fe concentration in muskmelon (Manh and Wang, 2014).

Vermicompost application has positive effects on seed germination and on photosynthetic pigments of vegetable crops (Ahirwar and Hussain, 2015). Similarly, Kumar and Lekeshmanaswamy (2016) also reported that application of vermicompost to chilli and orka resulted in increased number and weight of fruits per plant, better seed germination compared to control.

Kashem *et al*. (2015) tried graded doses of vermicompost incorporation @ 0, 5, 10, 15 and 20 t/ha in comparison to levels of inorganic fertilizers @ 50%, 100%, 200% and reported that vermicompost application @ 20 t/ha significantly increased growth and yield in tomato in comparison to all the treatments.

Application of vermicompost @ 6.0 t ha^{-1}significantly increased marketable brinjal yields throughout the harvest season and further had significant effect on quality parameters plant length and dry weight; root length and dry weight; number leaves, area and dry weight and number of clusters per plant, number of fruits per cluster, mean fruit weight in comparison to other tried levels of vermicompost (Najar *et al*., 2015).

Adhikari *et al*. (2016) reported that application of vermicompost significantly enhanced growth parameters (plant height, stem diameter, number of branches, average fruit weight) and yield parameters of bell pepper followed by poultry manure, farmyard manure, goat manure, chemical fertilizers and control.

The incorporation of vermicompost not only increased the plant growth, total soluble protein and K^+/Na^+ and Ca^+/Na ratios but also reduced malondialdehyde and proline content under high saline conditions aerial parts of blessed thistle and peppermint (Xu *et al*., 2016).

2.1.3 Effect of PM on the growth, yield and quality

Sharu and Meerabai (2001) studied the effect of poultry manure, vermicompost and neem cake, singly (100 %) or in combination (25, 50 or 75 %) with inorganic N (25, 50 or 75 %) on chilli. They have reported the highest fruit yield (9.66 t ha^{-1}) with 50 per cent poultry manure+50 per cent inorganic N. they have further concluded that application of poultry manure in 1:1 ratio with inorganic as best combination not only for yield but also for quality parameters.

Khaliq *et al.* (2004) reported that application of half N (100 kg ha^{-1}) as poultry manure (6.90 t ha^{-1}) + 100 kg N ha^{-1} as urea significantly increased number of cobs per plant, grain weight and grain yield of Pioneer 3062 variety of corn in comparison to application of FYM and urea alone and in combination.

Kumar *et al*. (2006) studied the effect of organic manure (1.0 and 2.0 q neem cake and 5.0 and 10 t poultry manure ha^{-1}) in combination with N fertilizer applications on growth and yield of chilli. They recommended that application of poultry manure at 10 t + 75 per cent recommended rate of N fertilizer ha^{-1} gave significantly high fresh and dry yields compared to other tried treatments.

Amanullah *et al*. (2010) reported that application of poultry manure (5 t ha^{-1}) with farm yard manure (12.5 t ha^{-1}) increased availability of NPK in soil. Further they have reported higher uptake, tuber yield in cassava and minimum losses of soil nutrients under same treatment.

Ewulo *et al*. (2008) also reported that the application of poultry manure @ 25 t ha^{-1} in tomato influenced physico-chemical properties of soil i.e. increased soil organic matter, N, P,

moisture content and reduced bulk density and increased leaf N, P, K, Ca and Mg concentrations of tomato, growth parameters (plant height, number of branches, root length, number and weight of fruits) and yield in comparison to control.

Ullah *et al*. (2008) reported that with addition of 20% poultry manure + 20% cow dung+ 20% mustard oilcake + 40% RDF in brinjal gave maximum growth (number of branches, length, diameter, weight of fruit, number of fruits per plant), productivity besides increasing organic matter content and availability of N, P, K and S in the soil in contrast to cow dung, mustard oilcake, poultry manure and chemical fertilizers singly.

Significant impact on soil properties (decreases bulk density, increases total porosity, infiltration capacity and water holding capacity), nutrient supplying ability, yield and quality of crops has also been recorded with the application of poutry manure by Amanullah *et al*. (2010).

Adekiya and Agbede (2017) reported that incorporation of poultry manure at 30 t/ha atleast 3 weeks before transplanting of tomato seedlings resulted increase in organic matter, soil and leaf nutrient concentrations of N, P, K, Ca, Mg, growth and yield of tomato in comparison to broadcasting of poultry manure at the time of transplanting, 3 weeks after transplanting and 6 weeks after transplanting.

Ahmad *et al*. (2017) reported that application of poultry manure @ 0.8 kg m^{-2} to coriander has significantly increased growth, quality and yield parameters in comparison to farmyard manure and compost both @ 1.0 kg m^{-2} and control (without any organic application).

Application of poultry manure @ 5.0 t/ ha along with 75% RDF in brinjal reported significant increase in yield and available N, P and K contents in the soil in comparison to control, application of sewage sludge, urban compost and chemical fertilizers alone and in combination (Saikumar and Jeevanrao, 2017).

Tswanya *et al*. (2017) applied different rates of poultry droppings (0, 5, 10, 15, 20 t ha^{-1}) with two okra varieties, LD 88-1 and Kukurasungi Local and reported that poultry droppings at the rate of 15 t ha^{-1} increased the fruit yield and average plant height, number of leaves per plant, number of flowers per plant, number of fruits per plant, fruit length in LD 88-1 in comparison to other variety.

2.1.4 Effect of FYM, VC and CF on the growth, yield and quality

Sharma *et al*. (2009) reported that application of vermicompost @ 5 t ha^{-1} + 100 per cent NPK in okra and vermicompost @ 12.5 t ha^{-1} + 100 per cent NPK in onion significantly increased yield, content and uptake of NPK, however, it was at significantly par with farmyard manure @ 10 t ha^{-1} + 100 per cent NPK in okra and farmyard manure @ 25 t ha^{-1} + 100 per cent in onion.

Chatterjee and Bandyopadhayay (2014) studied the effect of organic, inorganic and biofertilizers on plant nutrient status and their availability in tomato. They concluded that application of farmyard manure, vermicompost, biofertilizers and 75% of recommended doses of inorganic fertilizers resulted in significant increased uptake of plant nutrients and also improved the post-harvest soil fertility status of soil.

Kumar *et al*. (2015) studied the effects of different combination of vermicompost, farm yard manure, Azospirillum and RDF and reported that application of 25% FYM (5 t ha^{-1}) + 75% Vermicompost (3.75 t ha^{-1}) gave maximum growth (plant height, number of primary and secondary branches), quality (essential oil and moisture content in seeds) and yield (number of umbels per plant, number of umblets per umbel, number of umbel per plant, weight of seeds and yield) of coriander in comparison to other treatment.

Studies conducted by Srimathi, (2015) revealed that incorporation of vermicompost @ 3.1 t ha^{-1} along with foliar application of humic acid (0.1 per cent) significantly influenced growth parameters (plant, root length, number of leaves, curd diameter, average curd weight) and yield of cauliflower in comparison to control, RDF through chemical fertilizers, RDF through farm yard manure, spray of panchgavya alone.

Kumar (2016) reported that among different organic treatments comprising vermicompost, sugarcane pressmud compost, farm yard manure, sewage sludge singly and along with RDF and control. Further he concluded that application of vermicompost @ 5 t ha^{-1} + 50% RDF significantly increased growth parameters (plant height, root length, dry weight, leaf area index, chlorophyll content, number of flowers per plant), quality parameters (crude protein, dietary fiber, total carbohydrates and total sugar) and yield of brinjal.

Mishra *et al*. (2018) reported that application of vermicompost (@100 per cent), FYM (@100 per cent), PSB (@100 per cent), Azospirilum (@100 per cent) and neemcake (@100

per cent) in brinjal has significantly enhanced growth parameters, quality and yield of fruits in comparison to control and recommended dose of fertilizers alone.

2.1.5 Effect of FYM, PM, biofertilizers and CF on the growth, yield and quality

Arahunashi (2011) reported that combined application of 100 per cent RDF, FYM @ 38 t ha^{-1} and Poultry manure @ 10.4 t ha^{-1} recorded on par results of plant height, number of branches, crop canopy spread, leaf area, dry matter production and quality attributes viz., ascorbic acid, lycopene content, protein, reducing sugar, TSS, shelf life of fruit increased and juice content and number of fruits of tomato and pH increased significantly with application poultry manure @ 10.4 t/ha with all organics and their combinations with vermicompost and RDF.

Shree *et al*. (2014) reported that application of farmyard manure (5 t ha^{-1}), poultry manure (2 t ha^{-1}), *Azospirillum* with half of recommended doses of chemical fertilizer gave highest plant growth (spread and height), curd diameter, depth, volume, weight, yield and quality (ascorbic acid) of cauliflower in comparison to poultry manure, FYM, vermicompost and RDF singly or in other combinations.

Lakshmi *et al*. (2015) reported effect of organic manures (farm yard manure, vermicompost and poultry manure) and inorganic fertilizers on tomato and noticed that 50% RDF + 50% FYM influenced plant growth and yield, however application of 50% RDF + 50% Vermicompost significantly influenced fruit quality (ascorbic acid, TSS, titrable acidity, juiciness and shelf life).

Rehman *et al*. (2015) reported that organic manures (Farm yard manure 25 t ha^{-1} + Poultry manure 5 t ha^{-1} + Mushroom waste 10 t ha^{-1}) significantly influenced growth (reduced number of days to flowering, fruit set, fruit harvest and increased fruit length and diameter) and yield of brinjal in contrast to control (No fertilizer) or inorganic fertilizers (NPK @ 100:50:50 kg ha^{-1}) alone.

Bhattarai and Sapkota (2016) studied effect of application of farmyard manure, vermicompost and poultry manure on cucumber and reported significant increase on yield per plot and per hectare with application of half vermicompost + half poultry manure and pH value was near to neutral in treatment Poultry manure @ 5 ton/ha. Similarly, the maximum organic matter percentage and soil available nitrogen were recorded with treatment

vermicompost @ 4 ton/ha whereas the highest available phosphorus and potassium were found in treatment poultry manure @ 5 ton/ha.

2.2 EFFECT OF LIQUID ORGANIC INPUTS ALONE OR IN COMBINATION ON GROWTH, YIELD AND QUALITY

2.2.1 Effect of Panchgavya on growth, yield and quality

Somasundram *et al*. (2003) reported that application of panchgavya @ 3 per cent foliar application has significantly increased number of seeds per pod and grain yield of green gram and it was at par with RDF.

The coconut water used in Panchgavya contains kinetin which increases the plant biomass and yield (Mamaril and Lopez, 1997). Mohan (2008) evaluated effect of different liquid inputs (Panchgavya @ 3 and 5 per cent and Amritpani @ 3 and 5 per cent) and solid organic (Bokashi @ 750 kg ha^{-1} and 1250 kg ha^{-1}) on tomato and recorded that panchgavya has enhanced growth (plant height, number of branches, number of leaves, days to flowering, number of flowers per plant), yield (number of fruits per plant and yield per plant) and concluded as most cost effective followed by Amritpani and Bokashi.

Arumugam and Anburani (2008) studied the effect of organic amendments and pressmud on the growth and yield characters of tomato. The combined application of farmyard manure + vermicompost + panchgavya as foliar spray resulted in improving the growth characters *viz*., plant height, internodal length, number of branches, number of leaves and leaf area and yield characters such as number of flower, clusters per plant, number of flowers per cluster, number of fruits per plant, single fruit weight and fruit yield per plant in tomato followed by the application of 6.25 t pressmud ha^{-1} + 2.5 t vermicompost ha^{-1} + 3 per cent panchgavya.

Studies conducted by Sanjutha *et al*. (2008) on the effect of organic bio regulator slurry and panchgavya on Kalmegh revealed significant increase in uptake of N, P and K under FYM @ 15t ha-1 + NPK @ 75:75:50 kg ha-1 + Panchgavya @ 3% foliar spray on Kalmegh.

Application of panchgavya as seed treatment reported to enhance germination percentage of pea crop and further the foliar spray at 30, 45 and 60 days after transplanting/

days after sowing increased yield of knol-khol, onion and pea. The application of panchgavya @ 2 per cent also reported to control stalk rot disease of cauliflower (Chadha *et al*., 2011).

Ravichandran *et al.* (2011) studied the effect of foliar spray of panchgavya on the yield of potato. They have recorded significant increase in total number of the tubers and total tuber yield in the treatment receiving 3% spraying of panchgavya at 15 days interval as compared to 3% spraying of panchgavya at 8 days interval and control. They have also reported that soaking the produce in 3% panchgavya solution before storage reduced weight loss, delay the sprouting leading to improve storability of seed potatoes.

Vimalendran and Wahab (2013) reported effect of four foliar sprays of panchgavya @ 3 per cent concentration at 15, 25, 35 and 45 days after sowing (DAS) along with 100 per cent RDF significantly increased the yield of babycorn.

Jain *et al.* (2014) applied four levels of Panchgavya @ 2, 4, 6, 10 per cent on seeds of cereal (wheat and rice) and legumes (pea, gram, green gram, black green, dry bean, lentil, moth bean and soybean) and reported that different concentrations have positive influence on root- shoot length and chlorophyll content, available soil nutrient levels, microbial activity as compared to FYM and vermicompost application.

The effect of bio-inoculant (vesicular arbuscular mycorrhiza) and bio-formulations (panchgavya and amritpani @ 3 per cent) on buckwheat was studied by (Sakubai *et al*., 2014). They have reported significant increase in growth, yield and quality.

The use of panchgavya as spray, drench or seed dipping or seedlings dipping has reported to improve growth and yield parameters of different crops and also improve nutrient uptake and soil fertility (Sivakumar, 2014). Similarly, Swain *et al.* (2015) opined that spraying of panchgavya at 3 per cent at 10 days interval on chilli reported highest plant height, early 50% flowering, maximum number of flowers, number of fruit and yield.

Snake gourd yield (fruit per plant, fruit weight) was enhanced also improved growth parameters (vine length, stem girth, dry matter production) of the plant with the application of vermicompost + 3 per cent spray of panchgavya in comparison to vermicompost + 3G extract @ 3 per cent (Mohan *et al*. 2016).

Sumalatha *et al*. (2017) studied the effect of foliar spray of 5% panchgavya on cowpea (AV-5) and recorded higher germination percentage, mean seedling length, seedling dry weight, seedling vigour index I, seedling vigour index II, minimum electrical conductivity in comparison to other panchgavya spray concentrations (0, 2.5 and 7.5 per cent).

2.2.2 Effect of Jeevamrit on growth, yield and quality

Credit for development of recipes for jeevamrut and its extensive use goes to Palekar (2006). Jeevamrut is a rich bio-formulation contains consortia of beneficial microbes. This formulation is used within 3-7 days of formation. It can be drenched on mulch either by drip irrigation or through spraying. It is also effective in quick decomposition of crop residues if applied with irrigation water given for field preparation Pathak and Ram (2013).

Application of jeevamrit to field crops rice and wheat reported significant higher counts of bacteria and fungi in soil (Aulakh *et al*. 2013). As jeevamrit enhances microbial activity in soil and helps in improvement of soil fertility (Joshi, 2008).

Studies conducted by Manjunatha *et al*. (2009) revealed that application of farm yard manure along with jeevamrit on sunflower significantly increased yield, microbial activity by solubilization and nutrient uptake. Singh and Grover (2011) revealed that application of organic inputs (farmyard manure + jeevamrit + biodynamics) in wheat field gave higher price for the organic yield in comparison to application of inorganic inputs.

Pawar *et al*. (2012) reported that application of farmyard manure 5 t ha^{-1}+ vermicompost 2.5 t ha^{-1} + jeevamrut 2 times (30 and 45 days after sowing) recorded significant increase in growth parameters, yield parameters and quality parameters viz., protein, starch, sucrose and TSS and total NPK uptake by in sweet corn in comparison to other organic manures in combination or alone.

Dwivedi *et al*. (2014) reported that application of jeevamrit @ 5 % has increased plant height of Cape gooseberry besides enhanced physico-chemical properties of soil in comparison to application of amritpani, vermicompost and FYM. Patil *et al*. (2014) reported that application of FYM @ 20.5 t ha^{-1} + jeevamrit @ 500 l ha^{-1} (30 and 45 days after sowing) on pigeon pea significantly enhanced plant growth parameters (plant height, number of

branches per plant , number of compound leaves, leaf area per plant) and yield (seed and stock).

Raksar *et al*. (2014) reported that application of organic manures (FYM, compost, green manures, vermicompost), biofertilizers (Azotobacter, Rhizobium, PSB), biopesticides and fungicides (trichoderma), trap crops (rajgira, marigold, coriander, sorghum, castor and maize), biological pest control (amrutpani, vermiwash, dashparniark, neem ark) and soil health (jeevamrit) and INM has increased fruit yield and B:C ratio of tomato, brinjal and bulb yield and B:C ratio of onion in crop intensification system in comparison to control.

Potkile *et al.* (2017) reported that application of jeevamrut along with vermicompost (@ 100 per cent RDN) significantly gave maximum growth and yield of soyabean and wheat in comparison to incorporation of organic manures (FYM, VC and compost) alone and along with jeevamrut, three crop residues (cotton, wheat and soybean) @ 5 ton ha^{-1} along with jeevamrut in soyabean and wheat crop.

Hameedi *et al*. (2018) reported that application of vermicompost @ 7 t/ ha + jeevamrit (drenching @ 5% + foliar @ spray 3%) significantly increased growth parameters (plant height, number of branches, leaf area index, number of fruits per plant) and yield of capsicum and FYM @10 t/ha + VC 3.5 t/ha + Jeevamrut (drenching @ 5 % + foliar spray @ 3 %) application has significantly increased quality parameters (TSS and ascorbic acid content).

Application of jeevamrit @ 5 per cent in nutrient film technique along with Hoagland Nutrient Solution (HNS) reported significant increase in growth (numbers of leaves, root length, leaf area), quality and yield of lettuce in comparison to control which is fertigation with Hoagland Nutrient Solution only (Spehia *et al* .,2018).

2.2.3 Effect of Panchagavya and Jeevamrit on growth, yield and quality

Chandrakala *et al*. (2007) recorded significantly higher uptake of N, P and K by combined application of beejamrutha +jeevamrutha +panchgavya and increased dry fruit yield of chilli and application of FYM + beejamrut + jeevamrut + panchgavya recorded significantly higher dehydrogenase activity in soil.

Devakumar *et al*. (2008) reported that liquid manures like beejamrutha, jeevamrutha and panchgavya have higher microbial population of bacteria, fungi, actinomycets, N-fixers

and P-solubilizers. Further, they have reported that application of these formulations have increased yield in paddy, field bean, maize and soyabean.

Gore and Shreenivasa (2009) revealed that combined application of Beejamruth, Jeevamruth and Panchgavya on 75 and 160 days after sowing of tomato increased the enzymatic activities, plant growth parameters, yield and N, P and K concentrations and enzymatic activities in soil.

Halder *et al*. (2015) studied incidence of amaranthus foliage feeders in relation to different organic soil amendments and concluded that lowest leaf damage in treatment consisting of 50% FYM-N + Panchgavya + Biofertilizers (*Azotobacter* and PSB) which is at par with treatment of 50% Vermicompost-N + Jeevamrit + Biofertilizer (*Azotobacter* and PSB).

Sahare (2015) reported that application of combined organics EC (enriched compost 1/3)+VC (vermicompost 1/3)+GLM (green leaf manure 1/3) equivalent to RDF + FYM in combination with foliar application of jeevamrut @ 500 litre ha-^{1} at planting, 30 and 60 days after sowing + panchgavya @ 5% at panicle emergence and flowering stages recorded significantly higher growth parameters (plant height, number of tillers at harvest, total dry matter at harvest, productive tillers per panicle, productive tillers per hill), higher grain yield and straw yield with high protein content which was on par with control treatments i.e. RDF + FYM and RDF alone.

Studies conducted by Brar (2017) revealed that application of 90 per cent RDN (50:50 ratio of vermicompost and poultry manure) + panchgavya @ 5%+ jeevamrit @ 5% + amritpani (@ 5% + PGPR reported significant increase in plant growth parameters, fruit set, yield of capsicum and also increased available NPK levels and biological properties of soil in comparison to control (100 % RDN only) and other treatments.

Safiullah *et al*. (2018) reported that application of 100 per cent NADEP compost in comparison to 75 and 50 per cent NADEP compost recorded significantly higher plant height, cob weight/plant, green cob and fodder yield; cob length and cob and stem girth of sweet corn and among liquid manures application of panchgavya and jeevamrit @ 600 L ha^{-1} recorded higher total reducing and non reducing sugar content in comparison to application of sanjeevak, amrit pani and control.

Chapter - 3

MATERIALS AND METHODS

The present investigation entitled **"Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)"** was carried out at the experimental farm of Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan- 173230 (HP), India during summer months of March to May 2017 and 2018. The details of the materials used and techniques employed are given below:

3.1 GENERAL DESCRIPTION OF THE STUDY AREA

3.1.1 Location

The experimental site was the research farm of the Department of Soil Science and Water Management, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP). It is situated at 30º52′ North latitude and 77º11′ East longitude, at an elevation of 1260 m above mean sea level and representing the mid hill zone of Himachal Pradesh.

3.1.2 Climate

The study area falls in sub-temperate, sub-humid agro-climatic zone-II of Himachal Pradesh. The average annual rainfall of the area is about 1115 mm and about 75 per cent of it is received during the monsoon period (mid-June to mid-September). Winter rains are meagre and received during the month of January and February. May-June are the hottest and December-January are the coldest months.

3.1.3 Soils

The soils of study area fall in the order Inceptisol and sub group Eutrochrept according to Soil Taxonomy of USDA. These soils owe their origin to ferromagnesian shales and dolomitic limestone. The soil properties of experimental site are given in table 3.1.

Table 3.1 Soil properties of experimental site before the start of the experiment

S. No.	Soil Property	Values Obtained
1	pH (1:2.5)	6.78
2	EC (dSm_{-1})	0.22
3	Organic Carbon (g/kg)	18.6
4	Available N (kg ha^{-1})	354.93
5	Available P (kg ha^{-1})	67.89
6	Available K (kg ha^{-1})	308.53
7	DTPA extractable Cu (ppm)	2.19
8	DTPA extractable Zn (ppm)	2.22
9	DTPA extractable Fe (ppm)	12.78
10	DTPA extractable Mn (ppm)	10.39

3.2 FIELD STUDIES

The present study was aimed at evaluating the effect of bulky and liquid organic nutrient sources on growth, yield and quality of French bean and various soil properties. The experiment was laid out in Randomized Block Design with ten treatments and three replications during spring-summer season 2017 and 2018. The bulky organic sources of nutrients were farm yard manure, vermicompost and poultry manure and that of liquid nature were Panchgavya and jeevamruta, applied according to the treatments. The trial during the year 2017 was discontinued, since it was badly damaged by wild animals.

3.2.1 Experimental Details

The experiment comprised of three replications. Each replication had 10 treatment plots of size 2m×2m. The treatments in each replication were allocated at random as per layout depicted in table 3.2.

No. of treatments : 10

No. of replications: 3

Total no. of Plots: 30

Crop: French Bean (*Phaseolus vulgaris* L.)

Variety: Contender (bush type)

Spacing: 50cm×20cm

Plot size: 2m ×2m

Experimental Design: Randomized Block Design

Inputs Used:

1. Bulky and concentrated manures:

i) Farm Yard Manure (FYM)

ii) Vermicompost(VC)

iii) Poultry Manure (PM)

2. Liquid Organic inputs:

i) Panchgavya

ii) Jeevamrut

3.2 FIELD LAYOUT

R_1T_1	R_2T_{10}	R_3T_2
R_1T_6	R_2T_5	R_3T_3
R_1T_4	R_2T_1	R_3T_7
R_1T_3	R_2T_6	R_3T_8
R_1T_9	R_2T_3	R_3T_5
R_1T_{10}	R_2T_2	R_3T_1
R_1T_7	R_2T_4	R_3T_9
R_1T_2	R_2T_8	R_3T_{10}
R_1T_5	R_2T_9	R_3T_4
R_1T_8	R_2T_7	R_3T_6

Treatment Details:

T_1 : 100% RDN*

T_2 : 90% RDN + Panchgavya (5%)

T_3 : 90% RDN + Jeevamrut (5%)

T_4 : 90% RDN + Panchgavya (5%) + Jeevamrut (5%)

T_5 : 80% RDN + Panchgavya (5%)

T_6 : 80% RDN + Jeevamrut (5%)

T_7 : 80% RDN + Panchgavya (5%) + Jeevamrut (5%)

T_8 : 70% RDN + Panchgavya (5%)

T_9 : 70% RDN + Jeevamrut (5%)

T_{10} : 70% RDN + Panchgavya (5%) + Jeevamrut (5%)

*Recommended dozes of Nutrients

Table 3.3 Recommended doses of nutrients (RDN) for French bean as per Package of practices of vegetable crops

Nutrient	Quantity/ha	Quantity/plot ($4m^2$)
FYM	200 qha^{-1}	8 kg
N	50 kg ha^{-1}	20 g
P_2O_5	100 kg ha^{-1}	40 g
K_2O	50 kg ha^{-1}	20 g

The recommended doses of nutrients (table 3.3) were applied by using vermicompost and poultry manure in a 50:50 ratio on nutrient content basis. The quantity of vermicompost and poultry manure were quantified on the basis of nitrogen equivalence (table 3.5). Full amount of vermicompost and poultry manure were applied and mixed with soil in the very first week. The Panchgavya (5%) and Jeevamrut (5%) organic formulations were applied two times as soil drench @ 250 ml per plant at 15 days interval after two weeks of sowing upto the third picking of the crop. The experimental plants were given uniform recommended cultural practices during the entire course of study.

Table 3.4 Quantity of nutrients in Bulky and concentrated manure

Manures	Nutrient content (%)		
	N	**P_2O_5**	**K_2O**
Farm Yard Manure	0.5%	0.2%	0.5%
Vermicompost	1.75%	1.5%	0.9%
Poultry Manure	3.03%	2.63%	1.4%

Table 3.5 Quantity of vermicompost and poultry manure used in 50:50 ratio on the basis of Nitrogen equivalence

TREATMENTS	VERMICOMPOST	POULTRY MANURE
T_1 (100%)	571 g	330 g
T_2(90%)	514 g	297 g
T_3(90%)	514 g	297 g
T_4(90%)	514 g	297 g
T_5(80%)	457 g	264 g
T_6(80%)	457 g	264 g
T_7(80%)	457 g	264 g
T_8(70%)	400 g	231 g
T_9(70%)	400 g	231 g
T_{10}(70%)	400 g	231 g

Table 3.6. Quantity of nurients (g) added through vermicompost and poultry manure in $4m^2$ plot

Treatments	Vermicompost			Poultry Manure		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1 (100%)	10	8.60	5.10	10	8.70	4.60
T_2 (90%)	9	7.74	4.59	9	7.83	4.14
T_3 (90%)	9	7.74	4.59	9	7.83	4.14
T_4 (90%)	9	7.74	4.59	9	7.83	4.14
T_5 (80%)	8	6.88	4.08	8	6.96	3.68
T_6 (80%)	8	6.88	4.08	8	6.96	3.68
T_7 (80%)	8	6.88	4.08	8	6.96	3.68
T_8 (70%)	7	6.02	3.57	7	6.09	3.22
T_9 (70%)	7	6.02	3.57	7	6.09	3.22
T_{10} (70%)	7	6.02	3.57	7	6.09	3.22

3.2.3 Ingredients and Flow chart for the Preparation of Panchgavya and Jeevamrut Preparation of Panchgavya:

Panchgavya was prepared by dissolving the following ingredients as suggested by Sreenivasa *et al.*, 2011:

Ingredients	Quantity
Cow dung	1 kg
Cow urine	1 litre
Cow milk	2 litre
Cow ghee	1 kg
Cow curd	2 kg
Jaggery	2 kg
Sugarcane juice	2 litre
Coconut	1 fruit
Banana	1 dozen

- **Five litres of Panchgavya was added in hundred litres of water for its soil application**

Flow chart of preparation of Panchgavya

Mix thoroughly the fresh cow dung + cow ghee
↓
Incubate for 2 days
↓
Add cow urine
↓
Stir properly (morning and evening, daily for one week)

↓

Add sugarcane juice & jaggery

↓

Add cow milk + cow curd + coconut water + 12 bananas

↓

Stir properly (morning and evening, daily for 3 week)

↓

Panchgavya is ready for soil drench

- **Preparation of Jeevamrut:**

Jeevamrut was prepared by dissolving the following ingredients as suggested by Sreenivasa *et al.*, 2011:

Ingredients: `	**Quantity**
Cow Dung	10 kg
Cow Urine	10 litres
Jaggery	2 kg
Pulse Floor	2 kg
Live Soil	1 kg
Water	200 litres

For soil application dilution of 5 litres of jeevamrut in 100 litres of water is done.

Flow chart of preparation of Jeevamrut

Add fresh cow dung + cow urine in water

↓

Mix jaggery + pulse floor and live soil in water

↓

Mix the above both and Stir properly (morning and evening)

↓

On fifth day filter the solution and filtrate is ready for soil drench

3.3 OBSERVATIONS RECORDED AND THEIR METHODOLOGIES:

3.3.1 Plant parameters

1. Plant height (cm)

The final plant height was measured in centimeters from the ground level to the tip of the plant at maturity. The height of 5 plants per plot was measured at the time of first harvest. Plant height was taken using the meter scale, height was measured from the soil surface to the tip of the top most leaf.

2. Number of pods per plant:

The number of marketable green pods harvested from successive harvests were summed and expressed as total number of pods per plant.

3. Pod length (cm)

The length of three pods from individual plants measured from basal end to proximal end was averaged and expressed in centimeters (cm).

4. Pod width (cm)

The maximum width i.e. suture to suture end of pods was measured using vernier calipers taking three pods and then averaged and recorded in centimeters (cm).

5. Pod yield per plant (kg)

Fruit weight was taken after every picking, plant wise. After last picking the total weight was calculated in gram. Green pods from each observational plant were picked randomly during harvesting period for recording the weight of pods. The green pods were harvested at edible maturity and average weight of pods per plant was worked out using electric weighing balance.

6. Pod yield per hectare (kg)

From pod yield per plant, the pod yield in quintals per hectare was determined by plant yield x plant population.

7. Pod weight (g)

The weight of randomly selected ten pods per plant at maturity was pooled and calculated average pod weight in gram.

8. Number of days to first harvesting

The number of day taken from germination to start of first picking.

9. Harvest duration

Total number of days from first harvesting to final harvesting were counted and average value was expressed as harvest duration.

10. Total NPK in Plant shoot, root and fruit and their uptake

The plant samples (pod , shoot and root) collected were washed, air dried in shade and subsequently in an oven at 65±5ºC till constant weight. They were grounded in an electric grinder and stored in paper bags for chemical analysis. The methods followed for the determination of total nitrogen, phosphorous, potash, copper, zinc, iron, manganese in plant samples are given in table 3.7. For the estimation of nitrogen, 1 g of well ground samples (pod, shoot and root) were digested in concentrated H_2SO_4, in the presence of digestion mixture K_2SO_4, $CuSO_4$ and Se powder (10:1:0.1). After digestion the nitrogen was determined by micro-kjeldahl method. For the determination of other macro and micro nutrients, 1 g of well ground plant samples (pod, shoot and root) were digested in di-acid mixture of nitric acid and perchloric acid in the ratio of 4:1. In order to have complete transfer of digestion material, three washing of digestion flask were given with distilled water and the volume made up to 100 ml. Phosphorus in the extract was determined by vanao-molybdo yellow colour method, while potassium was determined by flame photometric method. The Cu, Fe, Mn, Zn were determined in the extract using Atomic Absorption Spectrophotometer.

Table 3.7 Procedures used for plant nutrient content estimations:

S. No.	Nutrient	Method Employed	Reference
1.	Nitrogen	Micro-kjeldhal distillation	A.O.A.C. (1970)
2.	Phosphorus	Vanado-molybdate-phosphoric yellow colour method	Jackson (1973)
3.	Potassium	Flame photometer	Jackson (1973)
4.	Micronutrient cations (Zn, Cu, Fe and Mn)	Atomic absorption spectrophotometer (AAS)	Vogel (1978)

3.3.2 SOIL CHEMICAL PROPERTIES

The composite soil samples from 0-15 cm soil depth were collected before start of experiment. After crop harvesting both the years of experimentation soil samples from 0-15 cm soil depth from each plot were collected to ascertain the effect of different organic inputs on pH, organic carbon, available N, P, K and available Cu, Fe, Zn, Mn. Collected soil samples were air dried in shade and ground with the help of wooden pestle and mortar, passed through 2 mm sieve and stored in polythene bags for further analysis, as per the method given in Table 3.8.

Table 3.8 Procedures used for soil chemical properties and nutrient analysis:

S. No.	Parameter	Method Employed	Reference
1.	**pH**	1:2 soil: water suspension, with the help of digital pH meter	Jackson (1973)
2.	**EC**	1:2 soil: water suspension, with the help of digital EC meter.	Jackson (1973)
3.	**Organic carbon**	Rapid titration method	Walkley and Black (1934)
4.	**Available N**	Alkaline potassium permanganate method	Subbiah and Asija (1956)
5.	**Available P**	Olsen's method	Olsen *et al.*(1954)
6.	**Available K**	Ammonium acetate method	Merwin and Peech (1951)
7.	**DTPA extractable Zn, Fe, Mn, Cu**	Atomic Absorption Spectrophotometer (AAS)	Lindsay and Norvell (1978)

3.3.2 MICROBIOLOGICAL PROPERTIES

i) Viable Microbial Count

The soil viable microbial count, was recorded adopting the serial dilution standard spread plate technique as described by Subbarao (1999) on nutrient agar (NA) medium, potato dextrose agar medium and Kenknight and Munaier's medium. The population was expressed as colony forming units per gram of soil (cfu g^{-1} soil).

a) COMPOSITION OF NUTRIENT AGAR MEDIUM:

Peptone	:	5 g
NaCl	:	5 g
Beef extract	:	3 g
Agar -agar	:	1.5-2%
Water	:	1000 ml
pH	:	6.8 ± 0.2

b) COMPOSITION OF POTATO DEXTROSE AGAR:

Potatoes, peeled and diced	:	200 g
D-Glucose	:	20 g
Agar	:	15 g
Distilled water	:	1000 ml

c) COMPOSITION OF KENKNIGHT AND MUNAIER'S MEDIUM:

Dextrose	:	1.00 g
KH_2PO_4	:	0.10 g
$NaNO_3$	:	0.10 g
KCl	:	0.10 g
$MgSO_4.7H_2O$	:	0.10 g
Agar	:	15.00 g
Distilled Water	:	1000 ml

(ii) Total Microbial Biomass

Microbial biomass-C was determined by soil fumigation extraction method as detailed by Vance *et al*. (1987). In this method, 20 g of soil was fumigated with 50 ml chloroform in vacuum desiccators for 24 hour in dark and other 20 g soil sample was refrigerated, then both the samples (fumigated and unfumigated) were extracted with 80 ml of 0.5 M K_2SO_4, for half an hour and filtered through Whatman no.1 filter paper. Then added 2 ml of 66.5 mM $K_2Cr_2O_7$ and 5 ml digestion mixture containing H_2SO_4 and ortho-phosphoric acid (2:1) to 8 ml filtrate and heated on hot plate at 120°C for 30 minutes. The final volume was made to 250 ml with distilled water and 2-3 drops of ferroin indicator was added and titrated against 0.005 N Ferrous ammonium sulphates (FAS).

$$\text{MB-C } (\mu g\ g^{-1} \text{ soil}) = \frac{EC\ (F) - EC\ (UF)}{K}$$

Where,

K = 0.25±0.05 (factor which represents the efficiency of extraction of microbial biomass carbon)

EC (F) = Total amount of extractable carbon in fumigated soil samples.

EC (UF) = Total amount of extractable carbon in un-fumigated soil samples.

(iii) Soil enzymes

The dehydrogenases, phosphatases and ureases enzymes were measured by adapting the standard procedures as described below:

Dehydrogenase

The dehydrogenase enzyme estimation was carried out by method given by Casida *et al*. (1964). One gram of soil was incubated for 12 hours with 1 ml of 3% TTC (Triphenyltetrazolium chloride) and 0.5 ml of 1% glucose. After incubation 10 ml of methanol was added. Then the test tube was shaken and allowed to stand in dark for 24 hours. Supernatant was withdrawn and colour intensity was measured using blue filter at 485 nm wavelength. The amount of formazan formed from standard curve prepared from TPF (Triphenylformazan) was in the range of 0.04 to 0.5 mg 10 ml^{-1}. The results were expressed in the terms of TPF per hour per hour per gram of soil (mg TPF $h^{-1}g^{-1}$ soil).

Phosphatase

The phosphatase enzyme estimation was carried out by method given by Tabatabai and Bremner (1969). One gram of soil taken in test tube was incubated with 1ml of 5mM buffered sodium p-nitrophenyl phosphate in acetate buffer (pH 5.2) and 0.3ml toluene at 37^{o}C for 1 hour. Determination of p-nitrophenol involved the colorimetric analysis of the extract obtained by treating the incubated soil sample with 4 ml water, 10 ml of 0.5 M NaOH and by filtering it through Whatman no. 42 filter paper. The suspension obtained by shaking the mixture for 1 minute and absorbance of yellow color of p-nitrophenol released was determined spectrophotometrically at 420 nm wavelength. The standard curve was prepared by p-nitrophenol (10-100 ppm). The result was expressed as µ mole of p-nitrophenol per gram soil per hour (µ mole PNP h^{-1} g^{-1}soil).

Urease

10 g of dry and sieved soil was incubated for 15 min with 15 ml of toluene. 10 ml of urea solution and 20 ml of citrate buffer were added, mixed and incubated for 3 hours at 37^{o} C. Then diluted to 100 ml with water, mixed and filtered. Pipette out 1 ml of filtrate, added 9 ml of water, 4 ml phenate solution and 3 ml of sodium hypochlorite solution. Mixed and allowed standing for 20 minutes until the maximum colour was obtained. Diluted to 50 ml with water, mixed well and read the transmittance or absorbance at 630 nm against the blank. The standard curve was prepared from ammonium sulphate solution (10 µg N ml^{-1}). Results were expressed as µg NH_4^+ g^{-1} soil hr^{-1} to get Urease number. Urease number was multiplied by 0.32 to obtain urease units (Hoffman, 1965).

3.4 STATISTICAL ANALYSIS

The data generated from the present investigation were subjected to statistically analysis using the Microsoft-Excel and OPSTAT. The level of significance was tested for different variable at 5% level of significance (Gomez and Gomez, 1984). As outline of analysis of variance based on randomized block design (RBD) with 't' treatments and 'r' replications was prepared. The analysis of variance ANOVA tables have been given in APPENDIX.

ANOVA for RBD:

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F_{cal}
Treatments	**(t-1)**	**St**	**Mt= St/ (t-1)**	**Mt/Me**
Replications	**(r-1)**	**Sr**	**Mr= Sr/(r-1)**	**Mr/Me**
Error	**(r-1) (t-1)**	**Se**	**Me= Se/(r-1) (t-1)**	
Total	**(rt-1)**	**ST**		

Where,

r = Number of replications

t = Number of treatments

Sr = Sum of squares due to replications

St = Sum of squares due to treatments

Se = Sum of squares due to error

ST = Total sum of squares

Mr = Mean sum of squares due to replications

Mt = Mean sum of squares due to treatments

Me = Mean sum of squares due to error

The replication and treatment mean sum of square were tested against error mean squares by 'F' test at (r-1), (r-1) (t-1) and (t-1), (r-1) (t-1) degree of freedom for RBD at 5% level of significance.

The calculated F-values were compared with tabulated F- value. When F- test was found significant, critical difference was calculated to find out the superiority of one treatment over the others.

The standard error and critical difference were calculated as follow:

$CD_{0.05}$ = S.E.(d)xt(0.05)(r-1)(t-1)df

$SE(d)\pm$ = $\sqrt{2\ Me/r}$

$SE(m)\pm$ = $\sqrt{Me/r}$

Where,

$SE(m)\pm$ = Standard error of mean

$SE(d)\pm$ = Standard error of difference

$CD_{0.05}$ = Critical difference at 5 per cent level of significance

Chapter - 4

RESULTS AND DISCUSSION

The present investigation entitled, "**Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)"** was conducted at the experimental farm of Department of Soil Science and Water Management, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the spring summer season of the year 2018. The results obtained in relation to soil properties, pod and plant characteristics have been presented and discussed with possible explanations under the following broad headings:

4.1 Effect of organic nutrient sources on plant growth and yield.

4.2 Effect of organic nutrient sources on soil properties.

4.1 EFFECT OF ORGANIC NUTRIENT SOURCES ON PLANT GROWTH AND YIELD

4.1.1 Plant height (cm)

The application of various organic inputs registered a significant effect on different plant parameters as shown in Table 4.1.The data presented revealed that maximum (38.20 cm) plant height of French bean plant was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which is about 16.57% higher as compared to treatment T_1 (100 % RDN) and was statistically at par with treatment T_7 (80% RDN + 5% Panchgavya +5% Jeevamrut) and treatment T_{10} (70% RDN + 5% Panchagvya +5% Jeevamrut). Minimum (32.77 cm) height of the plant was recorded in T_1 i.e. 100 % RDN and has been found to be statistically at par with treatment T_3 (90% RDN + 5% Jeevamrut), T_6 (80% RDN + 5% Jeevamrut) and T_9 (70% RDN +5% Jeevamrut). These results are also in line with those of Sarma *et al.* (2014) who reported that the height of French bean plant was significantly increased by the application of organic manures, vermicompost and FYM. A significant increase in plant height in capsicum due to the application of panchgavya has also been reported by Swain *et al.* (2015) and of application of vermicompost and jeevamrut by Hameedi *et al.* (2018).

4.1.2 Number of pods per plant

The data presented in table 4.1 further revealed that maximum (34.77) number of pods per plant were also recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which is about 26.11% higher as compared to treatment T_1 (100 % RDN) and was statistically at par with treatment T_7 (80% RDN + 5% Panchgavya +5% Jeevamrut). Minimum (27.57) number of pods per plant were recorded in T_1 i.e. 100 % RDN. The findings corroborate those of Singh *et al.* (2011), who reported that the number of pods per plant in French bean was significantly increased by the application of organic manures which had been used to reduce the application of inorganic fertilizers under irrigated conditions.

4.1.3 Pod length (cm)

The application of various organic inputs registered a significant effect on the pod length of French bean as shown in Table 4.1.The data presented revealed that maximum (11.93 cm) long pods were recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut), whereas, minimum (9.41 cm) pod length was recorded in T_1 i.e. 100 % RDN which were found to be statistically at par with treatment T_3 (90% RDN + 5% Jeevamrut), T_6 (80% RDN + 5% Jeevamrut) and T_9 (70% RDN +5% Jeevamrut). These results are also in line with those of Premi *et al.* (2004) who reported that the pod length in Indian mustard (*Brassica juncea*) was significantly increased by the application of organic manures, and can be ascribed to the better soil conditions and improved uptake of nutrients from the soil under organic management systems.

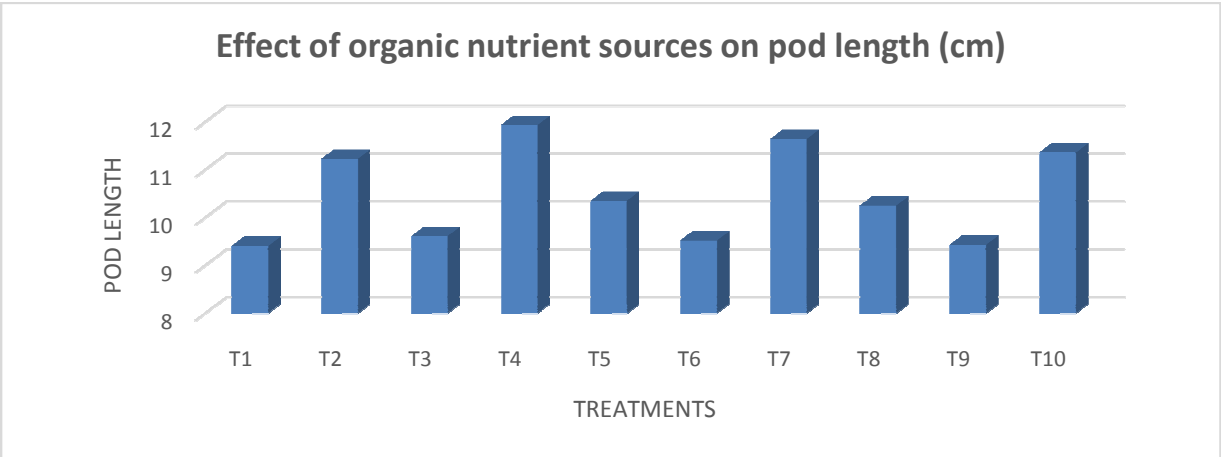
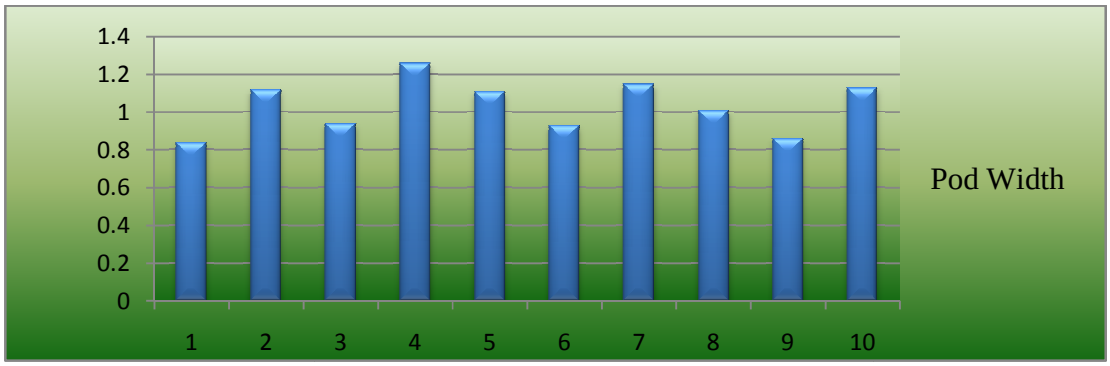


Table 4.1: Effect of bulky organic nutrient sources on plant height (cm), number of pods and pod length (cm) of French bean

Treatments	Plant height (cm)	Number of pods per plant	Pod length (cm)
T_1 : 100% RDN*	32.77	27.57	9.41
T_2 : 90% RDN + 5% PG	34.70	31.03	11.23
T_3 : 90% RDN + 5% JV	33.20	29.73	9.61
T_4 : 90% RDN + 5% PG + 5% JV	38.20	34.77	11.93
T_5 : 80% RDN + 5% PG	34.67	30.80	10.35
T_6 : 80% RDN + 5% JV	33.17	28.30	9.52
T_7 : 80% RDN + 5% PG + 5% JV	37.70	34.63	11.64
T_8 : 70% RDN + 5% PG	33.73	30.00	10.25
T_9 : 70% RDN + 5% JV	32.90	28.07	9.43
T_{10} : 70% RDN + 5% PG + 5% JV	37.60	31.80	11.36
Mean	34.86	30.67	10.47
$C.D_{(0.05)}$	**0.69**	**0.65**	**0.21**

4.1.4 Pod width (cm)

The application of various organic inputs registered a significant effect on the pod width of French bean as shown in Table 4.2. The data presented revealed that maximum pod width of 1.26 cm was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which was statistically at par with treatment T_2 (90% RDN +5% Panchgavya), T_5 (80% RDN +5% Panchgavya), T_7 (80% RDN + 5% Panchgavya +5% Jeevamrut) and treatment T_{10} (70% RDN + 5% Panchgavya +5% Jeevamrut). Minimum pod width (0.84 cm), however, was recorded in T_1 i.e. 100 % RDN with a value of 0.84 cm. These results are also in line with those of Rakesh *et al.* (2017) who studied the effect of Panchgavya on growth and yield of *Abelmoschus esculentus* (cv. Arka Anamika) and also with those of Choudhary *et al.* (2017) who studied the effect of Panchgavya on growth and yield of Blackgram (*Vigna mungo* L.), where the effect of manures in conjunction with panchgavya and jeevamrut have been found to increase the pod width of beans.



4.1.5 Yield (quintal per hectare)

The application of various organic inputs registered a significant effect on the pod yield of French bean as shown in Table 4.2. The data presented revealed that maximum yield (71.67 q ha^{-1}) was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) and the minimum pod yield (44.66 q ha^{-1}) was recorded in T_1 i.e. 100 % RDN. These results are also in line with those of Choudhary *et al.* (2017) who studied the effect of Panchgavya on growth and yield of Blackgram (*Vigna mungo* L.).

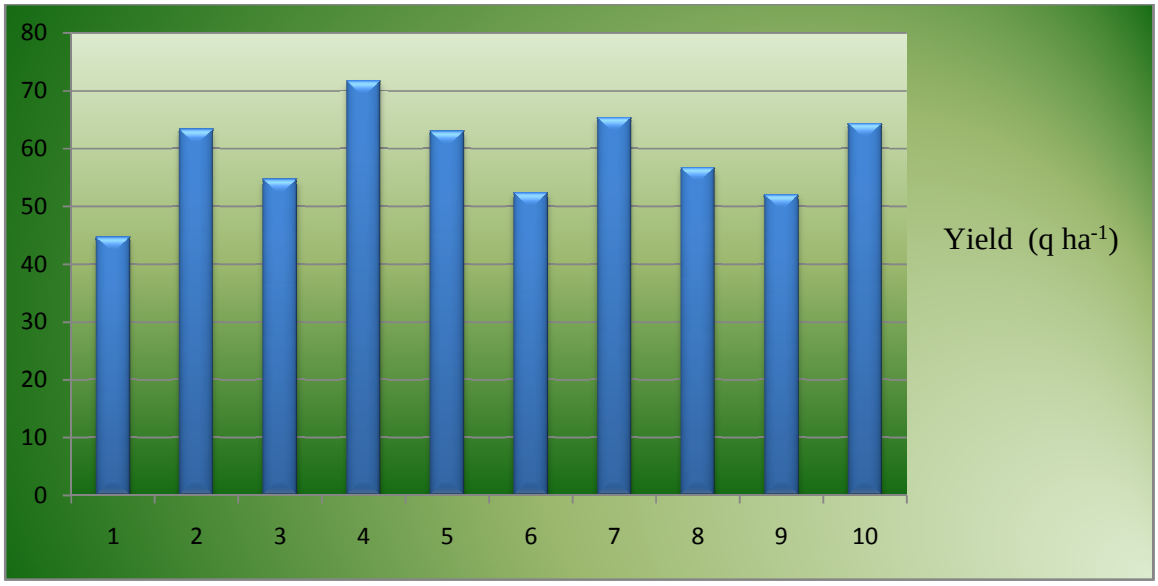


Table 4.2: Effect of organic nutrient sources on pod width and yield of French bean

Treatments	Pod Width (cm)	Pod yield (q ha^{-1})
T_1 : 100% RDN*	0.84	44.66
T_2 : 90% RDN + 5% PG	1.12	63.33
T_3 : 90% RDN + 5% JV	0.94	54.67
T_4 : 90% RDN + 5% PG + 5% JV	1.26	71.67
T_5 : 80% RDN + 5% PG	1.11	63.00
T_6 : 80% RDN + 5% JV	0.93	52.33
T_7 : 80% RDN + 5% PG + 5% JV	1.15	65.33
T_8 : 70% RDN + 5% PG	1.01	56.67
T_9 : 70% RDN + 5% JV	0.86	52.00
T_{10} : 70% RDN + 5% PG + 5% JV	1.13	64.33
Mean	1.03	58.8
$C.D_{(0.05)}$	**0.17**	**3.51**

4.1.6 Pod weight

The application of various organic inputs registered a significant effect on the pod weight of French bean as shown in Table 4.3. The data presented revealed that maximum pod weight (2.34 g) was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut), whereas, the minimum pod weight of 1.44 g was recorded in T_1 i.e. 100 % RDN. These results are also in line with those of Rakesh *et al.* (2017) who studied the effect of Panchgavya on growth and yield of *Abelmoschus esculentus* and also with those of Boraiah *et al.* (2017) who studied the effect of panchgavya, jeevamruta and cow urine on the yield of Capsicum (*Capsicum annuum* L. var. grossum). The better moisture and nutrient regimes under the organic treatments seem to have a positive effect on the growth attributes of French bean.

4.1.7 Number of days to first harvesting

The data presented in table 4.3 revealed that minimum number of days (59.18 days) the plant took for first harvesting or the earliest harvest was under treatment T_1 i.e. 100 % RDN. The maximum number of days (64.45 days) that the plant took for first harvesting was under treatment T_5 80% RDN + 5% Panchgavya. These results are also in line with those of Dev (2010) who reported that the number of days to first harvesting in French bean cv. Lakshmi in lower hills of northern India was significantly effected by the application of organic manures. The control treatment seems to have led to the early onset of the reproductive phase in the plants which was delayed in case of the organic nutrient treatments with panchgavya and jeevamrut.

4.1.8 Harvest duration

The application of various organic inputs registered a significant effect on harvest duration of the crop as shown in Table 4.3. The data presented revealed that maximum harvest duration of 46.49 days was recorded in treatment T_8 (70% RDN + 5% Panchgavya) and was statistically at par with treatments T_1 (43.56 days), T_4 (45.62 days), T_9 (45.33 days) and T_{10} (43.50 days). Minimum harvest duration of 41.02 days was recorded in treatment T_2 (90% RDN +5% Panchgavya). These findings are in conformity with those of Dev (2010) who reported that the harvest duration in French bean cv. Lakshmi in lower hills of northern India was significantly

affected by the application of organic manures. Although, no definite trend was observed, but the treatment effects were found to be significant.

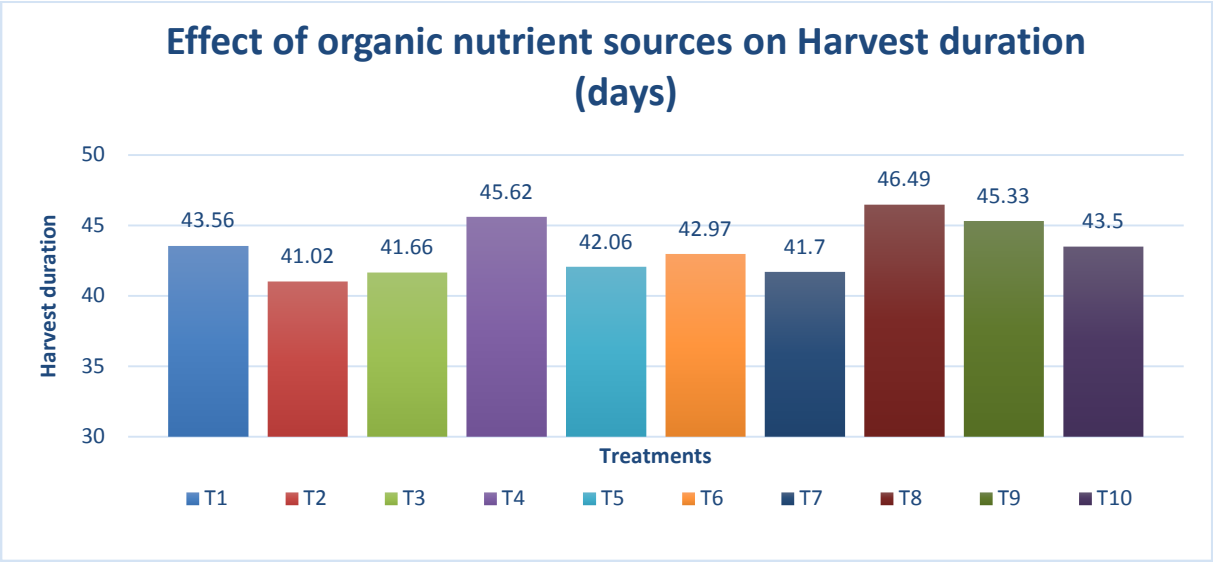


Table 4.3: Effect of organic nutrient sources on pod weight, number of days to first harvesting and harvest duration in French bean

Treatments	Pod weight (g)	Number of days to first harvesting	Harvest duration (days)
T_1 : 100% RDN*	1.44	59.18	43.56
T_2 : 90% RDN + 5% PG	1.94	60.82	41.02
T_3 : 90% RDN + 5% JV	1.90	62.50	41.66
T_4 : 90% RDN + 5% PG + 5% JV	2.34	60.51	45.62
T_5 : 80% RDN + 5% PG	1.93	64.45	42.06
T_6 : 80% RDN + 5% JV	1.86	62.86	42.97
T_7 : 80% RDN + 5% PG + 5% JV	2.08	63.51	41.70
T_8 : 70% RDN + 5% PG	1.91	60.18	46.49
T_9 : 70% RDN + 5% JV	1.70	61.43	45.33
T_{10} : 70% RDN + 5% PG + 5% JV	2.06	63.34	43.50
Mean	1.92	61.88	43.39
$C.D_{(0.05)}$	**0.24**	**0.90**	**3.45**

4.1.9 Total dry matter content of plants

The data presented in table 4.4 revealed that the maximum shoot dry weight (72.8 g plant^{-1}) was of the plants developed under treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut), which was statistically at par with the treatments T_7 and T_{10}. The minimum dry weight of

shoots was 45.6 g plant^{-1} for control plants. The root dry weight did not show any significant differences, although the maximum root dry weight of 7.3 g plant^{-1} was in T_7 and minimum in T_1. The dry weight of pods was maximum in T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) with a value of 8.3 g plant^{-1} while the minimum was in treatment T_1 i.e. 100 % RDN.

Table 4.4 Effect of organic nutrient sources on dry matter content (g plant^{-1}) in French bean

Treatments	Dry Matter (g plant^{-1})		
	Shoot	**Root**	**Pod**
T_1 : 100% RDN*	45.6	6.4	6.1
T_2 : 90% RDN + 5% PG	63.5	7.1	7.6
T_3 : 90% RDN + 5% JV	59.2	7.0	6.7
T_4 : 90% RDN + 5% PG + 5% JV	72.8	7.2	8.3
T_5 : 80% RDN + 5% PG	62.8	7.1	7.2
T_6 : 80% RDN + 5% JV	58.4	6.7	6.4
T_7 : 80% RDN + 5% PG + 5% JV	70.4	7.3	8.1
T_8 : 70% RDN + 5% PG	60.7	6.9	7.1
T_9 : 70% RDN + 5% JV	52.1	6.7	6.4
T_{10} : 70% RDN + 5% PG + 5% JV	68.4	7.2	7.8
Mean	61.4	6.9	7.2
$C.D_{(0.05)}$	**6.30**	**NS**	**0.3**

4.2. EFFECT OF ORGANIC NUTRIENT SOURCES ON TOTAL NPK CONTENT AND THEIR UPTAKE BY PLANTS

4.2.1 Total NPK content in shoot

The effect of various organic inputs on N content in plant shoots is shown in Table 4.5. The data presented revealed that maximum N content (2.40 per cent) was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which was statistically significant as compared to other treatments. The minimum N content of 1.75 per cent was recorded in T_1 i.e. 100 % RDN. The P content in plant shoots (Table 4.5) revealed a maximum P content of 0.39 per cent recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut). The minimum P content of 0.21 per cent was however recorded in control i.e. 100 % RDN.

The application of various organic inputs registered a significant effect on K content in plant shoots (Table 4.5). The data showed that maximum K content (3.21 per cent) was again

recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) and was statistically superior to all the other treatments. Minimum K content in shoots (2.26%) was recorded in T_1 i.e. 100 % RDN.

These results are in line with the findings of Upadhyay (2018) who concluded that NPK content was significantly affected by the application of panchgavya in transplanted rice (*Oryza sativa*) under middle Gangetic plains of India.

Table 4.5: Effect of organic nutrient sources on total N, P and K content in French bean shoots (including leaves)

Treatments	N content in shoots (%)	P content in shoots (%)	K content in shoots (%)
T_1 : 100% RDN*	1.75	0.21	2.26
T_2 : 90% RDN + 5% PG	2.00	0.32	2.88
T_3 : 90% RDN + 5% JV	1.89	0.30	2.39
T_4 : 90% RDN + 5% PG + 5% JV	2.40	0.39	3.21
T_5 : 80% RDN + 5% PG	2.05	0.31	2.58
T_6 : 80% RDN + 5% JV	1.79	0.24	2.36
T_7 : 80% RDN + 5% PG + 5% JV	2.25	0.35	3.06
T_8 : 70% RDN + 5% PG	1.94	0.30	2.54
T_9 : 70% RDN + 5% JV	1.80	0.24	2.27
T_{10} : 70% RDN + 5% PG + 5% JV	2.19	0.36	3.01
Mean	2.01	0.30	2.66
$C.D_{(0.05)}$	**0.11**	**0.02**	**0.08**

4.2.2 Total NPK content in pods

The application of various organic inputs was found to have a significant effect on P content in plant pods. The data presented in Table 4.6 revealed that maximum N content of 2.33 per cent was recorded in treatment T_4 consisting of 90% RDN + 5% Panchgavya + 5% Jeevamrut. Minimum N content of 1.71 per cent was recorded in T_1 i.e. 100 % RDN. The P content in plant pods revealed that maximum P content (0.33 per cent) was again recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) and treatment T_7 (80% RDN + 5% Panchgavya +5% Jeevamrut). The minimum P content in pods (0.21 per cent) was recorded in T_1 i.e. 100 % RDN and treatment T_6 i.e. 80% RDN + 5% JV.

Similarly, the K content in plant pods (Table 4.6) revealed that the maximum K content of 2.97 per cent was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut)

which was statistically at par with treatment T_7 (80% RDN + 5% Panchgavya +5% Jeevamrut). The minimum K content of 2.23 per cent was recorded in control (100 % RDN).

These results are in agreement with those of Yildrim *et al.* (2011) who observed a significant increase in nutrient content in Broccoli by the application of organic inputs and bacterial inoculation. Furthermore, Weber *et al.* (2007) reported a significant increase in the nutrient content and other soil properties by the application of composts.

Table 4.6: Effect of organic nutrient sources on total N, P and K content in French bean pods

Treatments	N content in pods (%)	P content in pods (%)	K content in pods (%)
T_1 : 100% RDN*	1.71	0.21	2.23
T_2 : 90% RDN + 5% PG	1.94	0.28	2.65
T_3 : 90% RDN + 5% JV	1.80	0.27	2.26
T_4 : 90% RDN + 5% PG + 5% JV	2.33	0.33	2.97
T_5 : 80% RDN + 5% PG	1.91	0.26	2.56
T_6 : 80% RDN + 5% JV	1.75	0.21	2.27
T_7 : 80% RDN + 5% PG + 5% JV	2.25	0.33	2.95
T_8 : 70% RDN + 5% PG	1.89	0.27	2.51
T_9 : 70% RDN + 5% JV	1.75	0.23	2.27
T_{10} : 70% RDN + 5% PG + 5% JV	2.09	0.30	2.76
Mean	1.94	0.27	2.54
$C.D_{(0.05)}$	**0.06**	**0.02**	**0.13**

4.2.3 Total NPK content in root

The application of various organic inputs registered a significant effect on N content in plant roots as shown in Table 4.7. The data revealed that maximum N content of 2.25 per cent was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) while the minimum N content 1.65 per cent was recorded in T_1 (100 % RDN).

The maximum P content in plant roots (0.32 per cent) was also recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which was statistically superior over all the other treatments. The minimum P content (0.19 per cent) was recorded in control i.e. 100 % RDN, as well as in treatment T_9 (70% RDN +5% Jeevamrut).

Similarly the K content in plant roots was maximum (2.96 per cent) in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) and the minimum K content (2.06 per cent) was recorded in 100 % RDN treatment

Table 4.7: Effect of organic nutrient sources on total N, P and K content in French bean roots

Treatments	N content in roots (%)	P content in roots (%)	K content in roots (%)
T_1 : 100% RDN*	1.65	0.19	2.06
T_2 : 90% RDN + 5% PG	1.89	0.26	2.56
T_3 : 90% RDN + 5% JV	1.81	0.24	2.20
T_4 : 90% RDN + 5% PG + 5% JV	2.25	0.32	2.96
T_5 : 80% RDN + 5% PG	1.82	0.25	2.44
T_6 : 80% RDN + 5% JV	1.76	0.21	2.18
T_7 : 80% RDN + 5% PG + 5% JV	2.05	0.29	2.87
T_8 : 70% RDN + 5% PG	1.82	0.24	2.33
T_9 : 70% RDN + 5% JV	1.72	0.19	2.58
T_{10} : 70% RDN + 5% PG + 5% JV	2.00	0.28	2.43
Mean	1.88	0.25	2.46
$C.D_{(0.05)}$	**0.10**	**0.02**	**0.05**

4.2.4 Total NPK uptake

The application of various organic inputs registered a significant effect on the total uptake of NPK by the plant as shown in Table 4.8. The total uptake derived from the dry biomass and nutrient content in plants followed the trend obtained for NPK uptake in shoots, roots and pods as described in Appendices and the total uptake is the sum total of all the values described therein. The data presented revealed that maximum N uptake (167.4 kg ha^{-1}) was recorded in treatment T_4 comprising of 90% RDN + 5% Panchgavya + 5% Jeevamrut. The minimum N uptake of 79.3 kg ha^{-1} was recorded in control. Maximum P uptake (26.4 kg ha^{-1}) and K uptake (223.1 kg ha^{-1}) were recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) while the minimum P uptake (9.4 kg ha^{-1}) and K-uptake (102.1 kg ha^{-1}) were recorded in control comprising of 100 % RDN. These results are in conformity with the findings of Premsekhar and Rajasheree (2009) who reported that application of FYM, poultry manure and vermicompost gives a significant increase in the uptake of macronutrients in okra. Furthermore, Naidu *et al.* (2009) also reported a significant increase in the nutrient uptake and residual fertility

in chilli (cv. byadgi dabbi) by the application of organic inputs. These results are also in conformity with the findings of Patel *et al.* (2018) who studied the effect of Panchgavya and Jeevamrut on yield, chemical and biological properties of soil and nutrients uptake by kharif groundnut (*Arachis hypogaea* L.). The organic inputs including panchgavya and jeevamrut have a positive effect on the soil health and biological activity, which creates favourable conditions for the uptake of nutrients from the soil and their accumulation in plants.

Table 4.8: Effect of organic nutrient sources on total N, P and K uptake (kg ha^{-1}) by French bean

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 : 100% RDN*	79.3	9.4	102.1
T_2 : 90% RDN + 5% PG	123.0	19.3	175.2
T_3 : 90% RDN + 5% JV	109.4	16.9	137.6
T_4 : 90% RDN + 5% PG + 5% JV	167.4	26.4	223.1
T_5 : 80% RDN + 5% PG	122.9	18.2	156.9
T_6 : 80% RDN + 5% JV	101.5	13.5	132.6
T_7 : 80% RDN + 5% PG + 5% JV	151.8	23.5	206.6
T_8 : 70% RDN + 5% PG	113.3	17.4	148.3
T_9 : 70% RDN + 5% JV	93.6	12.1	120.5
T_{10} : 70% RDN + 5% PG + 5% JV	144.0	23.0	195.5
Mean	120.6	17.9	159.8
C.D$_{(0.05)}$			

4.3 EFFECT OF ORGANIC NUTRIENT SOURCES ON SOIL PROPERTIES

4.3.1 Soil pH, electrical conductivity (EC)

The data on soil pH and EC clearly revealed that none of the tried treatments had any significant impact on these properties of soil (Table 4.9). It was, however, observed that the application of organic sources of nutrients decreased the soil pH and brought it to a slightly acidic regime. The values for pH ranged from 6.33 to 6.60 and that of EC ranged between 0.17 dS m^{-1} to 0.21 dS m^{-1}. Any significant changes in these properties may be observed after long term experimentation. These results on soil pH and EC are in accordance with the studies carried out by Selvi *et al.* (2004) who revealed that only long term experimentation may bring changes in some of the physico-chemical properties of soil, and no short term changes are observed.

Table 4.9: Effect of organic nutrient sources on soil pH and electrical conductivity of soil

Treatments	pH	Electrical conductivity ($dS\ m^{-1}$)
T_1 : 100% RDN*	6.60	0.19
T_2 : 90% RDN + 5% PG	6.35	0.17
T_3 : 90% RDN + 5% JV	6.41	0.17
T_4 : 90% RDN + 5% PG + 5% JV	6.42	0.18
T_5 : 80% RDN + 5% PG	6.33	0.21
T_6 : 80% RDN + 5% JV	6.48	0.18
T_7 : 80% RDN + 5% PG + 5% JV	6.42	0.17
T_8 : 70% RDN + 5% PG	6.53	0.17
T_9 : 70% RDN + 5% JV	6.55	0.19
T_{10} : 70% RDN + 5% PG + 5% JV	6.56	0.19
Mean	6.47	0.18
$C.D_{(0.05)}$	**NS**	**NS**

4.3.2 Organic Carbon

The application of various organic inputs registered a significant effect on organic carbon content of the soil (Table 4.10). The data presented revealed that maximum soil organic carbon of 2.31 per cent was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut), which was statistically at par with treatment T_7 (80% RDN + 5%Panchgavya +5%Jeevamrut) and T_{10} (70% RDN + 5% Panchgavya +5% Jeevamrut).

Table 4.10: Effect of organic nutrient sources on organic carbon (%)

Treatments	Organic Carbon (%)
T_1 : 100% RDN*	1.62
T_2 : 90% RDN + 5% PG	2.14
T_3 : 90% RDN + 5% JV	1.82
T_4 : 90% RDN + 5% PG + 5% JV	2.31
T_5 : 80% RDN + 5% PG	2.01
T_6 : 80% RDN + 5% JV	1.75
T_7 : 80% RDN + 5% PG + 5% JV	2.25
T_8 : 70% RDN + 5% PG	1.85
T_9 : 70% RDN + 5% JV	1.70
T_{10} : 70% RDN + 5% PG + 5% JV	2.25
Mean	1.97
$C.D_{(0.05)}$	**0.12**

The minimum value of 1.62 per cent organic carbon was recorded in T_1 i.e. 100 % RDN. These results are in conformity with the findings of Patel *et al*. (2018) who studied the effect of Panchgavya and Jeevamrut on yield, chemical and biological properties of soil and nutrients uptake by kharif groundnut (*Arachis hypogaea* L.), and found that the organic amendments like panchgavya and jeevamrut have a beneficial effect on soil organic carbon.

4.3.3 Available macronutrients

The organic inputs had a significant effect on available N in soil (Table 4.11). The data presented revealed that maximum value of soil available N of 372.46 kg ha^{-1} was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut), which was statistically at par with treatment T_{10} (70% RDN + 5% Panchgavya +5% Jeevamrut). The available P was maximum (70.99 kg ha^{-1}) in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) and was statistically at par with treatment T_2 (90% RDN +5% Panchgavya), T_7 (80% RDN + 5%Panchgavya +5%Jeevamrut) and T_{10} (70% RDN + 5% Panchgavya +5% Jeevamrut). Minimum available P (52.96 kg ha^{-1}) was again recorded in control.

Table 4.11: Effect of organic nutrient sources on available macro nutrient content (kg ha^{-1}) in soil

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 : 100% RDN*	307.62	52.96	357.36
T_2 : 90% RDN + 5% PG	345.55	65.11	387.55
T_3 : 90% RDN + 5% JV	344.75	60.38	365.72
T_4 : 90% RDN + 5% PG + 5% JV	372.46	70.99	402.22
T_5 : 80% RDN + 5% PG	337.47	64.07	387.25
T_6 : 80% RDN + 5% JV	351.81	54.28	362.68
T_7 : 80% RDN + 5% PG + 5% JV	351.62	68.65	393.06
T_8 : 70% RDN + 5% PG	349.58	61.21	383.27
T_9 : 70% RDN + 5% JV	323.43	53.51	360.73
T_{10} : 70% RDN + 5% PG + 5% JV	359.03	67.07	389.10
Mean	344.33	61.82	378.89
$C.D_{(0.05)}$	**19.28**	**6.69**	**15.19**

The exchangeable potassium content in the soil was found to be maximum (402.22 kg ha^{-1}) in the treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which was statistically at par with treatment T_2 (90% RDN +5% Panchgavya), T_5 (80% RDN +5% Panchgavya), T_7 (80%

RDN + 5%Panchgavya +5%Jeevamrut) and T_{10} (70% RDN + 5% Panchgavya +5% Jeevamrut). The minimum value (357.36 kg ha^{-1}) as in previous cases was recorded in T_1 i.e. 100 % RDN.

The results obtained are in conformity with the findings of Patel *et al.* (2018) who studied the effect of Panchgavya and Jeevamrut on yield, chemical and biological properties of soil and nutrients uptake by kharif groundnut (*Arachis hypogaea* L.).

4.3.4 DTPA extractable cations

The effect of application of various organic inputs on available micronutrient cations is presented in table 4.12. The data presented revealed that maximum values of micronutrient cations (Zn, Cu, Fe, Mn *viz.* 2.42 mg kg^{-1}, 3.42 mg kg^{-1}, 16.30 mg kg^{-1}, and 11.43 mg kg^{-1} , respectively) were recorded in T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) while the minimum (2.13 mg kg^{-1}, 2.70 mg kg^{-1}, 14.69 mg kg^{-1}, and 10.58 mg kg^{-1} , respectively) were recorded in T_1 i.e. 100 % RDN. The results were significant only with respect to Fe and Mn. Similar results were also reported by Abusaleha and Shanmugavelu (1988) and Naidu *et al.* (1999) in okra who reported that the application of organic manure such as farm yard manure, poultry manure and vermicompost significantly increase the micronutrients content in plants.

Table 4.12: Effect of organic nutrient sources on DTPA extractable cations (mg kg^{-1}) in soil

Treatments	Zn	Cu	Fe	Mn
T_1 : 100% RDN*	2.13	2.70	14.69	10.58
T_2 : 90% RDN + 5% PG	2.31	2.77	16.24	11.12
T_3 : 90% RDN + 5% JV	2.24	2.92	15.81	10.76
T_4 : 90% RDN + 5% PG + 5% JV	2.42	3.42	16.30	11.43
T_5 : 80% RDN + 5% PG	2.31	3.01	16.11	11.06
T_6 : 80% RDN + 5% JV	2.21	3.30	15.69	10.68
T_7 : 80% RDN + 5% PG + 5% JV	2.41	3.25	16.25	11.36
T_8 : 70% RDN + 5% PG	2.28	3.40	15.81	10.87
T_9 : 70% RDN + 5% JV	2.17	3.41	15.25	10.60
T_{10} : 70% RDN + 5% PG + 5% JV	2.33	2.94	16.24	11.16
Mean	2.28	3.11	15.84	10.96
$C.D_{(0.05)}$	**NS**	**NS**	**0.26**	**0.35**

4.3.5 Soil microbiological properties

4.3.5.1 Microbial count

The soil microbial (Table 4.13) revealed that maximum microbial count (146.7 $\times 10^5$ cfu g^{-1} soil) was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) showing

38.87 % increase over the minimum microbial count (105.7×10^5 cfu g^{-1} soil), that was recorded in T_1 i.e. 100 % RDN. Similar results were also reported by Rakesh *et al*. (2017) who studied the effect of Panchgavya on growth and yield of *Abelmoschus esculentus* (cv. Arka Anamika) and also by Amalraj *et al*. (2013) whose area of study was microbiological analysis of Panchgavya, Vermicompost, and FYM and their effect on plant growth promotion of pigeon pea (*Cajanus cajan* L.). The formulations of Jeevamrut and Panchgavya themselves are known to contain several microorganism and their application alongwith FYM and VC helped in increasing the microbial population.

Table 4.13: Effect of organic nutrient sources on total microbial count

Treatments	Total Microbial count ($\times10^5$ cfu g^{-1} soil)
T_1 : 100% RDN*	105.7
T_2 : 90% RDN + 5% PG	131.6
T_3 : 90% RDN + 5% JV	122.6
T_4 : 90% RDN + 5% PG + 5% JV	146.7
T_5 : 80% RDN + 5% PG	129.8
T_6 : 80% RDN + 5% JV	118.2
T_7 : 80% RDN + 5% PG + 5% JV	132.4
T_8 : 70% RDN + 5% PG	129.5
T_9 : 70% RDN + 5% JV	116.4
T_{10} : 70% RDN + 5% PG + 5% JV	132.2
Mean	126.5
$C.D_{(0.05)}$	**4.58**

4.3.5.2 Microbial biomass-C

The microbial biomass-C varied significantly in soil as shown in Table 4.14. The data revealed that maximum microbial biomass-C (60.5 µg g^{-1} soil) was recorded in treatment T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut), which was statistically at par with T_7 (80% RDN + 5%Panchgavya +5%Jeevamrut), whereas, the minimum value (29.2 µg g^{-1} soil) was recorded in T_1 i.e. 100 % RDN. The results are in line with those of Mallesha *et al.* (2017) who studied the effect of organic nutrient management practices on soil enzyme activity and microbial biomass at harvest of bajra in bajra-groundnut cropping system and Amalraj *et al.*

(2013) who studied the effect of Panchgavya, Vermicompost, and FYM on soil enzymatic activity and plant growth promotion of pigeon pea (*Cajanus cajan* L.). The increase in the microbial count under Panchgavya and Jeevamrut alongwith FYM and VC results in simultaneous increase in the microbial biomass, as the two properties are interrelated.

Table 4.14: Effect of organic nutrient sources on microbial biomass-C

Treatments	Microbial Biomass-C ($\mu g\ g^{-1}$ soil)
T_1 : 100% RDN*	29.2
T_2 : 90% RDN + 5% PG	47.2
T_3 : 90% RDN + 5% JV	36.9
T_4 : 90% RDN + 5% PG + 5% JV	60.5
T_5 : 80% RDN + 5% PG	44.5
T_6 : 80% RDN + 5% JV	32.0
T_7 : 80% RDN + 5% PG + 5% JV	57.7
T_8 : 70% RDN + 5% PG	41.8
T_9 : 70% RDN + 5% JV	30.9
T_{10} : 70% RDN + 5% PG + 5% JV	48.8
Mean	42.97
$C.D_{(0.05)}$	**3.07**

c) Soil enzymes

The dehydrogenase activity in soil (Table 4.15) revealed that maximum value (4.9 mg TPF h^{-1} g^{-1} soil) was observed in T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut). Minimum value for dehydrogenase activity (2.8 TPF h^{-1} g^{-1} soil) was recorded in T_1 i.e. 100 % RDN.

The application of various organic inputs registered a significant effect on phosphatase activity in soil as shown in Table 4.15. The data presented revealed that maximum value for phosphatase activity (30.0 µmole PNP $h^{-1}g^{-1}$ soil) was recorded in T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which was statistically at par with T_7 (80% RDN + 5% Panchgavya +5% Jeevamrut) and T_{10} (70% RDN + 5% Panchgavya +5% Jeevamrut). The minimum value for phosphatase activity (19.2 µmole PNP $h^{-1}g^{-1}$ soil) was recorded in T_1 i.e. control. These results are supported by the findings of Srilatha *et al.* (2013) who reported that the application of FYM significantly increased the phosphatase activity in the soil.

The urease activity in soil, as shown in table 4.15, was found to be significantly influenced by organic inputs. The data presented revealed that maximum value for urease activity (0.32 mg NH_4^+ g^{-1} soil) was recorded in T_4 (90% RDN + 5% Panchgavya + 5% Jeevamrut) which was statistically at par with treatment T_2, T_5, T_7 and T_{10}, whereas, the minimum value (0.18 mg $NH_4^+g^{-1}$ soil) was recorded in T_1. The results on soil enzyme activity are in line with the findings of Mallesha *et al.* (2017) who studied the effect of organic nutrient management practices on soil enzyme activity and microbial biomass at harvest of bajra in bajra-groundnut cropping system. The results are in conformation with the findings of Gore and Sreenivasa (2011) who also stated that the enzymatic activity in soil increases with the application of beejamrut, jeevamrut and panchgavya in tomato. Chandrakala *et al*. (2007) also found enzyme activity to increase with the use of these amendments in chilli. The increased microbial activity under Panchgavya and Jeevamrut result in the increased enzyme activity.

Table 4.15: Effect of organic nutrient sources on soil enzyme activity

Treatments	Dehydrogenase (mg TPF h^{-1} g^{-1} soil)	Phosphatase (µmole PNP $h^{-1}g^{-1}$ soil)	Urease (mg $NH_4^+g^{-1}$ soil)
T_1 : 100% RDN*	2.8	19.2	0.18
T_2 : 90% RDN + 5% PG	4.3	25.6	0.27
T_3 : 90% RDN + 5% JV	3.4	23.5	0.23
T_4 : 90% RDN + 5% PG + 5% JV	4.9	30.0	0.32
T_5 : 80% RDN + 5% PG	3.9	24.8	0.23
T_6 : 80% RDN + 5% JV	3.3	23.4	0.22
T_7 : 80% RDN + 5% PG + 5% JV	4.4	28.0	0.31
T_8 : 70% RDN + 5% PG	3.6	23.7	0.23
T_9 : 70% RDN + 5% JV	2.9	23.2	0.19
T_{10} : 70% RDN + 5% PG + 5% JV	4.4	26.0	0.27
Mean	3.8	24.7	0.25
$C.D_{(0.05)}$	**0.12**	**4.34**	**0.05**

Chapter - 5

SUMMARY AND CONCLUSION

Present investigations entitled, **"Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)"** were conducted at the experimental farm of the Department of Soil Science and Water Management, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, (HP) during the spring summer season of the year 2018.

The salient findings of the experimentation have been summarized below:

- Plant height was significantly improved by various organic amendments. Maximum plant height (38.20 cm) was recorded under treatment T_4 (90% RDN + Panchgavya @5% + Jeevamrut @5%) which is about 16.6 % more than the control treatment T_1 (100% RDN). Maximum number of pods per plant (34.77) were recorded in T_4 which is about 26.1 % higher as compared to treatment T_1. Maximum pod length (11.93 cm), maximum pod width (1.26 cm) , maximum pod yield per plant (71.67g), maximum pod yield per plot (2.88 kg) and maximum pod weight (2.34 g) were also observed under T_4. The minimum number of days (59.18 days) the plant took for first harvesting was under treatment T_1, whereas, the maximum number of days (64.45 days) that the plant took for first harvesting was under treatment T_5 (80% RDN + 5% Panchgavya). The maximum harvest duration (46.49 days) was recorded in T_8 (70% RDN + 5%Panchgavya) while the minimum duration (41.02 days) was recorded in T_2 (90% RDN +5% Panchgavya).
- The total NPK content in shoot, root and pods was also significantly influenced by various combinations of organic sources of inputs. Maximum shoot N (2.40%), P (0.39 %), and K (3.21 %) were recorded under T_4**.** Maximum root N (2.25%), P (0.31 %), and K (2.96 %) were recorded under T_4**.** Maximum pod N (2.33%), P (0.33 %), and K (2.97 %) were also recorded under T_4**.**
- The total uptake of NPK by the plant was significantly increased by the application of various organic inputs. After adding the uptake by shoots, roots and pods it was observed that the highest total N uptake (167.4 kg ha^{-1}), P uptake (16.9 kg ha^{-1}) and K uptake (223.1 kg ha^{-1}) were recorded under treatment T_4 (90% RDN + Panchgavya @5% + Jeevamrut @5%). The maximum uptake of NPK were 25.4, 191.3 and 135.1 per cent higher in the best treatment as compared to the control.

- Application of different organic inputs did not influence the soil pH and EC. However, a significant effect on soil organic carbon was observed. The highest organic carbon (2.31%) was recorded in treatment T_4. The available NPK and DTPA extractable cations (Cu, Fe, Zn and Mn) registered a significant increase by the application of various organic inputs under T_4 wherein the corresponding values for available NPK content were 372.46 kg ha^{-1}, 70.99 kg ha^{-1}, 402.22 kg ha^{-1}, respectively showing an increase of 21.1, 34.0 and 12.6 per cent over control. For DTPA extractable cations (Cu, Fe, Zn and Mn) the maximum values were 2.42 mg kg^{-1}, 3.42 mg kg^{-1}, 16.30 mg kg^{-1} and 11.43 mg kg^{-1} , respectively, which were 13.6, 26.7, 10.9 and 8.6 per cent higher than the control.
- The microbial counts of the soil were significantly influenced by various organic inputs. The maximum total microbial count (146.76 x 10^5 cfu g^{-1}) was recorded under treatment T_4 (90% RDN + Panchgavya @5% + Jeevamrut @5%). Significant effect was also recorded for microbial biomass-C by the application of various organic inputs. The highest microbial biomass-C (60.5 µg g^{-1} soil) was recorded in treatment T_4. The soil enzymes were also significantly influenced by the application of various organic inputs. The highest Dehydrogenase (4.9 mg TPF h^{-1} g^{-1} soil), Phosphatase (30.0 µmole PNP $h^{-1}g^{-1}$ soil) and Urease (0.32 mg $NH_4^+g^{-1}$ soil**)** were recorded in treatment T_4 (90% RDN + Panchgavya @5% + Jeevamrut @5%).

CONCLUSION:

From the present investigations, it is concluded that the application of 90 per cent of recommended dozes of nutrients on the basis of nitrogen equivalence through vermicompost and poultry manure in a 50:50 ratio along with the application of liquid organic formulations i.e., Panchgavya and Jeevamrut @ 5 per cent each, significantly increased the growth, yield and pod quality parameters and available macro and micronutrients, microbial count, microbial biomass and soil enzymes. Full amount of vermicompost and poultry manure should be applied and mixed with soil in the first week after sowing of seeds. The Panchgavya (5%) and Jeevamrut (5%) organic formulations should be applied two times as soil drench @ 250 ml per plant at 15 days interval after two weeks of sowing upto the third picking of the crop. Therefore, the developed nutrient module may be recommended, after conducting multi location trials, for enhanced productivity of French bean and sustaining and improving the soil health.

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ANNEXTURE – I

Fresh weight of shoot, root and pod (quintal per hectare)

Treatments	Shoot	Root	Pod
T1	29.01	9.17	44.66
T2	31.47	10.69	63.33
T3	29.87	10.08	54.67
T4	33.76	11.36	71.67
T5	30.48	10.61	63.00
T6	29.81	9.52	52.33
T7	32.40	11.17	65.33
T8	30.13	10.45	56.67
T9	29.09	9.36	52.00
T10	31.63	10.77	64.33
Mean	30.77	10.32	58.8
$C.D._{(0.05)}$	**1.68**	**0.97**	**3.51**

ANNEXTURE – II

Analysis of Variance table (ANOVA)

1. Analysis of Variance table for plant height:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.691		
Treatment	9	125.720	13.969	88.611
Error	18	2.838	0.158	
Total	29	129.248		

2. Analysis of Variance table for number of pods per plant:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.256		
Treatment	9	171.799	19.089	137.095
Error	18	2.506	0.139	
Total	29	174.561		

3. Analysis of Variance table for pod length:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.025		
Treatment	9	26.447	2.939	191.449
Error	18	0.276	0.015	
Total	29	26.748		

4. Analysis of Variance table for pod width:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.011		
Treatment	9	0.525	0.058	6.161
Error	18	0.170	0.009	
Total	29	0.707		

5. Analysis of Variance table for pod yield per plant:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.800		
Treatment	9	1,759.467	195.496	47.213
Error	18	74.533	4.141	
Total	29	1,834.800		

6. Analysis of Variance table for pod yield per plot:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.011		
Treatment	9	2.272	0.252	177.082
Error	18	0.026	0.001	
Total	29	2.308		

7. Analysis of Variance table for pod weight:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.031		
Treatment	9	1.504	0.167	8.421
Error	18	0.357	0.020	
Total	29	1.892		

8. Analysis of Variance table for number of days to first harvesting:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.246		
Treatment	9	78.353	8.706	31.788
Error	18	4.930	0.274	
Total	29	83.528		

9. Analysis of Variance table for harvest duration:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	25.927		
Treatment	9	95.311	10.590	2.662
Error	18	71.620	3.979	
Total	29	192.859		

10. Analysis of Variance table for N content in shoots:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.006		
Treatment	9	1.183	0.131	15.292
Error	18	0.155	0.009	
Total	29	1.343		

11. Analysis of Variance table for P content in shoots:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.008		
Treatment	9	0.093	0.010	15.269
Error	18	0.012	0.001	
Total	29	0.114		

12. Analysis of Variance table for K content in shoot:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.142		
Treatment	9	3.441	0.382	5.942
Error	18	1.158	0.064	
Total	29	4.741		

13. Analysis of Variance table for N content in pods:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.002		
Treatment	9	1.183	0.131	14.289
Error	18	0.166	0.009	
Total	29	1.350		

14. Analysis of Variance table for P content in pods:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.001		
Treatment	9	0.047	0.005	10.890
Error	18	0.009	0.000	
Total	29	0.057		

15. Analysis of Variance table for K content in pods:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.250		
Treatment	9	2.112	0.235	6.002
Error	18	0.704	0.039	
Total	29	3.065		

16. Analysis of Variance table for N content in roots:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.002		
Treatment	9	0.828	0.092	10.594
Error	18	0.156	0.009	
Total	29	0.985		

17. Analysis of Variance table for P content in roots:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.003		
Treatment	9	0.042	0.005	5.506
Error	18	0.015	0.001	
Total	29	0.060		

18. Analysis of Variance table for K content in roots:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.138		
Treatment	9	2.268	0.252	9.167
Error	18	0.495	0.027	
Total	29	2.900		

19. Analysis of Variance table for dry matter in roots:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.055		
Treatment	9	32.881	3.653	103.886
Error	18	0.633	0.035	
Total	29	33.569		

20. Analysis of Variance table for dry matter in shoots:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.008		
Treatment	9	40.685	4.521	158.272
Error	18	0.514	0.029	
Total	29	41.207		

21. Analysis of Variance table for dry matter in pods:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.152		
Treatment	9	86.474	9.608	634.716
Error	18	0.272	0.015	
Total	29	86.898		

ANNEXTURE – III

NUTRIENT UPTAKE BY SHOOT

Treatment	Shoot N-uptake		Shoot P-uptake		Shoot K-uptake	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
1	62.86	2.399	7.433	0.556	81.14	1.982
2	100.757	4.017	16.12	0.571	144.927	5.38
3	89.727	1.891	14.093	0.981	113.317	3.691
4	139.107	1.865	22.443	0.243	186.52	0.818
5	101.97	2.551	15.29	0.059	128.79	0.483
6	83.053	2.331	11.28	0.696	109.29	2.986
7	125.497	4.416	19.74	1.291	171.077	2.654
8	92.727	2.392	14.513	0.808	121.433	3.886
9	75.34	1.906	9.93	0.453	95.03	1.467
10	120.123	5.489	19.587	0.819	165.21	3.966
C.D.	6.127		1.278		5.994	
SE(m)	2.046		0.427		2.002	
SE(d)	2.894		0.604		2.831	
C.V.	3.576		4.916		2.633	

ANNEXTURE – IV

NUTRIENT UPTAKE BY ROOT:

Treatment	Root N-uptake		Root P-uptake		Root K-uptake	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
1	8.41	0.302	0.95	0.032	10.493	0.348
2	10.57	0.339	1.477	0.073	14.323	0.396
3	9.973	0.02	1.323	0.072	12.123	0.055
4	12.923	0.329	1.837	0.095	16.973	0.334
5	10.113	0.035	1.383	0.015	13.55	0.153
6	9.467	0.301	1.113	0.073	11.723	0.162
7	11.97	0.038	1.677	0.089	16.763	0.253
8	9.917	0.124	1.32	0.04	12.697	0.112
9	9.143	0.133	1.007	0.035	13.69	0.185
10	11.553	0.492	1.623	0.087	14.043	0.218
C.D.	0.596		0.131		0.563	
SE(m)	0.199		0.044		0.188	
SE(d)	0.282		0.062		0.266	
C.V.	3.315		5.528		2.39	

ANNEXTURE – V

NUTRIENT UPTAKE BY PODS:

Treatment	Pod N-uptake		Pod P-uptake		Pod K-uptake	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
1	8.043	0.384	0.987	0.09	10.457	0.546
2	11.693	0.357	1.67	0.075	15.96	0.585
3	9.667	0.169	1.467	0.027	12.113	0.257
4	15.417	0.495	2.16	0.075	19.653	0.287
5	10.837	0.398	1.497	0.062	14.543	0.408
6	8.933	0.333	1.073	0.087	11.583	0.407
7	14.343	0.4	2.08	0.079	18.773	0.158
8	10.683	0.232	1.547	0.044	14.173	0.244
9	9.07	0.301	1.173	0.067	11.733	0.468
10	12.337	0.066	1.77	0.036	16.29	0.292
C.D.	0.641		0.131		1.016	
SE(m)	0.214		0.044			
SE(d)	0.303		0.062			
C.V.	3.341		4.908			

ANNEXTURE – VI

Nutrient Uptake ANOVA

1. Shoot N-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	373.117		
Treatment	9	15,042.33	1,671.37	133.049
Error	18	226.117	12.562	
Total	29	15,641.56		

2. Shoot P-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	22.204		
Treatment	9	594.256	66.028	120.748
Error	18	9.843	0.547	
Total	29	626.303		

3. Shoot K-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	361.556		
Treatment	9	32,126.02	3,569.56	296.865
Error	18	216.435	12.024	
Total	29	32,704.01		

4. Root N-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	1.962		
Treatment	9	51.297	5.7	47.922
Error	18	2.141	0.119	
Total	29	55.399		

5. Root P-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0.163		
Treatment	9	2.3	0.256	44.479
Error	18	0.103	0.006	
Total	29	2.566		

6. Root K-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	1.691		
Treatment	9	114.814	12.757	120.104
Error	18	1.912	0.106	
Total	29	118.417		

7. Pod N-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	4.28		
Treatment	9	154.471	17.163	124.725
Error	18	2.477	0.138	
Total	29	161.227		

8. Pod P-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0.17		
Treatment	9	4.234	0.47	82.098
Error	18	0.103	0.006	
Total	29	4.508		

9. Pod K-uptake

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	2.845		
Treatment	9	265.383	29.487	85.425
Error	18	6.213	0.345	
Total	29	274.442		

ANNEXTURE – VII

1. Analysis of Variance table for N uptake:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	1.226		
Treatment	9	1,903.403	211.489	183.713
Error	18	20.721	1.151	
Total	29	1,925.350		

2. Analysis of Variance table for P uptake:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.833		
Treatment	9	56.404	6.267	88.295
Error	18	1.278	0.071	
Total	29	58.515		

3. Analysis of Variance table for K uptake:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	40.193		
Treatment	9	3,620.201	402.245	57.591
Error	18	125.721	6.984	
Total	29	3,786.114		

4. Analysis of Variance table for soil pH:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.029		
Treatment	9	0.242	0.027	11.863
Error	18	0.041	0.002	
Total	29	0.311		

5. Analysis of Variance table for EC:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.000		
Treatment	9	0.005	0.001	5.159
Error	18	0.002	0.000	
Total	29	0.008		

6. Analysis of Variance table for Organic Carbon percentage:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.008		
Treatment	9	1.756	0.195	40.700
Error	18	0.086	0.005	
Total	29	1.851		

7. Analysis of Variance table for available N:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	406.011		
Treatment	9	8,931.678	992.409	7.980
Error	18	2,238.591	124.366	
Total	29	11,576.280		

8. Analysis of Variance table for available P:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	28.023		
Treatment	9	1,142.833	126.981	8.470
Error	18	269.852	14.992	
Total	29	1,440.707		

9. Analysis of Variance table for available K:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	233.387		
Treatment	9	6,729.387	747.710	9.689
Error	18	1,389.068	77.170	
Total	29	8,351.843		

10. Analysis of Variance table for DTPA extractable Zn cation in soil:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.001		
Treatment	9	0.245	0.027	24.439
Error	18	0.020	0.001	
Total	29	0.266		

11. Analysis of Variance table for DTPA extractable Cu cation in soil:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.007		
Treatment	9	2.049	0.228	60.803
Error	18	0.067	0.004	
Total	29	2.123		

12. Analysis of Variance table for DTPA extractable Fe cation in soil:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.031		
Treatment	9	7.391	0.821	35.908
Error	18	0.412	0.023	
Total	29	7.834		

13. Analysis of Variance table for DTPA extractable Mn cation in soil:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.078		
Treatment	9	2.603	0.289	6.917
Error	18	0.753	0.042	
Total	29	3.433		

14. Analysis of Variance table for Microbial count:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	26.256		
Treatment	9	3,424.438	380.493	54.119
Error	18	126.552	7.031	
Total	29	3,577.246		

15. Analysis of Variance table for Microbial biomass:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	3.414		
Treatment	9	3,220.535	357.837	113.797
Error	18	56.602	3.145	
Total	29	3,280.551		

16. Analysis of Variance table for Dehyderogenase:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.015		
Treatment	9	12.909	1.434	273.916
Error	18	0.094	0.005	
Total	29	13.019		

17. Analysis of Variance table for Phosphatase:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	28.737		
Treatment	9	235.225	26.136	4.141
Error	18	113.613	6.312	
Total	29	377.575		

18. Analysis of Variance table for Urease:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.001		
Treatment	9	0.060	0.007	9.172
Error	18	0.013	0.001	
Total	29	0.074		

19. Analysis of Variance table for fresh weight of shoot:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	1.388		
Treatment	9	62.800	6.978	7.378
Error	18	17.023	0.946	
Total	29	81.210		

20. Analysis of Variance table for fresh weight of root:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.051		
Treatment	9	15.578	1.731	5.494
Error	18	5.671	0.315	
Total	29	21.300		

21. Analysis of Variance table for fresh weight of pod:

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.800		
Treatment	9	1,759.467	195.496	47.213
Error	18	74.533	4.141	
Total	29	1,834.800		

22. Analysis of Variance table for yield (kg per hectare):

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	5,120.000		
Treatment	9	11,260,586.667	1,251,176.296	47.213
Error	18	477,013.333	26,500.741	
Total	29	11,742,720.000		

23. Analysis of Variance table for dry matter content in shoot (%):

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.008		
Treatment	9	40.685	4.521	158.272
Error	18	0.514	0.029	
Total	29	41.207		

24. Analysis of Variance table for dry matter content in root (%):

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.055		
Treatment	9	32.881	3.653	103.886
Error	18	0.633	0.035	
Total	29	33.569		

25. Analysis of Variance table for dry matter content in pod (%):

Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F calculated
Replication	2	0.152		
Treatment	9	86.474	9.608	634.716
Error	18	0.272	0.015	
Total	29	86.898		

Department of Soil Science and Water Management
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Title of Thesis	:	**"Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)"**
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Admission Number	:	F-2016-50-M
Major Discipline	:	Soil Science
Minor Discipline (s)	:	a) Vegetable Science
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Year of Award of Degree	:	2018
No. of pages in Thesis	:	60+xiv
No. of words in Abstract	:	341
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ABSTRACT

The present study entitled, **"Effect of organic nutrient sources on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)"** was carried out in the experimental farm of Department of Soil Science and Water management at Nauni, Solan, Himachal Pradesh, during the year 2018. Ten treatment combinations arranged in a randomized block design comprising three bulky organic manures viz. Farm Yard Manure, Vermicompost and Poultry manure and two liquid organic inputs i.e. Panchgavya and Jeevamrut, replicated thrice. Maximum plant height (38.20 cm) , number of pods per plant (34.77) , pod length (11.93 cm), pod width (1.26 cm) , pod yield per plant (71.67g), pod yield per plot (2.88 kg) and pod weight (2.34 g) were observed under T_4 comprising of 90% RDN + Panchgavya @5% + Jeevamrut @5%. Similarly, the maximum shoot N (2.40%), P (0.39 %), and K (3.21 %) were recorded under T_4**.** Maximum root N (2.25%), P (0.31 %), and K (2.96 %) and maximum pod N (2.33%), P (0.33 %), and K (2.97 %) were also recorded under T_4**.** The total uptake of NPK by the plant was significantly increased by the application of various organic inputs. The highest total NP and K uptake of 167.4 ,16.9 and 223.1 kg ha^{-1}, respectively, were recorded with 90% RDN + Panchgavya @5% + Jeevamrut @5%), which were 25.4, 191.3 and 135.1 per cent higher as compared to the control. The highest organic carbon (2.31%), as well as available NPK and DTPA extractable cations (Cu, Fe, Zn and Mn) registered a significant increase by the application of various organic inputs . The maximum total microbial count (146.76 x 10^5 cfu g^{-1}) , microbial biomass-C (60.5 µg g^{-1} soil) were recorded under treatment T_4 (90% RDN + Panchgavya @5% + Jeevamrut @5%). The soil enzymes were also significantly influenced by the application of various organic inputs. The highest Dehydrogenase (4.9 mg TPF h^{-1} g^{-1} soil), Phosphatase (30.0 µmole PNP $h^{-1}g^{-1}$ soil) and Urease (0.32 mg $NH_4^+g^{-1}$ soil**)** were recorded in treatment T_4 (90% RDN + Panchgavya @5% + Jeevamrut @5%).

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B Sc	2016	Dr YS Parmar University Solan	UHF Nauni	71.9%	1st

Title of Thesis in M Sc: Applicable to Ph D students only
Fellowships/ Scholarships/ Gold Medals/Awards/ Any other Distinction
(Please mention the particular alongwith year of award) : No
Publications (Give Numbers only): N/A
Research papers (in peer-reviewed journals): No
Scientific Popular Articles: No
Others:
Visits abroad alongwith duration and purpose of visit: N/A
1.
2.
Any other Remarks: No

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