EFFECT OF DIFFERENT SOURCES OF PHOSPHORUS AND MULCH MATERIALS ON GROWTH AND YIELD OF FRENCH BEAN

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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF DIFFERENT SOURCES OF PHOSPHORUS AND MULCH MATERIALS ON GROWTH AND YIELD OF FRENCH BEAN" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE, embodies the result of a piece of bona fide research work carried out by RAKIBUL ISLAM, Registration No. 18-09099 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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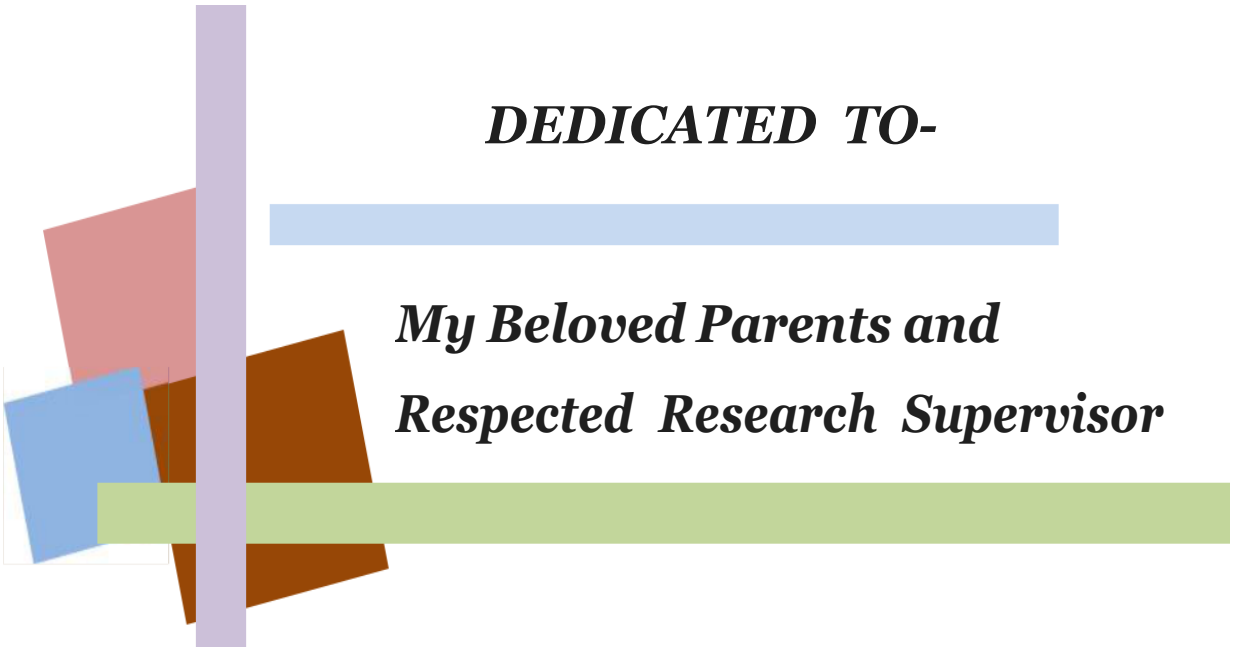

DEDICATED TO-

My Beloved Parents and

Respected Research Supervisor

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka -1207, during the period from November 2019 to February 2020 to study the effect of different sources of phosphorus and mulch materials on growth and yield of french bean. The experiment consisted of two factors. Factor A: different sources of phosphorus as P_1= 100% TSP (control), P_2= 50% TSP + 50% Vemicompost, P_3= 50% TSP + 50% Mushroom spent compost, P_4= 50% Vemicompost + 50% Mushroom spent compost and Factor B: different type of mulch materials as M_1 = No mulch (control), M_2 = White polythene mulch, M_3 = Black polythene mulch. The experiment was laid out in Randomized Complete Block Design with three replications. In case of different sources of phosphorus of french bean the maximum number of flower (29.06), the highest number of pod harvested per plant (24.00) and the highest yield (14.35 t/ha) were found from P_4 treatment, whereas the lowest from P_1 treatment. For different mulch materials the highest number of flower (29.37), the maximum number of pod per plant (24.21) and the highest yield (14.33 t/ha) were recorded from M_2 treatment, while the minimum were from M_0 treatment. Due to combined effect, the maximum number of flower (30.72), the maximum number of pod harvested per plant (26.83), the highest yield (16.76 t/ha) were observed from P_4M_2 treatment combination, while the lowest were from P_1M_0 treatment combination. The highest net return (2,74,100 Tk./ha) was obtained from P_4M_2 and the lowest (1,42,286 Tk./ha) in P_3M_1 treatment combination. The highest (2.19) benefit cost ratio was obtained from P_4M_2 treatment combination, while the lowest (1.63) in P_3M_1 treatment combination. So, the P_4M_2 treatment combination appeared to be the best for achieving the higher growth and yield of french bean.

LIST OF CONTENTS

LIST OF CONTENTS (CONT'D)

LIST OF CONTENTS (CONT'D)

LIST OF CONTENTS (CONT'D)

LIST OF TABLES

LIST OF TABLES (CONT'D)

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF APPENDICES (CONT'D)

LISTS OF ABBREVIATIONS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
Agril.	Agricultural
BARI	Bangladesh Agricultural Research Institute
BCR	Benefit Cost Ratio
cm	Centimeter
CV	Coefficient of variation
0_C	Degree of Centigrade
DAS	Days after sowing
et al.	and others *(at elli)*
Kg	Kilogram
Kg/ha	Kilogram/hectare
g	gram (s)
LSD	Least Significant Difference
MoP	Muriate of Potash
m	Meter
pH	Hydrogen ion conc.
RCBD	Randomized Complete Block Design
TSP	Triple Super Phosphate
Viz.	Namely
t/ha	ton/hectare
@	At the rate of
%	Percent

CHAPTER I

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family Leguminosae and subfamily Papiolionaceae which originated in the Central and South America (Swiader *et al*., 1992). It is a short durated high yielding crop and it can be utilized both as vegetable and pulse. It is widely cultivated in the temperate, tropical, subtropical regions of the world (George, 1985). It is cultivated in Italy, Africa, India, Spain, France, Brazil Peru, Mexico, Bangladesh etc. It is also known as kidney bean, snap bean, green bean, navy bean, pole bean, raj bean, wax bean, string bean and bonchi (Duke, 1983; Salukhe *et al.*, 1987; Tindall, 1988). In our country, french bean is known as jhar sheem. The green pods are used as cooked vegetable in our country and seeds are also used as pulse in Sylhet, Moulvibazar, Sonamgonj, Habigonj, Brahmmanbaria, Feni, Coxs bazar, Chittagong etc. French bean is nutritionally rich in both pod and seed. Each 100 g of pods contain on an average 36 calories food energy, 89% moisture, 2.7g of protein, 0.2 g of lipid, 7.9 g of CHO, 43 mg of Ca, 28 mg of P,1.4 mg of Fe, 0.8 mg of Thiamin and 8.5 mg of Niacin. On the other hand, dry bean seed supplies 336 calories food energy with 12% moisture, 21.7 g of proteins 1.5 g of lipid, 60.9 g of CHO, 120 mg of Ca, 0.37 mg of Thiamin and 2.4 mg of Niacin (Sehoonhoren and Rovset, 1993). Protein from beans and seeds are easily absorbed in human body than animal protein. French bean may also provide hay, silage and green pod. It can be used as feed to cattle, sheep, horses etc.

French bean plants are indeterminate, short, bushy and becoming popular for its tender pods and shelled beans. The crop is not extensively grown in Bangladesh but it has a great export potentiality. In Bangladesh, french bean is cultivated in Shylet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country. Hortex foundation exported 330 metric tons of fresh french bean during the year 2012-2013 (Anonymous, 2013). Now a days Hortex Foundations and BRAC are trying to extend the production area because french bean is now exportable vegetable among others. Recently, Bangladesh earns about US$ 15 million per annum be exporting fresh horticultural produces where french bean shares a large amount. Immature green pods

are also marketed as fresh, frozen or canned. The dry seeds of french bean have a good market price. As early vegetable crop, it can be cultivated successfully during winter season after harvest of transplanted Amman paddy and it would allow the growing of boro rice after harvesting of green pods. It can also be intercropped with maize, wheat, sunflower and sugarcane. Moreover, Bangladesh has a great opportunity to earn foreign exchange by exporting this crop. Because of its high nutritive value, good taste and wide range of use, the popularity of french bean is increasing day by day in Bangladesh like many countries of the world.

Production of french bean depends on many factors such as quality seed, variety, inorganic fertilizers, organic fertilizers, mulch materials and various management practices etc. Most nutrients needed by plants are supplied solely by soil. Insufficient supply of any of these nutrients may limit plant growth. In natural conditions, nutrients are recycled from plants to soil to meet plant needs. However, agricultural crops may require more nutrients than natural vegetation. Significant amounts of nutrients are also removed in harvested crops. Optimal crop growth and profitability may require fertilization with inorganic fertilizers, animal manures, green manures or legume management. Soil organic and inorganic phosphorus plays a significant role in phosphorus nutrition of crops especially in legume crops for nodulation and pod formation. Legume crops need more phosphorus as it is required for energy transformation that take place during nodule functioning (Hernandez *et al.*, 2009). Phosphorus can be applied to the soil in form of inorganic fertilizer (Triple Super Phosphate), organic fertilizer (cowdung, mushroom spent compost, vermicompost etc.), plant residues, agricultural wastes, industrial by-products etc. Especially vermicompost and mushroom spent compost supplies more N and P to the plants as compare to other organic fertilizer (Garg *et al.*, 2008).

Vermicompost is the product of the decomposition process using various species of worms. Vermicompost is an ideal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent these from harmful pests without polluting environment. Mushroom spent compost is the residual compost waste generated by mushroom production industry. After the mushroom have been harvested the spent compost can be used in organic farming to improve soil water

infiltration, water holding capacity, permeability, aeration, a lot of salt and unstable organic material. So it should be aged for about two years before applying.

Mulching is a desirable cultural management practice which is reported to improve soil moisture, physical conditions by enhancing biological activity of the soil fauna and increases soil fertility (Mann and Chakor, 1989; Lal, 1989). It improves soil retention of nutrients and water. It encourages microbial activity and worms in favor of soil and suppresses growth of weeds. Mulching also reduce the water loss from the soil by removing evaporation and reduce the irrigation requirements (Prihar *et al*., 1986). Mulching may be natural or artificial. In artificial mulching, soil surface is covered with crop residues or plant species or polythene sheets and these are generally practiced in the field of horticultural crop production.

The growth and yield of french bean can be increased through application of judicial combination of phosphorus, Vermicompost and Mushroom spent compost with each other. Optimum combination of different sources phosphorous and mulch materials may bring about considerable increase the growth and yield of french bean due to their complementary effects. Considering all above the factors, the present study was undertaken with the following objectives:

I. to determine the appropriate sources of phosphorus on growth and yield of french bean,

II. to find out the effective mulch material for yield and yield attributes of french bean production and

III. to identify suitable combination of different sources of phosphorus and mulch materials for better vegetative growth and maximum yield of french bean.

CHAPTER II

REVIEW OF LITERATURE

French bean (*Phaseolus vulgaris* L.) is popular and important legume vegetable crop grown during rabi season in Bangladesh. Various researches on aspects of french bean production technology have been carried out worldwide. Many research work have been done in different parts of the world to study the effect of various sources of phosphorus and mulching on the growth and yield of french bean. However, on the base of this topic very little information is available regard on Bangladesh perspective and present study is presenting here the following heads:

2.1 Effects of different sources of phosphorus on the growth and yield of french bean:

El-hassan *et al.* (2017) conducted that treatments of compost and vermicompost with or without adding 50% of recommended dose of mineral fertilizers, were investigated on bean plants. The highest height of 68.00 cm and 58.85 cm was gained with 100% mineral fertilizer during the period of 2016 and 2017 respectively. Where it was 42 cm and 39.43 cm using 100% compost during 2016 and 2017 respectively and by using 100% vermicompost, it was 51.33 cm and 44.96 cm in 2016 and 2017 respectively.

An experiment was carried out by Islam *et al.* (2016) in the greenhouse of the institute of biological sciences, faculty of science, university of Malaya, Kualalumpur Malaysia during 2013 to 2014. They used as treatments as vermicompost (20%), traditional compost (20%) and N:P:K fertilizer to determine the growth and yield attributes of bush bean (*Phaseolus vulgaris*), yard long bean (*Vigna unguiculata*) and winged bean (*Psophocarpus tetragonolobus*). For bush bean, total plant height was the maximum 314.19 cm in vermicompost (20%) treated plants and the minimum 160.24 cm in the FP. Bush bean grown with vermicompost (20%) produced the highest number of pods 58.93 compared to 22.20 in the FP treatment. For bush bean, the length of the pod was highest in vermicompost (20%) treatment 10.76 cm followed by compost 9.87 cm and the shortest pod length were recorded in FP treated plants with 7.89 cm. For bush bean, single pod weight was highest in the

vermicompost (20%) treatments compared to the FP treatment with the maximum values of 5.09g and the minimum value observed were 3.76 g. Bush bean grown with vermicompost (20%) had the highest pod yield of 2.98 ton per ha followed by traditional compost (20%) and FP (20%) which provided 1.45 ton per ha and 0.83 ton per ha of pods respectively.

Rafat and Sharif (2015) carried out an experiment to study the effects of phosphorus fertilizer on yield and yield components of green bean (Sunray genotype). The rate of phosphorus fertilizer was 0, 20, 50, 75 and 100 kg ha. Analysis of variance indicated that phosphorus fertilizer had a significant effect on plant height, pod length, number of pods per plant, green pod yield, and harvest index. Correlation analysis indicated pod yield positively correlated with plant height, number of pods per plant and harvest index. The result of regression analysis indicated that there was a significant positive and quadratic relationship between P application and pod yield. Application of 50 kg P p e r ha lead to maximum values of plant height, pod length, number of pods per plant and pod yield. Phosphorus fertilizers increased also dry matter accumulation. Phosphorus supply beyond 50 kg P per ha generally resulted in decline of pod yield and yield components.

Lad *et al.* (2014) performed a 3- year field experiment during 2003-04, 2004-05 and 2005-06 with four levels of nitrogen (0, 50, 100 and150 kg/ha) and four levels of phosphorus (0, 25, 50 and 75 kg P_2O_5 ha-1) to find out their impact on growth, yield attributes, yield and economics of french bean (*phaseolus vulgaris* L.) grown under medium deep vertisol soil in marawada region. Nitrogen as higher dose (150 kg/ha) and phosphorus as higher dose (75 kg/ha) resulted significantly highest grain & straw yield of french bean and show at par result with crop receiving 100 kg N & 50 kg P_2O_5 per ha and it was more profitable than others.

A field experiment was studied by Singh *et al.* (2011) to investigated the effects of vermicompost, NPK fertilizer and organic mulch on crop growth, nodulation and pod yield of french bean. The length of shoot, primary branches number, shoot fresh weight and shoot dry weight, pod fresh weight and pod dry weight were increased by 28-63% through application of N:P_2O_5:K_2O @ 8:13:10 kg /ha + vermicompost 3.75 t / ha. Vermicompost application decreased nodule fresh weight and nodule dry weight by

44.9 and 44.5% respectively. This study proves that application of N: P_2O_5: K_2O fertilizer @ 8-15:13- 25:10-20 kg /ha, vermicompost @ 2.50-3.75 t /ha, 4 cm thick mulch of dried crop residues and 50% irrigation is the most suitable and sustainable factor to increase plant growth, pod formation, pod number, pod length, pod diameter and pod yield of french bean and soil health of mild-tropical climate during dry season.

An experiment was conducted by Jonathan *et al.* (2011) to study on Spent mushroom compost (SMC) of *Pleurotus pulmonarius* was used as soil conditioner for the improvement of growth of four common Nigerian vegetables (*Abelmoschus esculentus, Lycopersicum esculentum, Capsicum annum and Capsicumchinense*). The results of these investigations showed that the vegetables responded well to the SMC treatment. Each of them attained its best growth and gave the highest number of flowers and fruits when planted on 6 kg of depleted garden soil supplemented with 600 g of Spent mushroomcompost. The control experiment that has the seedlings of the vegetables planted on 6 kg of depleted garden soil only, without the application of SMC showed stunted and poor growth, with few or no flower and fruit production.

An experiment studied by Thakur *et al.* (2010) to evaluate the effect of various organic manures and biofertilizers on french bean. The experiment proved that among the treatments, combined application of vermicompost and biofertilizers increased the growth and yield of the crop in comparison to control treatment.

An observation at field research center of department of seed science and technology, H.N.B. garhwal university, India, during the period of Rabi season, 2007 by Singh and Chauhan (2009) to identify the effect of organic sources of nutrients viz., Vermicompost, FYM and along with inorganic fertilizers in french bean under irrigated condition with an objective to investigate the growth and yield without degrading soil quality by using various nutrient compositions. In this result, vermicompost treatment recorded the maximum height 30.13 cm of the french bean while minimum height growth of 21.09 cm was identified in N:P:K + vermicompost + FYM . In this investigation, maximum flowers number/ plant 36.4, pods / plant 25.2, pod length 10.8 cm and singlepod weight 12 g were gained from vermicompost treatment when the least values were identified in control treatment.

Amanullah *et al.* (2007) reported that the application of organic manure yielded higher uptake of NPK than the control. The study explored that uptake of nutrient was higher with composted poultry manure. The additional organic manure also acted as a source of nutrient which might have influenced their availability.

A research studied by Saxena *et al.* (2003) where PDR-14 was supplied with 0, 60 and 120 kg N and k per ha and 0, 60 and 90 kg P per ha on french bean (*Phaseolus vulgaris*) in Uttar Pradesh, India during Rabi season of 2000-2002. Leaf area distribution, leaf area index and relative growth rate were improved with growth stages and increasing rated of N, P and K. During both years, crop yield was increased with increasing rates of N and P.

Tewari and Singh (2000) observed from a trial to studied the optimum and economical dose of nitrogen (0, 40, 80, 120 or 160 kg /ha) and phosphorus (0, 20, 40 or 60 kg /ha) for better growth and yield of french bean. The highest pod yield per plant, seeds weight per plant and seed yield with the application of 120 kg N per ha whereas 160 kg N per ha significantly reduced seed yield.

A field experiment explored by Alves *et al*. (1999) in Brazil to observe the effect of productivity evaluation and seed quality of french bean cultivated with organic matter. 4 organic amendments applied of 5 levels (0, 5, 10, 15 and 20 ton ha^{-1} of earthworm or chicken manure and 0, 10, 20, 30 and 40 ton ha^{-1} of bovine or poultry manure) are used by them. The maximum production was observed in 30 ton ha^{-1} of poultry manure.

Singer *et al*. (1999) conducted an experiment to study the effects of delta mix and organic matter on growth and development of french bean crops. They applied different levels of delta mix and organic matter at 10 and 20 ton per ha and NPK fertilizers were applied at different level of doses. They identified that plant height, number of leaves and shoots number were significantly affected by the different levels of delta mix and different levels of organic matter and chemical fertilizers.

An experiment was studied by Devender *et al.* (1998) in cold desert, dry temperature region of Kinnaur to study the effect of nitrogen and phosphorus on

yield and uptake of nutrients in french bean (*Phaseolus vulgaris* L.). Plant height, pods per plant, seeds per pod and seed yield increased significantly up to 15 kg N and60 kg P_2O_5 kg per ha. The N and P uptake showed similar trend during both the years. Nutrients-use efficiency was significantly highest at their lower levels, i.e.15kg N and 30 kg P_2O_5 /ha gave significantly highest N and P-use efficiency respectively.

An experiment conducted by Adetunji (1990) reported that specific leaf weight clearly showed decreasing pattern by increasing the amounts of vermicompost (VC) and application of organic mulch. The finding shows that proper dose of vermicompost (VC) and organic mulching play an important role towards partitioning of photo assimilation from vegetative sources to reproductive sink (leaf to green pod) which will ultimately lead to development of yield and yield attributes.

A field experiment was observed by Abbound and Duque (1986) to investigate the effects of application of organic matter and vermiculite in a french bean- maize production. They observed that seed yield of the crop was increased by incorporation of organic matter.

2.2 Effects of different type of mulch materials on the growth and yield of french bean:

Vidyashree *et al.* (2019) conducted to examine the effect of different plastic color mulches viz., white on black, silver on black and complete black on growth and of yield of french bean (*Phaseolus vulgaris* L.*)* variety arka komal under different drip irrigation levels. Among coloured plastic mulches, white on black plastic mulch produced maximum plant height 38.68 cm, number of branches 6.00 per plant, yield 252.71 g per plant and yield 11.14 ton per hectare. Among the irrigation levels, 80 percent recorded maximum values for plant height 33.73 cm, number of branches 7.13 per plant, yield 300.67 g per plant and yield 14.06 ton per hectare. The interaction effect observed that white on black plastic mulch with 80 percent exhibited better plant height 33.73 cm, number of branches 7.13 per plant, yield 300.67 g per plant and yield 14.06 ton per hectare compared to other treatments.

A field experiment was conducted by Sahariar *et al.* (2015) to investigate the influence of mulching and plant spacing on growth and yield of french bean (*Phaseolus vulgaris* L.) during the period from November 2014 to January 2015. Both mulching and plant spacing influenced the growth and yield of french bean. Black polythene mulch produced the maximum yield 5.82 ton ha^{-1} and the minimum yield 4.92 ton ha^{-1} was recorded from no mulch treatment. The highest yield 6.22 ton ha^{-1} was produced from 30 cm x 15 cm plant spacing and the lowest 4.58 ton ha^{-1} was produced with 30 cm x 25 cm plant spacing. The interaction with black polythene mulch and 30 cm x 15 cm spacing produced the highest yield 6.97 ton ha^{-1} and the lowest yield 3.94 ton ha^{-1} was recorded from without mulching at spacing of 30 cm x 25 cm treatment combination.

Kwambe *et al.* (2015) carried out an experiment to determine the effect of organic and inorganic mulches on green bean (*Phaseolus vulgaris* L.) growth, development and yield on a clay loam soil of matsapha, swaziland. The results explored that black polythene, clear polythene and grass conserved moisture at root zone level. Soil temperature indicated a maximum value of 34°c for black polythene and a lowest of 26.5°c under grass. Weed infestation rate was recorded lowest value of 1.75 from black polythene and highest of 4.75 from grass mulched plots. The maximum and the minimum values for soil moisture content obtained were 74.56% under clear polythene and 45.77% for the control respectively. They considered to use black polythene mulch or when opting for organic mulch, grass mulch may be recommended to maximize growthand yield.

Wasihun (2013) conducted an experiment to study the effects of mulching on growth, yield and volumetric moisture content at four growth stages (initial, development, mid and late stage) and at different soil depths (0-30 cm and 30-60 cm) of snap bean. The treatments were considered as control (T_0), vetiver grass (T_1). susbania (T_2), white polythene mulch (T_3) and black polythene mulch (T_4). The highest average fresh pod yield 3,753.1 kg / ha was recorded with white plastic mulch while the lowest yield 2,844.4 kg / ha was recorded from control. It was found that, there were total yield reductions of snap bean by 32 % when compared with white plastic mulched. Marketable

yield was significantly affected by mulch application. The highest quality was observed mulch 3,528 kg / ha in white plastic where as the least quality was 2,438.8 kg / ha for control. Vetiver grass had significant role on moisture conservation but susbania mulches couldn't show any significant difference withcontrol. Therefore, the obtained result indicates that polythene may be the most preferable mulch to increase quality and production of snap bean through conserving moisture in soil profile.

A field experiment was performed by Kamal *et al.* (2010) at the Horticultural farm Bangladesh Agricultural Research Center, November 2006 to February 2007 to effect of mulching on growth and yield of french bean . The experiment consisted of four levels viz. (a) no mulch. (h) black polythene. (c) rice straw, (d) water hyacinth .The yield increased dueto using of mulches. mulch produced the maximum yield 15.01 ton / ha was recorded from black polythene mulch and the minimum yield was recorded 12.73 ton / ha from control treatment.

Rahman *et al*. (2007) conducted to study the effects of three mulches i.e (1) Senna siamea leaf, (2) straw and (3) water hyacinth and five irrigation regimes {IW (irrigation water)/CPE(cumulative pan evaporation) 1.0, IW/CPE 0.75, IW/CPE 0.50, IW/CPE 0.25 and no irrigation} on leaf water status and pod yield of common bean during the dry season of Bangladesh. Green pod can be grown successfully at IW/CPE 0.75 with Senna leaf mulching of common bean during the period of dry season in central Bangladesh.

Onder *et al.* (2006) studied an experiment to effects of water stress and mulch on green bean yield and yield components in greenhouse condition. The experiment was consisted on water stress levels (I_{100}, I_{66}, I_{33} and I_0) and mulch types (gray-Mg; black-Mb- and mulchless-Mo). The irrigation levels applied in this experiment significantly affected the yield and yield parameters. The irrigation at I_{100} level performed the maximum bean yield and un-irrigated treatment (I_0) gave the minimum values for yield and yield parameters. The irrigation level and mulch treatment interactions were significant on width of pod, length of pod and branch number per plant. The yield and almost all of yield components were not affected by mulch. However, the yields for green bean for the mulch treatments of Mg and Mb were higher than the mulchless treatment (Mo) under the water stress condition. The yield was not significantly

affected by the mulch types, but gray mulch type (Mg) has the highest yield of bean. The highest yield was obtained in I_0 x Mg conditions.

A field experiment conducted by Parvez *et al*. (2006) at the Horticulture farm, Bangladesh Agricultural University, Mymensingh during the period from December 2004 to February 2005 to investigate the effects of plant spacing and mulching on growth and yield of french bean crops. The experiment consisted of three plant spacings viz. (1) 30cm x 10cm, (2) 30cm x 15cm and (3) 30cm x 20cm and four types of mulch materials viz. (1) No mulch, (2) rice straw mulch, (3) water hyacinth mulch and (4) black polythene mulch were used. French bean pod yield 10.84 t/ha was obtained from 30cm x 15cm plant spacing which is highest of among the treatment. The maximum yield 11.73 t/ha was obtained from the black polythene mulch and the lowest (7.33 t/ha) was recorded from theplants grown without mulch (control). The maximum pod yield 12.85 t/ha was obtained from the treatment combination of black polythene on the production of French bean with 30cm x 15cm plant spacing while the lowest yield 6.61 t/ha was produced by the combination of 30cm x 20 cm and no mulch treatment.

Mozumder *et al.* (2005) conducted an experiment in a split plot design with 8 irrigation levels with or without mulch to observe optimum level of irrigation or mulch of dwarf french bean during two consecutive cropping seasons. Plant height, number of pods per plant, pod yield and profitability were increased from Straw mulch. Irrigation also influenced most of the yield and yield attributes except pod size and number of seeds per pod. The maximum number of pods per plant and Benefit Cost Ratio (5.03) was observed from fortnightly flood irrigation (6 mm) with mulch while maximum pod yield (19.77 t /ha) was obtained from half-weekly sprinkler irrigation (3 mm). The lowest yield (10.87 t /ha) was obtained from no irrigation (control) and without mulch.

Subhan (1988) studied an experiment on french bean to investigate the best mulch materials for french bean production. The treatment was consisted as rice straw, black polythene and transparent polythene mulches. It was found that Plant height and dry weight at 3 days after planting pod number and seed fresh weight are greater with either of the polythene mulch than with rice straw.

An experiment was studied by Barros (1987) in field trials DM yield for maize and beans and seed yield for beans were higher with straw mulch than with bare ground, although evapotranspiration rates were similar. In a dry year bean mulching only with high irrigation rates increased yields of french bean.

Fahim *et al.* (1987) studied an experiment with root rot of common bean (*Phaseolus vulgaris*) in Egypt. They used various chemicals and polythene sheet for preventing root rot. They found that polythene sheet increased soil temperature, reduced root rot and significantly increased the green pod yield of bean by mulching soil for six weeks.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November 2019 to February 2020 to effect of different sources of phosphorus and mulch materials on growth and yield of french bean. This chapter contents a brief description of the experimental period, location, soil and climatic condition of the experimental site and materials those were used for conducting the experiment i.e. treatment and design of the experiment, growing of crops, intercultural operations, data collection methods and procedure of data analysis for conducting the experiment and presented below under the following headings:

3.1 Experimental site

The research work was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh. The experiment was carried out during the period of rabi season and the location of the experimental site was situated at 90° 22 ' Elongitude and 23° 41' N latitude with an elevation of 8.6 meters above the sea level. The site of the experiment is presented in Appendix I

3.2 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series (FAO, 1988) under Modhupur Tract (AEZ - 28). The soil of the experimental field were analyzed in the Soil Testing Laboratory, Soil Research Development Institute Farmgate, Dhaka. The results showed that the soil contains 27% sand, 43% silt and 30% clay. The soil also contained 0.46% Organic carbon, 0.12 me/100 g soil exchangeable K, 0.05%Total N, 46 ppm available S and 20 ppm available P. The texture of soil was sandy loam with pH 5.47–5.63 and organic matter 0.83% which are presented in details in Appendix II.

3.3 Climatic condition of the experimental site

The climate of experimental area is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979).

The monthly average temperature, humidity and rainfall during the experimental period were collected from weather yard, Bangladesh meteorological department, and presented in Appendix III. During the experimental period the maximum temperature (25.80^{o} c) was recorded from November, 2019 and the minimum temperature (12.40^{o} c) from January, 2020, highest relative humidity (78%) was recorded from November, 2019, whereas the lowest relative humidity (68%) was recorded in January, 2020.

3.4 Experimental details

3.4.1 Planting materials

The seeds of french bean for the research work were collected from the horticulture research center (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur , Gazipur.

3.4.2 Experimental treatments:

The research experiment consists of two factors:

Factor A: Sources of Phosphorus

P_1 = 100% TSP (200 kg/ha)

P_2 = 50% TSP (100 kg/ha) + 50% Vermicompost (1.3 ton/ha)

P_3= 50% TSP (100 kg/ha) + 50% Mushroom Spent Compost (2.5 ton/ha)

P_4= 50% Vermicompost (1.3 ton/ha) + 50% Mushroom Spent Compost (2.5 ton/ha)

Factor B: Mulch Materials

M_0 = No mulch (control)

M_1 = White polythene mulch

M_2 = Black polythene mulch

There are 12 treatment combinations such as P_1M_0, P_1M_1, P_1M_2, P_2M_0, P_2M_1, P_2M_2, P_3M_0, P_3M_1, P_3M_2, P_4M_0, P_4M_1, P_4M_2.

3.4.3 Design and layout of the experiment

The two factor experiment was laid out the following Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combinations and in total 36 plots for 3 block. Each block consisted of 12 unit plots and the size of each unit plot was (.9 m x 0.9 m) or .81m^2. The distance between two replications was 1m and two plots was 0.5 m. The experimental layout is shown in figure 1.

3.5 Land preparation

At first the land was ploughed through a power-tiller and kept open to sunlight. Then the land was thoroughly prepared by ploughing and again cross ploughing. The weeds and stubbles of the field were removed. Then the land was divided into 36 unit plots with keeping plot to plot and block to block spacing. The bed of plots was made about 5 cm high from the soil surface with the excavated soil after creating drains around each plot. Furandan @ 16 kg/ha was mixed with the soil uniformly during land preparation for controlling soil borne insects. Sevin 50 WP @ 5 kg/ha was also applied to soil for protecting the seed and young plants from the attack of ants and cutworms.

3.6 Mulching set up

Mulching materials are set up after final land preparation and before seed sowing of specific mulch material as treatment wise on the plot.

3.7 Seed sowing

Two seeds were sown per hill at a depth of 3.0 cm on 12 November, 2019. Row to row and plant to plant distance were 30 cm and 15 cm respectfully (Plate 1). The seeds were covered with pulverized soil just after sowing in the hill and gently pressed with hands. Surrounding of the experimental plots, few seeds were also sown as border crop to reduce border effects.

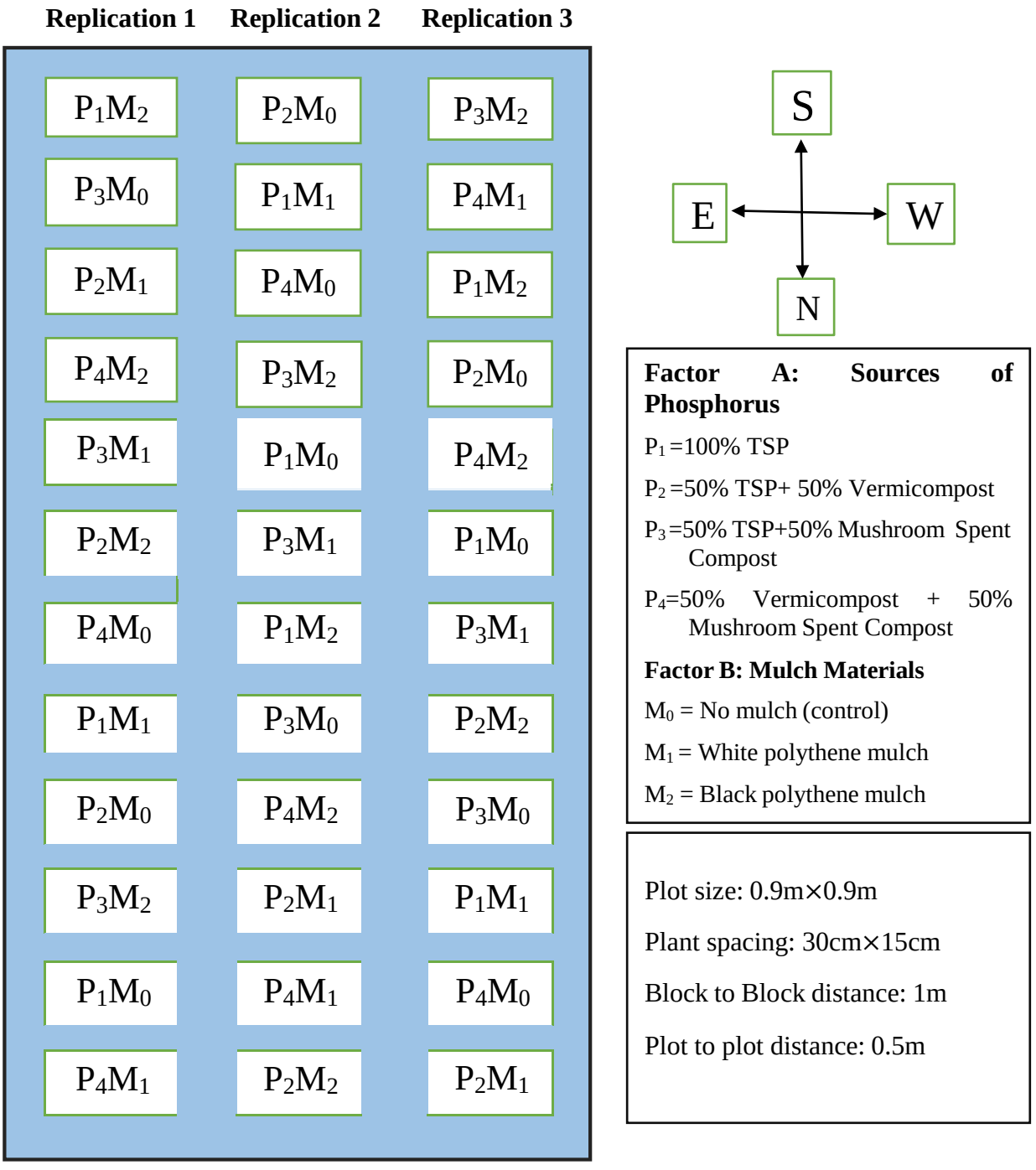


Figure 1. Layout of the experiment

3.8 Fertilizers and manures application

The fertilizer and manures for french bean crop were applied by the following way: Total amount of well decomposed cow dung, vermicompost, mushroom spent compost, Triple Supper Phosphate (TSP) and Muriate of Potash (MP) were applied and mixed with the soil during land preparation. As a source of nitrogen, Urea was applied. During final land preparation, 1/3 amount of urea was applied and rest amount was applied in two instalments at 15 days and 30 days after sowing (DAS). The fertilizers which were applied mixed in appropriate portion with the plot soil.

Composition of phosphorus status (%) in vermicompost and mushroom spent compost:

Manures	Percentage (%) of phosphorus
Vermicompost	1.7
Mushroom spent compost	0.85

Source: Soil Research Development Institute (SRDI), 2018.

Application of inorganic and organic fertilizer in the field as treatment with following doses where recommended dose of TSP is 200 kg per ha (BARI, 2014). The amount of vermicompost and mushroom spent compost was calculated on the basis of phosphorus percentage in it.

Name	Dose per ha	Dose per plot
100% TSP	200 kg	16.2 g
50% TSP + 50% Vermicompost	100 kg +1.3 ton	8.1 g + 105.3 g
50% TSP + 50% Mushroom spent compost	100 kg + 2.5 ton	8.1 g + 202.5 g
50% Vermicompost + 50% Mushroom spent compost	1.3 ton + 2.5 ton	105.3 g + 202.5 g

The following manure and fertilizers were also applied also additionally at same rate all the plot recommended by BARI (2014):

Manure and fertilizer	Dose/ha	Dose/plot
Cow dung	5 ton	450 g
Urea	200 Kg	16.2 g
Muriate of potash (MP)	150 Kg	12.15 g

3.9 Intercultural operations

Various intercultural operations, such as gap filling, weeding, thinning, stalking, irrigation, pest and disease control etc. were done for better growth and development of the seedlings. The crop was kept free from weeds by regular weeding and irrigation was given when required.

3.9.1 Gap filling

At the time of seed sowing, 3-4 seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds missed to germinate after 1 week of germination. All gaps were filled in the evening and watering was done on transplanted plants to protect the seedlings from wilting and damage seedling as well as all the gaps was replaced by using healthy plants from the excess plants within two weeks.

3.9.2 Thinning

One healthy plant is kept after well-established of the plants in each hill and rest were removed.

3.9.3 Weeding

The experimental plots were kept weed free by hand weeding or khurpi.

3.9.4 Irrigation and drainage

Earlier on the seedling establishment stages light watering was given by a watering cane in every afternoon. After well establishment of the seedlings watering was given when required. At the reproductive stage water stress was not encountered and proper drainage system were made surrounding the experimental plots for drainage of excess water.

3.9.5 Stalking

Stalking was given in order to protect the plant from bending down when the plant attained at sufficient height.

3.10 Plant protection

3.10.1 Diseases

Some plants were attacked by bean common mosaic virus which is an important disease of french bean. These plants were removed from the plots and destroyed and admire 20 SL sprayed twice at the rate of 1ml / liter at 10 days interval. Seedlings were attacked by damping off and Dithane M-45 was sprayed twice at the rate of 2 ml litre-1 at an interval of 7 days.

3.10.2 Insect pests

At early stage of growth, some plants were attacked by insect's pests (mainly Aphid) and Malathion 57 EC was sprayed twice at the rate of 2 ml /liter at an interval of 7 days.

3.11 Harvesting

At tender stage, green pods were harvested through hand picking and it was weighted to estimate the yield of fresh pod (plate 1). At harvest, pods were nearby full size, with the seeds still small (about one quarter developed) with firm flesh (Swiader *et al.*, 1992) and the pods were soft and smooth.

3.12 Collection of data

At the time of data collection five representative plants were selected at random from each unit of plot to avoid border effect and tagged in the field. Data were collected periodically from the sample plants at 15 days interval. The details of data collection are given below:

3.12.1 Plant height (cm)

The plant height was recorded at 15, 30, 45 and 60 days after sowing (DAS). Plant height was taken from the ground level to the tip of largest leaf of the plants in centimeter (cm). Plant height of five randomly sampled plants were recorded and mean was calculated.

3.12.2 Number of compound leaves per plant

The number of compound leaves of five randomly selected plants in the plot was counted from each unit plot at 15 days interval from 15 to 60 DAS and means were calculated.

3.12.3 Leaf length (cm)

Leaf length of full grown leaves of five selected plant were measured by using a measuring scale in centimeter (cm) at 60 days after sowing (DAS) and mean was recorded.

3. 12.4 Leaf breadth (cm)

Leaf breadth of full grown leaves of five selected plant were measured by using a measuring scale in centimeter (cm) at 60 days after sowing (DAS) and mean was recorded.

3. 12.5 Number of branches per plant

The number of branches of five randomly selected plants from each plot was recorded at 60 DAS and mean was recorded.

3. 12.6 Days required to first flowering

The days required to first flowering for different treatments were counted and their mean values were recorded.

3. 12.7 Days required to 90% flowering

The days required to 90% flowering for different treatments were recorded.

3. 12.8 Number of flowers per plant

The number of flowers of each plant were counted from five randomly selected plants per unit ofplot and their mean values were calculated.

3. 12.9 Number of pods per plant

Total number of pods was counted and five randomly selected plants per plot were used to calculate the average number of pods per plant in three different harvesting.

3. 12.10 Length of green pod (cm)

Ten pods were randomly selected from green pods and measured using a centimeter scale and the mean value was calculated.

3. 12.11 Diameter of green pod (cm)

Diameter of green pods from ten randomly selected green pods and measured in cm with the help of a slide calipers and the average was measured in centimeter (cm).

3. 12.12 Number of seeds per pod

Numbers of seeds per green pod was recorded from ten randomly selected green pods and the mean value was recorded.

3. 12.13 Dry matter content of plant (%)

100 g plant from each plot were taken and cut into some small pieces. Then it was dried under direct sunshine for 3 days and then it was dried in an oven at 70^0C for 72 hours before taking the dry weight till it was constant and the dry weight was counted in gram (g) by using a beam balance. The percentage of dry matter of plant was calculated by the following formula-

$$\text{Dry matter content of shoot (\%)} = \frac{\text{Dry weight of shoot}}{\text{Fresh weight of shoot}} \times 100$$

3. 12.14 Pod yield per plant (g)

The tender green pods were harvested at regular interval from each unit plot and their weight was measured. When harvesting was done then the total pod weights were found out in each plant and expressed in gram (g).

3. 12.15 Pod yield per plot (g)

The fresh green pods were harvested at regular interval from each unit plot and their weight was taken. As harvesting was done and the total pod weights were measured in gram (g) in each unit of plot.

3. 12.16 Pod yield per hectare (t)

Finally, the green pods yield of french bean per plot was converted to yield per hectare and expressedin ton (t).

3.13 Statistical analysis

The experimental data obtained for different parameters were statistically analyzed by using `MSTAT C' computer program. The significance of the difference among the individual and treatment combinations means was estimated by the least significance difference test at 5% level of probability.

3.14 Economic analysis

Economic analysis of the experiment was done in order to find out the most profitable treatment combinations.

3.14.1 Analysis of total cost of production of french bean

All the input cost including non-material cost, interest on fixed capital of land, and miscellaneous were considered for computing the total cost of production. The interest of land rent and capital for 12 month was calculated 10% for six-month and 12% for four month respectively as well as miscellaneous cost was considered as 5% of the total input cost.

3.14.2 Gross Income or gross return

Gross income was calculated on the sale of marketable green pod of french bean.

3.14.3 Net Return

The total production cost was deducted from the gross income for each treatment combination to calculate the net return.

3.14.4 Benefit Cost Ratio (BCR)

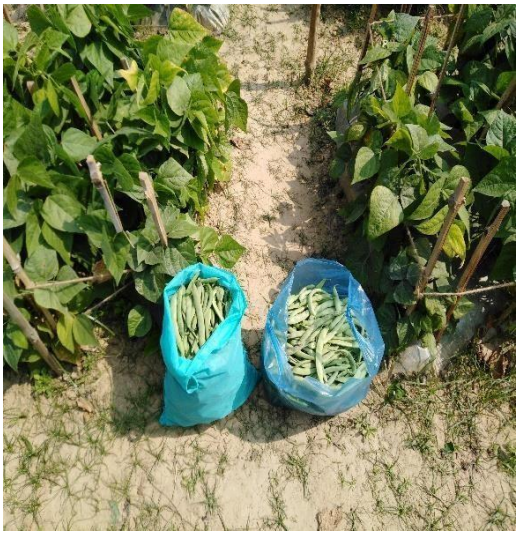
The benefit cost ratio (BCR) was calculated by the following formulae:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

A

B

C



D

Plate 1. Pictorial presentation of different operations during field experiment. A. Mulching set up, B. Fungicide spray, C. Harvesting of tender pod, D. Harvested French bean.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to compare growth and yield of french bean as influenced by various sources of phosphorus and mulch materials. Data on different growth and other parameter, yield attributes and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in appendix section (IV-XI). The result of the experiment have been presented and discussed in this chapter under the following headings:

4.1 Plant height (cm)

Plant height is an important character of a plant, which is closely related to proper growth and development of a plant and finally produced higher yield. Plant height of french bean varied significantly at 15, 30, 45 and 60 days after sowing (DAS) due to different sources of phosphorus (Table 1 and Appendix IV). At 60 DAS, the longest (54.17 cm) plant was produced from P_4 (50% vermicompost + 50% mushroom spent compost) treatment and the shortest (46.76 cm) was found from P_1 (100% TSP) treatment .The increase of height may be influenced due to the absorption of nutrients and more particularly organic materials might have played a dominant role in it. The present result also agrees well with El-hassan *et al*. (2017).

Table 1. Effect of different sources of phosphorus on plant height at different days after sowing (DAS) of french bean

Treatments	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
P_1	14.34 c	35.12 d	42.65 c	46.76 d
P_2	15.10 b	37.09 b	45.31 b	52.05 b
P_3	14.68 bc	36.03 c	43.38 c	49.61 c
P_4	15.72 a	38.27 a	47.61 a	54.17 a
CV %	7.41	8.67	8.25	9.98
LSD (0.05)	0.43	0.45	0.73	0.84

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost

Different mulching materials significantly influenced on plant height of french bean at 15, 30, 45 and 60 days after sowing (DAS) (Table 2 and Appendix IV). At 60 DAS, the highest plant height (53.49 cm) was produced from M_2 (Black polythene) treatment. The shortest (47.65 cm) plant was produced in M_0 (no mulch) treatment. Mulching was found to be more effective during the early stage of plant growth. The present result also agrees well with Subhan (1988).

Table 2. Effect of different mulch materials on plant height at different days after sowing (DAS) of french bean

Treatments	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
M_0	14.23 c	34.72 c	41.73 c	47.65 c
M_1	14.95 b	36.49 b	45.02 b	50.81 b
M_2	15.70 a	38.67 a	47.47 a	53.49 a
CV %	7.41	8.67	8.25	9.98
LSD (0.05)	0.37	0.39	0.63	0.72

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

Combined effect of different sources of phosphorus and mulch materials on Plant height was found statistically significant due to different days after sowing (Table 3 and Appendix IV). At 60 DAS, the tallest (57.24 cm) plant was produced from P_4M_2 (50% vermicompost + 50% spent mushroom compost and black polythene mulch) treatment combination and shortest (43.32 cm) plant was produced in P_1M_0 (100% TSP and no mulch) treatment combination. Plant height may be influenced due to the favorable and balanced absorption of nutrients and supplying available moisture due to using mulch materials which increased the role of photosynthesis, reduced transpiration and stimulation of root system.

Table 3. Combined effect of different sources of phosphorus and mulch materials on plant height at different days after sowing (DAS) of french bean

Treatment	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
P_1M_0	13.81 g	33.73 h	39.26 f	43.32 g
P_1M_1	14.02 fg	34.80 fg	43.00 d	46.93 f
P_1M_2	15.19 bcde	36.80 d	45.70 c	50.04 de
P_2M_0	14.46 efg	35.07 f	42.71 d	49.27 e
P_2M_1	15.15 cde	36.80 d	45.53 c	52.32 c
P_2M_2	15.68 bc	39.33 b	47.71 b	54.57 b
P_3M_0	14.00 fg	34.20 gh	41.00 e	46.88 f
P_3M_1	14.72 def	35.97 e	43.51 d	49.84 de
P_3M_2	15.31 bcd	37.83 c	45.62 c	52.12 c
P_4M_0	14.65 def	35.87 e	43.96 d	51.14 cd
P_4M_1	15.91 ab	38.26 c	48.04 b	54.14 b
P_4M_2	16.61 a	40.68 a	50.84 a	57.24 a
CV %	7.41	8.67	8.25	9.98
LSD (0.05)	0.75	0.78	1.27	1.45

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

4.2 Number of compound leaves per plant

Number of leaves per plant is a vital part of crop plant because of its physiological role in photosynthetic activities. French bean yield is directly related to the number of leaves. Number of compound leaves per plant of french bean was varied significantly at 30, 45 and 60 days after sowing (DAS) due to different sources of phosphorus (Table 4 and Appendix V); but at 15 DAS, it showed non-significant effect. At 60 DAS, the highest number compound of leaves (27.75) per plant was obtained from P_4 (50% vermicompost + 50% mushroom spent compost) treatment and the lowest (24.60) was

observed from P_1 (100% TSP) treatment. Vermicompost and mushroom spent compostare rich in its phosphorus compare to other organic fertilizer. This favorable condition creates better nutrient absorption for vegetative growth and consequently, the maximum number of leaves was found by vermicompost and mushroom spent compost.

Table 4. Effect of different sources of phosphorus on number of compound leaves per plant at different days after sowing (DAS) of french bean

Treatments	Number of compound leaves per plant			
	15 DAS	30 DAS	45 DAS	60 DAS
P_1	2.972	14.38 d	19.08 d	24.60 d
P_2	3.00	17.13 b	21.36 b	26.88 b
P_3	2.91	15.52 c	20.55 c	25.86 c
P_4	3.27	18.86 a	22.52 a	27.75 a
CV %	8.16	10.97	10.68	11.58
LSD (0.05)	ns	0.80	0.50	0.49

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% Mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost

The variation in number of compound leaves per plant of french bean varied significantly at 30, 45 and 60 days after sowing (DAS) except 15 DAS due to different mulch materials (Table 5 and Appendix V). At 60 DAS, the highest (27.83) number of compound leaves per plant was obtained from M_2 (black polythene mulch) treatment and the lowest (24.57) was observed from M_0 (no mulch) treatment. The higher number of leaves per plant was obtained due to mulching may be attributed to favorable condition utilized by plants.

Table 5. Effect of different mulch materials on number of compound leaves per plant at different days after sowing (DAS) of french bean

Treatments	Number of compound leaves per plant			
	15 DAS	30 DAS	45 DAS	60 DAS
M_0	2.75	14.68 c	18.83 c	24.57 c
M_1	3.10	16.54 b	20.72 b	26.43 b
M_2	3.27	18.20 a	23.08 a	27.83 a
CV %	8.16	10.97	10.68	11.58
LSD (0.05)	ns	0.69	0.43	0.42

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

Combined effect of different sources of phosphorus and mulch materials on compound leaves number of plant was found statistically significant due to different days at 30, 45 and 60 after sowing (DAS) except 15 DAS (Table 6 and Appendix V). At 60 DAS, the maximum number of compound leaves (29.43) was produced from P_4M_2 (50% vermicompost + 50% mushroom spent compost and black polythene mulch) treatment combination and minimum number of leaves (23.05) was produced in P_1M_0 (100% TSP and no mulch)) treatment combination.

Table 6. Combined Effect of different source of phosphorus and mulch materials on number of compound leaves per plant at different days after sowing (DAS) of french bean

Treatments	Number of compound leaves per plant			
	15 DAS	30 DAS	45 DAS	60 DAS
P_1M_0	3.00	12.66 h	17.75 e	23.05 j
P_1M_1	2.83	14.25 fg	19.00 d	24.81 hi
P_1M_2	3.08	16.25 cde	20.50 c	25.94 fg
P_2M_0	2.58	15.25 ef	18.91 d	25.18 gh
P_2M_1	3.16	17.33 c	21.00 c	26.89 de
P_2M_2	3.25	18.83 b	24.16 a	28.57 b
P_3M_0	2.50	13.83 gh	18.33 de	24.00 i

P_3M_1	3.00	15.83 de	20.66 c	26.22 ef
P_3M_2	3.25	16.91 cd	22.66 b	27.36 cd
P_4M_0	2.91	17.00 cd	20.33 c	26.04 f
P_4M_1	3.41	18.75 b	22.25 b	27.80 bc
P_4M_2	3.50	20.83 a	25.00 a	29.43 a
CV %	8.16	10.97	10.68	11.58
LSD (0.05)	ns	1.39	0.86	0.85

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

4.3 Leaf length (cm)

Leaf length of french bean varied apparently due to application of different sources of phosphorus (Table 7 and Appendix V). Results revealed that at harvest, the maximum leaf length (23.50 cm) was observed from P_1 (100% TSP) treatment and minimum leaf length (19.96 cm) was found from P_3 (50% TSP + 50% mushroom spent compost) treatment. The productivity of field crops depends mainly on the size of leaf, the photosynthesis system as well as on the length of time during, which it remains active. The optimum phosphorus levels might have induced stronger physiological activity in the production of largest length of leaf. Singh and Chauhan (2009) reported similar trends of results.

Leaf length of french bean varied due to application of different type of mulching (Table 8 and Appendix V). At harvest time, the maximum leaf length (23.73 cm) was observed from M_2 (Black polythene) treatment and minimum leaf length (19.71 cm) was found from M_0 (no mulch) treatment.

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on leaf length of french bean at harvest (Table 9 and Appendix V). The result showed that maximum leaf length (25.86 cm) was recorded from treatment combination of P_1M_2 (100% TSP and black polythene mulch) which is significantly different from other treatment combination whereas the minimum leaf length (17.62 cm) was found from the treatment combination of P_3M_0 (50% TSP + 50% mushroom spent compost and no mulch).

4.4 Leaf breadth (cm)

Leaf breadth of french bean varied due to application of different sources` of phosphorus (Table. 7 and Appendix V). At harvest, maximum leaf breadth (10.63 cm) was observed from P_1 (100% TSP) treatment which is identical to P_2 and P_4 treatment and minimum leaf breadth (9.81 cm) was found from P_3 (50% TSP + 50% mushroom spent compost) treatment.

Leaf breadth of french bean varied due to application of different type of mulching (Table 8 and Appendix V). At harvest, the maximum leaf breadth (11.99 cm) was observed from M_2 (Black polythene) treatment and minimum leaf breadth (8.88 cm) was found from M_0 (no mulch) treatment.

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on leaf breadth of french bean at harvest (Table 9 and Appendix V). At harvest, the result showed that maximum leaf breadth (12.74 cm) was recorded from treatment combination of P_1M_2 (100% TSP and black polythene mulch material) which is significantly different from other treatment combinations whereas the minimum leaf breadth (8.36 cm) was found from the treatment combination of P_3M_0 (50% TSP + 50% mushroom spent compost and no mulch) treatment combination which is statistically similar to P_1M_0, P_2M_0 and P_4M_0 treatment combination.

4.5 Number of branches per plant

Number of branches per plant is very important parts which effect on yield of a plant. Phosphorus plays a vital role in several physiological process viz, photosynthesis, respiration, energy store and transfer, cell division which will significantly enhance the axillary stalk or branching of plants. Application of different sources of phosphorus showed significant variations on number of branches per plant of french bean (Table 7 and Appendix VI). At harvest the maximum number of branches (14.20) were found in P_4 (50% vermicompost + 50% mushroom spent compost) treatment while the minimum number of branches (10.71) were recorded in P_1 (100% TSP) treatment.

Branch number of french bean varied apparently due to application of different type of mulching (Table 8 and Appendix VI). The maximum branches number (14.06) were

observed from M_2 (Black polythene) treatment and minimum branch number (11.12) was found from M_0 (no mulch) treatment which result was similar Vidyashree *et al.* (2019).

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on number of branches of french bean at harvest (Table 9 and Appendix VI). The result showed that maximum number of branches (15.94) were recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch material) which is statistically similar with P_2M_2 (50 % TSP + 50% vermicompost with black polythene mulch) treatment combination whereas the minimum (9.76) was found from the treatment combination of P_1M_0 (100 % TSP + no mulch) which is statistically identical to P_3M_0 treatment combination and similar to P_1M_1 treatment combination.

Table 7. Effect of different sources of phosphorus on leaf length, leaf breadth and number of branches per plant of french bean

Treatments	At harvest (60 DAS)		
	Leaf length (cm)	Leaf breadth (cm)	Number of branches per plant
P_1	23.50 a	10.63 a	10.71 d
P_2	21.74 b	10.35 a	13.06 b
P_3	19.96 c	9.81 b	11.79 c
P_4	21.50 b	10.48 a	14.20 a
CV %	10.45	9.62	8.35
LSD (0.05)	0.87	0.46	0.31

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost

Table 8. Effect of different mulch materials on leaf length, leaf breadth and number of branches per plant of french bean

Treatments	At harvest (60 DAS)		
	Leaf length (cm)	Leaf breadth (cm)	Number of branches per plant
M_0	19.71 c	8.88 c	11.12 c
M_1	21.58 b	10.09 b	12.14 b
M_2	23.73 a	11.99 a	14.06 a
CV %	10.45	9.62	8.35
LSD (0.05)	0.75	0.40	0.57

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

Table 9. Combined effect of different sources of phosphorus and mulch materials on leaf length, leaf breadth and number of branches per plant of french bean

Treatments	At harvest (60 DAS)		
	Leaf length (cm)	Leaf breadth (cm)	Number of branches per plant
P_1M_0	21.65 cd	9.14 fg	9.76 f
P_1M_1	22.99 bc	10.02 de	10.64 ef
P_1M_2	25.86 a	12.74 a	11.73 de
P_2M_0	19.71 e	9.11 fg	11.94 d
P_2M_1	21.68 cd	10.05 de	12.32 d
P_2M_2	23.85 b	11.90 b	14.92 ab
P_3M_0	17.62 f	8.36 g	9.98 f
P_3M_1	20.45 de	9.48 ef	11.74 de
P_3M_2	21.81 cd	11.59 bc	13.64 c
P_4M_0	19.89 e	8.92 fg	12.81 cd
P_4M_1	21.22 de	10.80 cd	13.85 bc
P_4M_2	23.40 b	11.73 b	15.94 a
CV %	10.45	9.62	8.35
LSD (0.05)	1.51	0.80	1.14

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost. Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

4.6 Days required to first flowering

Days required to first flowering was showed statistically significant variation due to the different sources of phosphorus application (Table 10 and Appendix VI). The longest period (41.51 days) was required for first flower initiation from P_4 (50% vermi-compost + 50% mushroom spent compost) treatment. On the other hand, the shortest period (37.85 days) for first flowering from P_1 (100% TSP) treatment.

Days required to first flowering was showed statistically significant variation due to the different type mulching application (Table 11 and Appendix VI). The longest period (41.77 days) was required for first flower initiation from M_2 (Black polythene mulch) treatment. On the other hand, the shortest period (37.22 days) for first flowering from M_0 (no mulch) treatment.

Days required to first flowering was showed statistically significant variation due to the combined effect of different sources of phosphorus and various type of mulching application (Table 12 and Appendix VI). The longest period (44.66 days) was required for first flower initiation from P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch) treatment combination. On the other hand, the shortest period (36.22 days) for first flowering from P_1M_0 (100% TSP and no mulch) treatment combination which is statistically similar to P_3M_0 treatment combination. P_4M_2 treatment combination required more time to give flower. It may be occurred by highly vegetative growth of plant due to application of vermicompost, mushroom spent compost and using black polythene mulch.

4.7 Days to 90% flower initiation

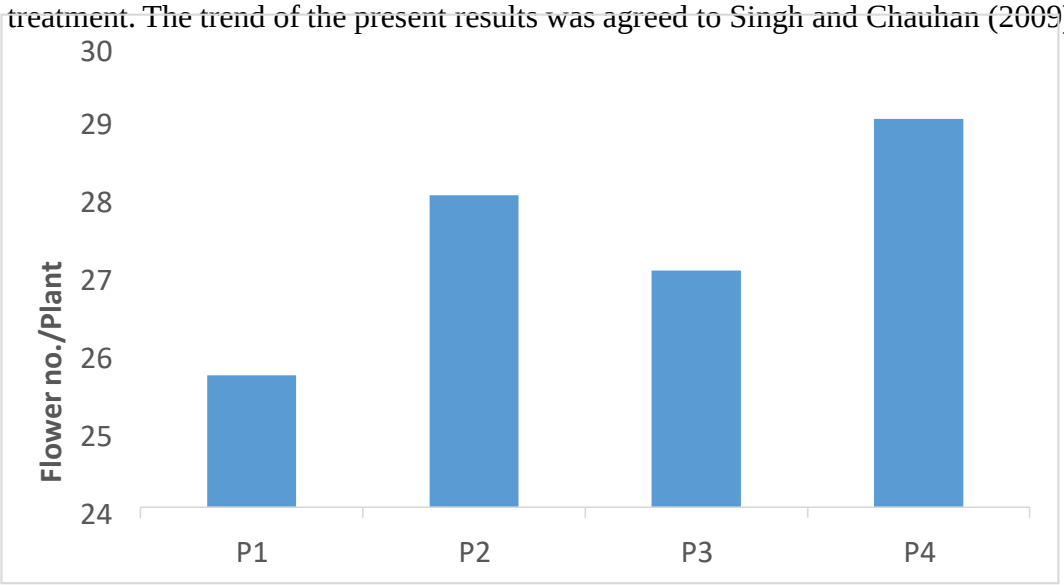
Days required to 90% flowering of french bean was showed statistically significant variation due to the different sources of phosphorus application (Table 10 and Appendix VI). The longest period (57.63 days) was required for 90% flower initiation from P_4 (50% vermicompost + 50% mushroom spent compost) treatment. On the other hand, the shortest period (49.40 days) for 90% flowering from P_1 (100% TSP) treatment.

Days required to 90% flowering of french bean was showed statistically significant variation due to the different type mulching application (Table 11 and Appendix VI). The longest period (57.01 days) was required for 90% flower initiation from M_2 (black polythene mulch) treatment. On the other hand, the shortest period (49.52 days) for 90% flowering from M_0 (no mulch) treatment.

Days required to 90% flowering was showed statistically significant variation due to the combined effect of different sources of phosphorus and various type mulching application (Table 12 and Appendix VI). The longest period (62.96 days) was required for 90% flower initiation from P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch) treatment combination. On the other hand, the shortest period (46.71 days) for 90% flowering from P_1M_0 (100% TSP and no mulch) treatment combination which is statistically similar to P_3M_0 treatment combination.

4.8 Number of flowers per plant

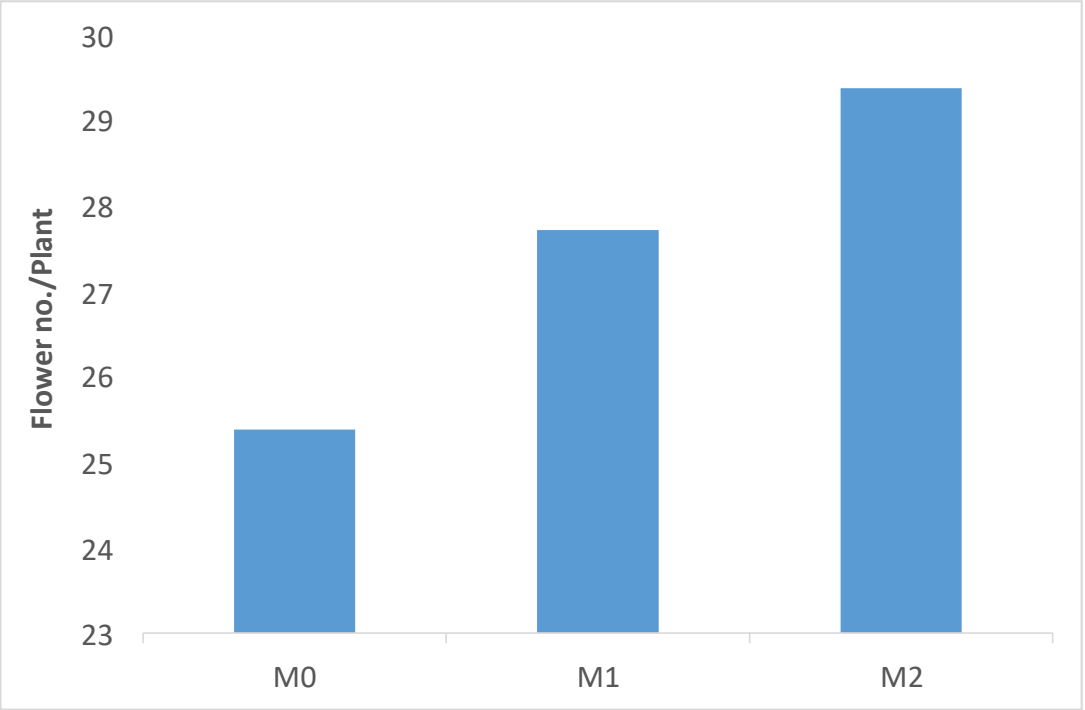
Application of different sources of phosphorus showed significant variation on number of flower per plant of french bean (Fig. 2 and Appendix VI, IX). The maximum number of flower (29.06) was found in P_4 (50% vermicompost + 50% mushroom spent compost) treatment which is statistically similar to P_2 (50% TSP +50% vermicompost) treatment. The minimum number of flower (25.72) was recorded in P_1 (100% TSP) treatment. The trend of the present results was agreed to Singh and Chauhan (2009).



Where, P1 = 100% TSP (control), P2 = 50% TSP+50% Vermicompost, P3= 50% TSP+ 50% mushroom spent compost, P4= 50% Vermicompost + 50% Mushroom spent compost

Fig. 2. Effect of different source of phosphorus on number of flower per plant of french bean

Flower number of french bean varied apparently due to application of different type of mulch materials (Fig. 3 and Appendix V, X). The maximum flower number (29.37) per plant was observed from M_2 (black polythene) treatment and minimum flower number (25.38) was found from M_0 (no mulch) treatment.



Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

Fig. 3. Effect of different mulch materials on number of flower per plant of French bean

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on flower number of french bean (Table 12 and Appendix VI). The result showed that maximum flower number (30.72) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch material) treatment combination which is statistically identical to P_2M_2 and statistically similar to P_4M_1, P_3M_2 and P_2M_1 treatment combinations whereas the minimum (24.26) was found from the treatment combination of P_1M_0 (50% TSP + 50% mushroom spent compost with no mulch) which is statistically identical to P_3M_0 treatment combinations and similar to P_1M_1 and P_2M_0 treatment combination. P_4M_2 treatment combination gave more flower due to growth of plant, more number of branches, long lasting of plant and other favorable factors.

Table 10. Effect of different sources of phosphorus on days required to first flower initiation, 90% flower initiation and number of flowers per plant of french bean

Treatments	Days required to flower initiation	
	1st	90%
P_1	37.85 d	49.40 d
P_2	39.55 b	54.16 b
P_3	38.77 c	50.59 c
P_4	41.51 a	57.63 a
CV %	13.65	10.66
LSD (0.05)	0.27	0.38

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost

Table 11. Effect of different mulch materials on days to first flower initiation, 90% flower initiation and number of flowers per plant of french bean

Treatments	Days required to flower initiation	
	1st	90%
M_0	37.22 c	49.52 c
M_1	39.27 b	52.31 b
M_2	41.77 a	57.01 a
CV %	13.65	10.66
LSD (0.05)	0.50	0.69

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

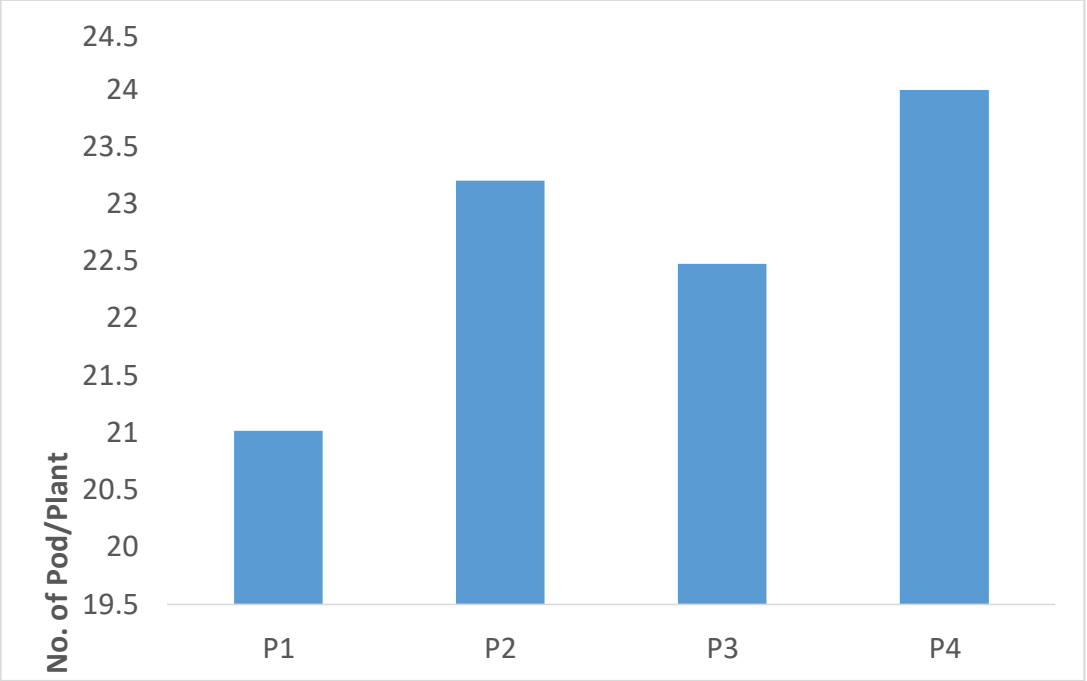
Table 12. Combined effect of different sources of phosphorus and mulch materials on days to first flower Initiation, 90% flower initiation and number of flowers per plant of french bean

Treatments	Days required to flower initiation		Number of flowers per plant
	1st	90%	
P_1M_0	36.22 h	46.71 h	24.26 f
P_1M_1	37.89 ef	48.89 fg	25.29 ef
P_1M_2	39.44 d	52.60 d	27.60 bcd
P_2M_0	37.44 fg	50.89 e	25.48 def
P_2M_1	39.11 d	53.28 cd	28.97 abc
P_2M_2	42.11 b	58.31 b	29.77 a
P_3M_0	36.78 gh	47.71 gh	24.7 f
P_3M_1	38.66 de	49.91 ef	27.14 cde
P_3M_2	40.89 c	54.17 c	29.39 ab
P_4M_0	38.44 def	52.77 d	27.05 cde
P_4M_1	41.44 bc	57.15 b	29.43 ab
P_4M_2	44.66 a	62.96 a	30.72 a
CV %	13.65	10.66	4.61
LSD (0.05)	1.01	1.28	2.1473

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost .Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

4.9 Number of pod per plant

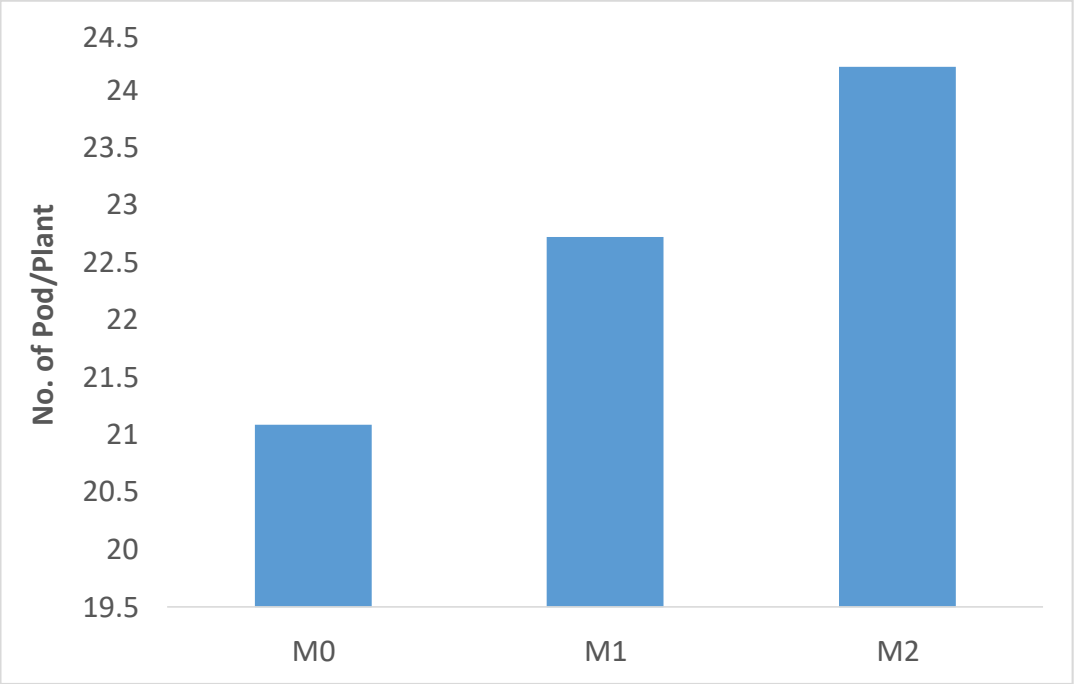
Application of different sources of phosphorus showed significant variations on number of pod per plant of french bean (Figure 4 and Appendix VII, IX). The maximum number of pod (24.00) was found in P_4 (50% vermicompost + 50% mushroom spent compost) treatment which is statistically similar to P_2 treatment. The minimum number of flower (21.02) was recorded in P_1 (100% TSP) treatment which was similar to the result of Adetunji (1990).



Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost.

Fig. 4. Effect of different source of phosphorus on number of pod per plant of french bean.

Pod number of French bean varied apparently due to application of different type of mulching (Fig. 5 and Appendix VII, X). The maximum flower number (24.21) was observed from M_2 (Black polythene) treatment and minimum flower number (21.09) was found from M_0 (no mulch) treatment. Subhan (1988) observed similar results.



Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

Fig. 5. Effect of different mulch materials on number of pod per plant of french bean

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on pod number of french bean (Table 15 and Appendix VII). The result showed that maximum number of pod (26.83) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch material) treatment combination whereas the minimum (20.04) was found from the treatment combination of P_1M_0 (100% TSP + no mulch) which is statistically similar to P_1M_2, P_2M_0 and P_3M_0 treatment combination. The plant of P_4M_2 plot contained more number of pod because of more number of flower and less abortion of flowers.

4.10 Length of green pod (cm)

Variation on length of green pod differed significantly among different sources of phosphorus of french bean (Table 13 and Appendix VII). Results revealed that maximum length of green pod (14.13 cm) was observed from P_4 (50% vermicompost + 50% mushroom spent compost) treatment and minimum pod length (12.66 cm) was found from P_1 100% TSP) treatment which is identical to P_3 treatment.

Variation on length of green pod differed significantly among different type of mulching of french bean (Table 14and Appendix VII). Results revealed that maximum length of green pod (14.02 cm) was observed from M_2 (black polythene mulch) treatment and minimum length of green pod (12.85 cm) was found from M_0 (no mulch) treatment.

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on length of green pod of french bean (Table 15 and Appendix VII). The result showed that maximum length of green pod (15.04 cm) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch material) treatment combination whereas the minimum (12.23 cm) was found from the treatment combination of P_1M_0 (50% TSP + 50% mushroom spent compost with no mulch) treatment combination which is statistically similar to P_3M_0 and P_1M_1 treatment combination.

4.11 Diameter of green pod (cm)

Variation on diameter of green pod differed significantly among different sources of phosphorus of french bean (Table 13 and Appendix VII). Results revealed that maximum diameter of green pod (.91 cm) was observed from P_4 (50% vermicompost + 50% mushroom spent compost) treatment and minimum pod diameter (.82 cm) was found from P_1 (100% TSP) treatment which is statistically identical to P_3 treatment.

Variation on diameter of green pod differed significantly among different type of mulching of french bean (Table 14 and Appendix VII). Results revealed that maximum diameter of green pod (.92 cm) was observed from M_2 (black polythene mulch) treatment and minimum pod diameter (.79 cm) was found from M_0 (no mulch) treatment.

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on diameter of green pod of french bean (Table 15 and Appendix VII). The result showed that maximum pod diameter (.98 cm) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom

spent compost with black polythene mulch material) treatment combination whereas the minimum (.75 cm) was found from the treatment combination of P_1M_0 (50% TSP + 50% mushroom spent compost and no mulch) treatment combination which is statistically identical to P_3M_0 treatment combination.

4.12 Number of seeds per green pod

Number of seeds per green pod was significantly influenced by different sources of phosphorous of french bean (Table 13 and Appendix VII). Maximum number of seeds per green pod (5.71) was observed from P_4 (50% vermicompost + 50% mushroom spent compost) treatment and minimum number of seeds per pod (4.84) was found from P_1 (100% TSP) treatment which is statistically identical to P_3 treatment.

Significant variation was recorded on number of seeds per green pod for the effect of different type of mulching on french bean (Table 14 and Appendix VII). The maximum number of seed per green pod (5.72) was observed from M_2 (black polythene mulch) treatment and minimum number of seed per pod (4.74) was found from M_0 (no mulch) treatment.

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation of number of seeds per green pod on french bean (Table 15 and Appendix VII). The result showed that maximum number of seed per pod (6.38) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch) treatment combination whereas the minimum number of seed per pod (4.45) was found from the treatment combination of P_1M_0 (50% TSP + 50% spent mushroom compost and no mulch) treatment combination which is statistically identical to P_3M_0 treatment combination.

Table 13.Effect of different sources of phosphorus on length of green pod, diameter of green pod, number of seed/ green pod of french bean

Treatments	length of green pod (cm)	Diameter of green pod (cm)	Number of seeds Per green pod
P_1	12.66 d	0.82 c	4.84 c
P_2	13.73 b	0.86 b	5.45 b
P_3	13.13 c	0.84 c	4.88 c
P_4	14.13 a	0.91 a	5.71 a
CV %	9.56	12.87	9.37
LSD (0.05)	0.16	0.02	0.19

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost

Table 14. Effect of different mulch materials on length of green pod, diameter of green pod, number of seeds/ green pod of french bean

Treatments	length of green pod (cm)	Diameter of green pod (cm)	Number of seeds Per green pod
M_0	12.85 c	0.79 c	4.74 c
M_1	13.36 b	0.86 b	5.20 b
M_2	14.02 a	0.92 a	5.72 a
CV %	9.56	12.87	9.37
LSD (0.05)	0.28	0.01	0.17

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. . Where, M_0 = No mulch (control), M_1 = White polythene mulch,M_2 = Black polythene mulch

Table 15.Combined effect of different sources of phosphorus and mulch materials on number of green pod/plant, length of green pod, diameter of green pod, number of seeds/ green pod of french bean

Treatments	Number of green Pod per plant	length of green pod (cm)	Diameter of green pod (cm)	Number of seeds Per green pod
P_1M_0	20.047 f	12.23 h	0.75 g	4.45 g
P_1M_1	21.907 de	12.71 gh	0.83 ef	4.83 f
P_1M_2	21.127 ef	13.04 fg	0.87 cd	5.25 cde
P_2M_0	21.48 ef	13.33 def	0.81 f	4.91 ef
P_2M_1	23.247 cd	13.62 cde	0.86 de	5.49 cd
P_2M_2	24.907 b	14.23 b	0.92 b	5.94 b
P_3M_0	21.027 ef	12.54 gh	0.77 g	4.45 g
P_3M_1	22.427 cde	13.08 efg	0.85 de	4.90 f
P_3M_2	23.99 bc	13.77 bcd	0.90 bc	5.29 cd
P_4M_0	21.837 de	13.32 def	0.86 de	5.16 def
P_4M_1	23.343 bcd	14.04 bc	0.90 bc	5.59 c
P_4M_2	26.83 a	15.04 a	0.98 a	6.38 a
CV %	4.30	9.56	12.87	9.37
LSD (0.05)	1.6517	0.57	0.03	0.34

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost. Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

4.13 Dry matter content of plant (%)

There was no significant difference on dry matter content of plant of french bean among different sources of phosphorus (Table 16 Appendix VIII). The data on the percentage of dry matter content of plant was found to be significant in terms of different type of mulch materials on french bean (Table 17 and Appendix VIII). Results indicated that the highest (23.98 %) dry matter content of plant was observed from the M_2 (black polythene mulch) treatment while the lowest was (20.66%) recorded from M_1 (no mulch) treatment.

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation of dry matter content on french bean (Table 18 and Appendix VIII). The result showed that the highest dry matter content (24.96 %) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch material) treatment combination whereas the lowest dry matter content of plant (20.55%) was found from the treatment combination of P_3M_0 (50% TSP + 50% mushroom spent compost and no mulch) which is statistically identical to P_1M_0, P_4M_0 and P_2M_0 treatment combination.

4.14 Pod yield per plant (g)

Application of different sources of phosphorus showed significant variation on pod yield per plant of french bean (Table 16 and Appendix VIII). The highest pod yield per plant (64.70 g) was found in P_4 (50% vermicompost + 50% mushroom spent compost) treatment. The lowest pod yield per plant (52.60) was recorded in P_1 (100% TSP) treatment, which is identical to P_3 (50% TSP + 50% mushroom spent compost) treatment. Organic fertilizer have long time effect on soil and plant can easily uptake from soil and also for long time. As a result, the pod yield per plant was high from organic fertilizer. Singh and Chauhan (2009) reported similar trends of results.

Pod yield per plant of french bean varied apparently due to application of different type of mulching (Table 17 and Appendix VIII). The highest pod yield per plant (63.89 g) was observed from M_2 (Black polythene) treatment and the lowest Pod yield per plant (49.56 g) was found from M_0 (no mulch) treatment. Mulching materials increase water holding capacity in the soil. So the french bean plant did not fell the scarcity of water and plant got fulfil nutrients and because of suppress weeds by using mulching specially black polythene mulch. This result was similar to Sahariar *et al.* (2015).

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on pod yield per plant of french bean (Table 18 and Appendix VIII). The result showed that highest pod yield per plant (75.56 g) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost and black polythene mulch material) treatment combination whereas the lowest pod yield per plant (43.90 g) was found from the treatment combination of P_1M_0 (100% TSP and no mulch).

4.15 Pod yield per plot (g)

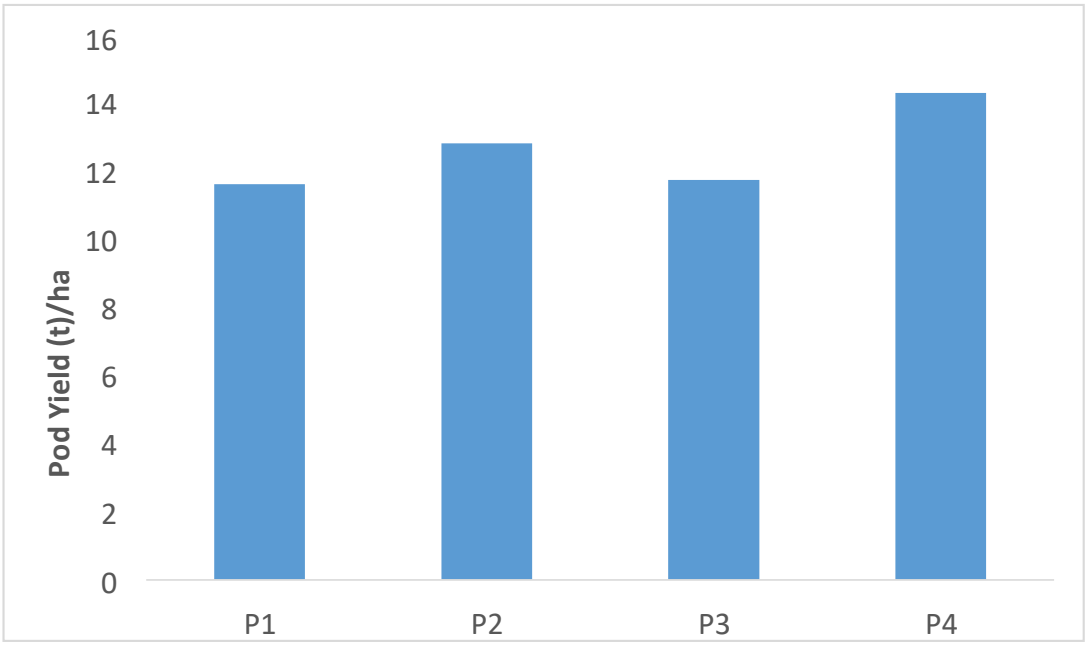
Application of different sources of phosphorus showed significant variations on pod yield per plot of french bean (Table 16 and Appendix VIII). The highest pod yield per plot (1163.1 g) was found in P_4 (50% vermicompost + 50% mushroom spent compost) treatment. The lowest pod yield per plot (945.0 g) was recorded in P_1 (100%TSP) treatment which is identical to P_3 (50% TSP + 50% mushroom spent compost) treatment.

Pod yield per plot of French bean varied apparently due to application of different type of mulch materials (Table 17 and Appendix VIII). The highest pod yield per plot (1147.9 g) was observed from M_2 (black polythene) treatment and the lowest pod yield per plot (890.0 g) was found from M_0 (no mulch) treatment.

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on pod yield per plot of french bean (Table 18 and Appendix VIII). The result showed that highest pod yield per plot (1358.2 g) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch material) treatment combination whereas the lowest pod yield per plot (787.4 g) was found from the treatment combination of P_1M_0 (100% TSP and no mulch).

4.16 Pod yield per hectare (ton)

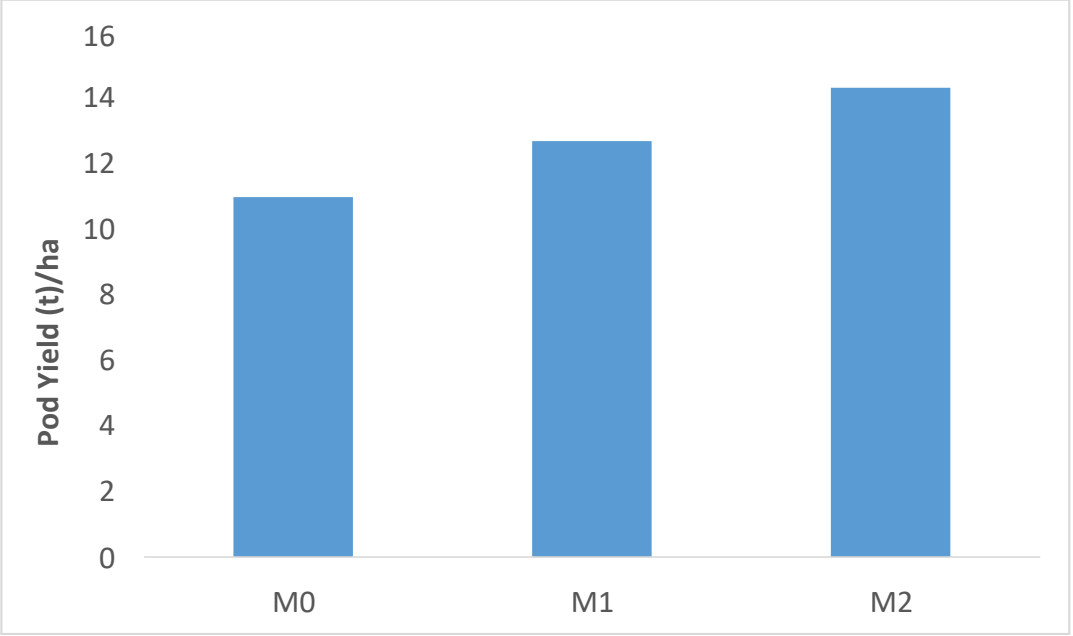
Application of different sources of phosphorus showed significant variations on pod yield per hectare of french bean (Fig. 6 and Appendix VIII, IX). The highest pod yield per hectare (14.35 t) was found in P_4 (50% vermicompost + 50% mushroom spent compost) treatment. The lowest pod yield per hectare (11.664 t) was recorded in P_1 (100% TSP) treatment which is identical to P_3 (50% TSP + 50% mushroom spent compost) treatment. Thakur *et al.* (2010) reported similar trends of results.



Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost

Fig. 6. Effect of different source of phosphorus on pod yield per hectare of french bean

Pod yield per ha of french bean varied apparently due to application of different type of mulching (Fig. 7 and Appendix VIII, X). The highest pod yield per hectare (14.33 ton) was observed from M_2 (Black polythene) treatment and the lowest pod yield per plot (10.98 t) was found from M_0 (control) treatment. The similar result was found Kamal *et al.* (2010).



.

Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

Figure 7. Effect of different mulch materials on pod yield per hectare of french bean

Combined effect of different sources of phosphorus and mulch materials showed statistically significant variation on pod yield per hectare of french bean (Table 18 and Appendix VIII). The result showed that highest pod yield per hectare (16.76 t) was recorded from treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost with black polythene mulch material) treatment combination whereas the lowest pod yield per hectare (9.72 t) was found from P_1M_0 (100% TSP + no mulch) treatment combination.

Table 16. Effect of different sources of phosphorus on dry matter content (%) of plant, pod yield/plant, pod yield/plot of french bean

Treatments	Dry matter content of plant (%)	Pod yield/plant (g)	Pod yield/plot (g)
P_1	22.12	52.60 c	945.0 c
P_2	22.22	57.09 b	1025.1 b
P_3	21.85	53.19 c	955.5 c
P_4	22.99	64.70 a	1163.1 a
CV %	5.32	10.42	11.46
LSD (0.05)	--	2.44	43.9

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost

Table 17. Effect of different mulch materials on dry matter content (%) of plant, pod yield/plant, pod yield/plot of french bean

Treatments	Dry matter content of plant (%)	Yield/plant (g)	Yield/plot (g)
M_0	20.66 c	49.56 c	890.0 c
M_1	22.24 b	57.23 b	1028.6 b
M_2	23.98 a	63.89 a	1147.9 a
CV %	5.32	10.42	11.46
LSD (0.05)	0.39	2.11	38.1

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch

Table 18.Combined effect of different sources of phosphorus and mulch materials on dry matter content (%) of plant, pod yield/plant, pod yield/plot, pod yield/ ha of french bean

Treatments	Dry matter content of plant (%)	Yield/plant (g)	Yield/plot (g)	Yield/ha (ton)
P_1M_0	20.73 e	43.90 g	787.4 g	9.72 g
P_1M_1	22.13 d	52.31 e	940.3 e	11.60 f
P_1M_2	23.49 bc	59.89 bc	1075.6 bc	13.27 cd
P_2M_0	20.65 e	51.97 e	934.0 e	11.53 f
P_2M_1	21.86 d	57.77 cd	1036.6 cd	12.79 de
P_2M_2	24.16 b	61.54 bc	1104.6 bc	14.30 b
P_3M_0	20.55 e	47.36 f	850.6 f	10.50 f
P_3M_1	21.68 d	55.32 de	994.5 de	12.27 ef
P_3M_2	23.31 c	58.58 cd	1052.9 cd	12.99 de
P_4M_0	20.72 e	55.00 de	988.1 de	12.19 ef
P_4M_1	23.30 c	63.54 b	1143.0 b	14.11 bc
P_4M_2	24.96 a	75.56 a	1358.2 a	16.76 a
CV %	5.32	10.42	11.46	12.65
LSD (0.05)	0.79	3.23	60.1	0.67

In a column, similar letter (s) means are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost. Where, M_0 = No mulch (control), M1 = White polythene mulch, M_2 = Black polythene mulch.

4.17 Economical analysis

All input costs for land preparation, cost of seed, fertilizer, pesticides, irrigation, mulching and manpower required for the operations from seed sowing to harvesting of french bean seed were recorded for unit plot and converted into cost per hectare. Fixed costs were same for all the treatment. The total cost of input and fixed cost were the total cost of production (Appendix XI.) The economic analysis was done to observe the gross and net return and the benefit cost ratio (BCR) in the present experiment and presented under the following headings:

4.17.1 Gross return

The combination treatment of different sources of phosphorous and mulch materials showed different gross return. The highest gross return (5,02,800 Tk./ha) was obtained from P_4M_2 (50% vermicompost + 50% mushroom spent compost and black polythene mulch material) treatment combination and the second highest gross return (4,29,000 Tk./ha) was found in P_2M_2 (50% TSP + 50% Vermicompost and Black polythene mulch) treatment combination. The lowest gross return (2,91,600 Tk./ha) was obtained from P_1M_0 (100% TSP and no mulch) treatment combination.

4.17.2 Net return

In case of net return, different treatments combination as different sources of phosphorous and mulch materials gave different net return. The highest net return (2,74,100 Tk./ha) was found from P_4M_2 (50% vermicompost + 50% mushroom spent compost and black polythene mulch material) treatment combination and the second highest net return (2,25,608 Tk./ha) was obtained from P_2M_2 (50% TSP + 50% Vermicompost and Black polythene mulch) treatment combination. The lowest net return (1,42,286 Tk./ha) was obtained P_3M_1 (50% TSP + 50% Mushroom spent compost and white polythene mulch) treatment combination.

4.17.3 Benefit cost ratio (BCR)

In the combination treatment of variety and spacing, the highest benefit cost ratio (2.19) was noted from P_4M_2 (50% vermicompost + 50% mushroom spent compost and black polythene mulch material) treatment combination and the second highest benefit cost ratio (2.14) was estimated from P_1M_2 (100% TSP with Black polythene mulch) treatment combination. The lowest benefit cost ratio (1.63) was obtained from P_3M_1 (50 % TSP + 50 % Mushroom spent compost and white polythene mulch) treatment combination. From economic point of view, it was apparent from the above results that the treatment combination of P_4M_2 (50% vermicompost + 50% mushroom spent compost and black polythene mulch material) was more profitable than rest of the treatment combination.

Table 19.Economic performances regarding gross return, net return and benefit cost ratio (BCR) of french bean

Treatment	Yield (t/ha)	Gross return (Tk./ ha)	Cost of production (Tk./ha)	Net return (Tk./ ha)	BCR
P_1M_0	9.72	291600	145561	146039	2.00
P_1M_1	11.60	348000	200506	147494	1.73
P_1M_2	13.27	398100	185632	212468	2.14
P_2M_0	11.53	345900	163321	182579	2.11
P_2M_1	12.79	383700	218266	165434	1.75
P_2M_2	14.30	429000	203392	225608	2.10
P_3M_0	10.50	315000	170869	144131	1.84
P_3M_1	12.27	368100	225814	142286	1.63
P_3M_2	12.99	389700	206490	183210	1.88
P_4M_0	12.19	365700	190840	174860	1.91
P_4M_1	14.11	423300	243574	179726	1.73
P_4M_2	16.76	502800	228700	274100	2.19

Here, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% mushroom spent compost, P_4= 50% Vermicompost + 50% Mushroom spent compost. Where, M_0 = No mulch (control), M1 = White polythene mulch, M_2 = Black polythene mulch.

Market price of green pod of French bean @ 30000 tk/ton.

CHAPTER V

SUMMARY AND CONCLUSION

The research was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during November 2019 to February 2020 to effect of different sources of phosphorus and mulch materials on growth and yield of french bean . Factor A: Different sources of phosphorus as P_1=100% TSP (control), P_2= 50% TSP + 50% Vemicompost, P_3= 50% TSP + 50% Mushroom spent compost, P_4= 50% Vemicompost + 50% Mushroom spent compost and Factor B: Different types of mulch materials as M_0 = No mulch (control), M_1 = White polythene mulch, M_2 = Black polythene mulch. Levels of these two factors made 12 treatment combinations and the numbers of plots were thirty six. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on the following parameters:-plant height, number of leaves per plant, leaf length, leaf breadth, number of branches per plant, days to first flowering, days to 90% flowering, number of flowers per plant, pod number, pod length, pod diameter, no. of seeds per pod, dry matter content of plant (%), yield per plant, yield per plot, yield per hectare and at last economic analysis of the experiment. The recorded data on different parameters were statistically analyzed by using`` MSTAT C" software.

At 60 days, the longest plant (54.17 cm) height and the maximum (27.75) number of leaves per plant were recorded from P_4 (50% Vermicompost + 50% Mushroom spent compost) treatment while the shortest plant (46.76 cm) height and the minimum (24.60) number of leaves per plant were recorded from P_1 (100% TSP) treatment. At 60 DAS, the highest leaf length (23.50 cm), the highest leaf breadth (10.63 cm) found from P_1 (100% TSP) treatment where the lowest (19.96 cm) leaf length and the lowest leaf breadth (9.81 cm) were recorded from P_3 (50% TSP+50% Mushroom spent compost). The highest (14.20) number of branches per plant found from P_4 (50%

Vermicompost +50% Mushroom spent compost) treatment and the lowest number of branches (10.71) per plant were recorded from P_1 (100% TSP) treatment. It was observed that maximum days (41.51) to first flowering, days (57.63) to 90% flowering, the highest number of flowers per plant (29.06) and the maximum number of pods per plant (24.03) were recorded from P_4 (50% Vermicompost + 50% Mushroom spent compost) treatment, whereas minimum days to first flowering (37.85), days to 90% flowering (49.40), the lowest number of flowers (25.72) per plant and the minimum (21.02) number of pods per plant were counted from P_1 (100% TSP) treatment. Results revealed that maximum pod length (14.13 cm), maximum diameter of pod (0.91 cm) and maximum no. of seed per plant (5.71) was observed from P_4 (50% Vermicompost + 50% Mushroom spent compost) treatment and minimum pod length (12.66 cm) diameter of pod (0.82 cm) and no. of seed per plant (4.84) was found from P1 (100% TSP) treatment. The dry matter content of plant is not statistically significant in case of different sources of phosphorus. The highest (64.70 g) pod yield per plant, the highest pod yield per plot (1163.1 g) and the highest pod yield per ha (14.35 t) was achieved from P_4 (50% Vermicompost + 50% Mushroom spent compost) treatment whereas the lowest (52.60 g) pod yield per plant, the lowest pod yield per plot (945.0 g) and the lowest pod yield per ha (11.66 t) were achieved from P_1 (100% TSP) treatment.

At 60 days, the longest plant (53.49 cm) height and the maximum (27.83) number of leaves per plant were recorded from M_2 (Black polythene mulch) treatment while the shortest plant (47.65 cm) height and the minimum (24.57) number of leaves per plant were recorded from M_0 (Control) treatment. The highest leaf length (23.73 cm), the highest leaf breadth (11.99 cm) found from M_2 (Black polythene mulch) treatment where the lowest (19.71 cm) leaf length and the lowest leaf breadth (8.88 cm) were recorded from M_0 (Control). The highest (14.06) number of branches per plant found from M_2 (Black polythene mulch) treatment and the lowest number of branches (11.12) per plant were recorded from M_0 (Control) treatment. It was observed that maximum days (41.77) to first flowering, days (57.01) to 90% flowering, the highest number of flowers per plant (29.37) and the maximum number of pods per plant (24.21) were recorded from M_2 (Black polythene mulch) treatment whereas minimum

days to first flowering (37.22), days to 90% flowering (49.52), the lowest number of flowers (25.38) per plant and the minimum (21.09) number of pods per plant were counted from M_0 (Control) treatment. Results revealed that maximum pod length (14.02 cm), maximum diameter of pod (0.92 cm) and maximum no. of seed per plant (5.72) was observed from M_2 (Black polythene mulch) treatment and minimum pod length (12.85 cm) diameter of pod (0.79 cm) and no. of seed per plant (4.74) was found from M_0 (Control) treatment. The highest dry matter (23.98 %) content of plant found in M_2 (Black polythene mulch) and lowest dry matter (20.66) content observed in M_0 (control) treatment. The highest (63.89 g) pod yield per plant, the highest pod yield per plot (1147.9 g) and the highest pod yield per ha (14.33 t) was achieved from M_2 (Black polythene mulch) treatment whereas the lowest (49.56 g) pod yield per plant, the lowest pod yield per plot (890.0 g) and the lowest pod yield per ha (10.98 t) were achieved from M_0 (Control) treatment.

At 60 days, the longest plant (57.24 cm) height and the maximum (29.43) number of leaves per plant were recorded from the treatment combination of P_4M_2 (50% Vermicompost +50% Mushroom spent compost and Black polythene mulch) while the shortest plant (43.32 cm) height and the minimum (23.05) number of leaves per plant were recorded from P_1M_0 (100% TSP and Control) treatment. At 60 DAS, the highest leaf length (25.86 cm), the highest leaf breadth (12.74 cm) found from P_1M_2 (100% TSP and Black polythene mulch) treatment combination where the lowest (17.62 cm) leaf length and the lowest leaf breadth (8.36 cm) were recorded from P_3M_0 (50% TSP+50% Mushroom spent compost and no mulch material) treatment combination. The highest (15.94) number of branches per plant found from P_4M_2 (50% Vermicompost +50% Mushroom spent compost and Black polythene mulch material) treatment combination and the lowest number of branches (9.76) per plant were recorded from P_1M_0 (100%TSP + no mulch material) treatment combination. It was observed that maximum days (44.66) to first flowering, days (62.96) to 90% flowering, the highest number of flowers per plant (30.72) and the maximum number of pods per plant (26.83) were recorded from P_4M_2 (50% Vermicompost +50% Mushroom spent compost and Black polythene mulch) treatment combination, whereas minimum days to first flowering (36.22), days to 90% flowering (46.71), the lowest number of flowers

(24.26) per plant and the minimum (20.04) number of pods per plant were counted from P_1M_0 (100% TSP and no mulch) treatment combination. Results revealed that maximum pod length (15.04 cm), maximum diameter of pod (0.98 cm) and maximum no. of seed per plant (6.38) was observed from P_4M_2 (50% Vermicompost +50% Mushroom spent compost and Black polythene mulch) treatment combination and minimum pod length (12.23 cm), diameter of pod (0.75 cm) and no. of seed per plant (4.45) was found from P1 (100% TSP and no mulch) treatment combination. The highest dry matter (24.96 %) content of plant found in P_4M_2 (50% Vermicompost +50% Mushroom spent compost and Black polythene mulch) treatment combination and lowest dry matter (20.55) content observed inP_3M_0 (50% TSP+ 50% Mushroom spent compost and control) treatment combination. The highest (75.56 g) pod yield per plant, the highest pod yield per plot (1358.2 g) and the highest pod yield per ha (16.76 t) was achieved from P_4M_2 (50% Vermicompost + 50% Mushroom spent compost and Black polythene mulch) treatment combination whereas the lowest (43.90 g) pod yield per plant, the lowest pod yield per plot (787.4.0 g) and the lowest pod yield per ha (9.72 t) were achieved from P_1M_0 (100% TSP and no mulch) treatment combination. The highest gross return (5,02,800 Tk./ha) was obtained from P_4M_2 (50% vermicompost + 50% Mushroom spent compost and black polythene mulch material) treatment combination and the lowest gross return (2,91,600 Tk./ha) was obtained from P_1M_0 (100% TSP and no mulch) treatment combination The highest net return (2,74,100 Tk./ha) was obtained from P_4M_2 (50% vermicompost + 50% Mushroom spent compost and black polythene mulch material) and the lowest (1,42,286 Tk./ha) in P_3M_1 (50% TSP+ 50% Mushroom spent compost and white polythene mulch) treatment combination. The highest (2.19) benefit cost ratio was obtained from P_4M_2 (50% vermicompost + 50% Mushroom spent compost and black polythene mulch material) treatment combination, while the lowest (1.63) in P_3M_1 (50% TSP + 50% Mushroom spent compost and white polythene mulch) treatment combination.

Conclusion and Recommendation: Based on the experimental results, it may be concluded that-

1. In the experiment, treatment P_4 (50% Vermicompost =1.3 t/ha +50% Mushroom spent compost =2.5 t/ha) was superior to the others.
2. In respect of all, the M_2 (Black polythene mulch) showed better performance than others.
3. The treatment combination of P_4M_2 (50% Vermicompost =1.3 t/ha +50% Mushroom spent compost =2.5 t/ha with Black polythene mulch) showed the best potentiality of 16.76 t/ha.

It may be recommended that farmers can use 50% vermicompost (1.3 ton/ha) + 50% mushroom spent compost (2.5 ton/ha) as a sources of phosphorus with black polythene mulch for french bean production. Considering the situation of the present experiment, further study might be conducted in different agro- ecological zones (AEZ) of Bangladesh for regional adaptability and other performances. The experiment was however, conducted in one season only and hence the results should be considered as a tentative. It is imperative that similar experiment should be carried out with more variables to reconfirm the recommendation.

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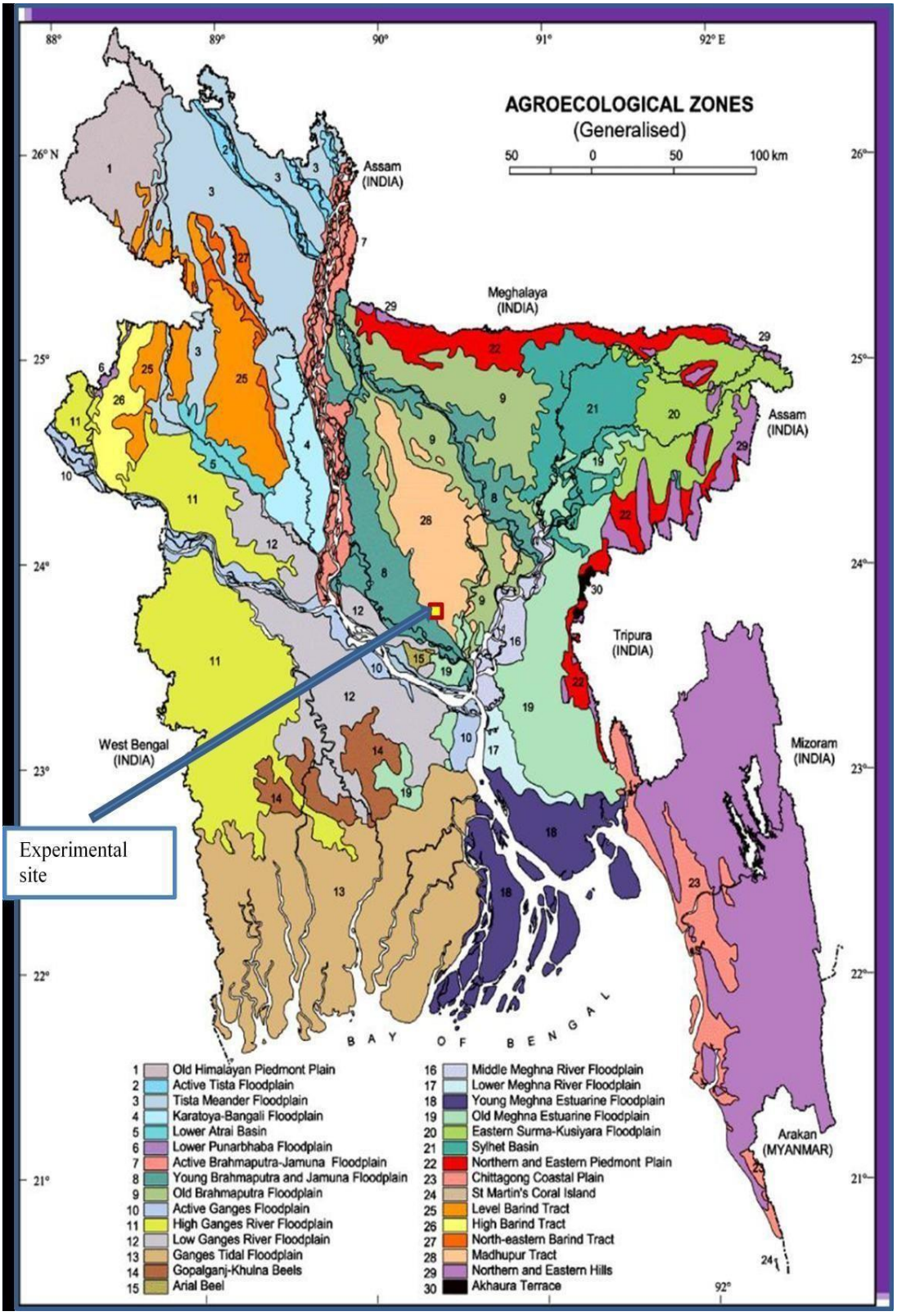
APPENDICES

Appendix I. Map showing the experimental site



Appendix II: Characteristics of Sher-e-Bangla Agricultural University soil is analysed by soil resources development institute (SRDI), khamar bari, farmgate, dhaka

A. Morphological characteristics of the experimental area

Morphological features	Characteristics
Location	Sher-e-bangla agricultural university
Aez	Madhupur tract (28)
Soil type	Shallow red brown terrace soil
Land type	High
Soil series	Tejgaon
Topography	Fairly leveled
Drainage system	Well drained

B. Physical and chemical properties of initial soil

Characteristics	Value
Sand %	27
silt %	43
clay %	30
Textural class	Silty-clay
pH	5.47 – 5.63
Organic carbon (%)	0.46
Organic matter (%)	0.83
Total n (%)	0.05
Exchangeable k (me/100 g soil)	0.12
Available s (ppm)	46
Available p (ppm)	20.00

Source: soil resources development institute (SRDI)

Appendix III: Monthly record of annual temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from October 2019 to March 2020 (site- dhaka)

Year	Month	Temperature(^{0}C)			Relative humidity (%)	Rainfall (mm)	Sunhine
		Max.	Mini.	Avg.			
2019	October	30.60	24.2	27.40	75.87	04	206.9
	November	29.85	18.50	24.17	70.12	00	235.2
	December	26.76	16.72	21.74	70.63	00	190.5
2020	January	24.05	13.82	18.93	62.04	00	197.6
	February	28.90	18.03	23.46	68.79	09	220.5
	March	32.24	22.10	27.17	78.82	68.5	208.2

Source: Bangladesh meteorological department (climatic division),Agargaon, Dhaka- 1212.

Appendix IV: Analysis of variance of the data on plant height at different days after sowing (DAS) as influenced by different sources of phosphorus and mulch materials of french bean

Source of variation	Degrees of freedom (df)	Mean square of plant height (cm) at different days after sowing			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	5.533	66.809	0.353	0.486
Factor-A:(different source of phosphorus)	3	57.377**	88.242**	7.767**	13.380**
Factor-B:(mulch materials)	2	46.576**	95.986**	12.098**	17.015**
A X B	6	31.049*	67.771*	4.026*	12.704*
Error	22	11.566	21.538	1.152	4.713

* significant at 0.05 level of probability; **significant at 0.01 level of probability and ^{ns} non-significant

Appendix V: Analysis of variance of the data on no. Of leaf at different days after sowing, leaf length, leaf breadth of french bean as influenced by different sources of phosphorus and mulch materials

Source of variation	Degrees of freedom (df)	Mean square of number of leaf at different days after sowing				Mean square of	
		15 DAS	30 DAS	45 DAS	60 DAS	Length of leaf	Breadth of leaf
Replication	2	3.021	3.787	8.902	20.701	0.041	5.472
Factor-A: (different sources of phosphorus)	3	6.481 ^{ns}	15.896*	87.875**	94.121**	1.262*	101.372**
Factor- B: (mulch materials)	2	9.095 ^{ns}	22.280*	85.623**	104.005**	4.093**	125.430**
A X B	6	2.282 ^{ns}	18.005*	55.516*	78.951*	1.406*	61.426*
Error	22	7.458	5.046	17.932	31.059	0.643	21.988

* significant at 0.05 level of probability; **significant at 0.01 level of probability and ^{ns} non-significant

Appendix VI: Analysis of variance of the data on number branches, days required to first flowering ,days required to 90% flowering, number of flower as influenced by different sources of phosphorus and mulch materials of french bean

Source of variation	Degrees of freedom (df)	Mean square of			
		Number of branches /plant	Days required to first flowering	Days required to 90% flowering	Number of flower /plant
Replication	2	249.51	2.290	2.108	1.7887
Factor- A: (different source of phosphorus)	3	1406.03**	29.637**	64.250**	18.3478*
Factor-B: (mulch materials)	2	5201.43**	24.808**	75.811**	48.135*
A X B	6	411.14*	19.771*	35.811*	0.9548*
Error	22	132.67	7.142	23.237	1.6081

* significant at 0.05 level of probability; **significant at 0.01 level of probability and ^{ns} non-significant

Appendix VII: Analysis of variance of the data on number of green pod/plant, length of green pod, diameter of green pod, number of seeds per green pod as influenced by different sources of phosphorus and mulch materials of french bean

Source of variation	Degrees of freedom (df)	Mean square of			
		Number of green pod /plant	Length of green pod (cm)	Diameter of green pod (cm)	Number of seeds / green pod
Replication	2	0.7608	443.5	0.184	1.453
Factor a (different source of phosphorus)	3	14.4191**	2409.3**	1.504**	20.426**
Factor B (mulch materials)	2	29.148**	45510.2**	1.251**	16.634**
A x B	6	2.8505**	6428.8**	1.488**	31.755**
Error	22	0.7608	535.4	0.196	0.432

* significant at 0.05 level of probability; ** significant at 0.01 level of probability and ns non-significant

Appendix VIII: Analysis of variance of the data of dry matter content (%) of plant, pod yield/plant, pod yield/plot, pod yield /ha as influenced by different sources of phosphorus and mulch materials of french bean

Source of variation	Degrees of freedom (df)	Mean square of			
		Dry matter content of plant (%)	Pod yield/ plant (g)	Pod yield/ plot (g)	Pod yield/ ha (t)
Replication	2	3.021	4.257	2.534	1.286
Factor-A: (different source of phosphorus)	3	2.481 ns	64.867 **	15.653**	43.370**
Factor B (mulch materials)	2	22.095 *	86.432**	21.543**	37.025**
A x B	6	17.282 *	31.977*	13.764**	28.204**
Error	22	5.458	9.296	1.821	2.113

* significant at 0.05 level of probability; ** significant at 0.01 level of probability and ns non-significan

Appendix IX: Effect of different sources of phosphorus on number of flower/plant, number of pod/plant, pod yield/ha of french bean

Phosphorus	Number of flower /plant	Number of pod/plant	Pod yield/ha (t)
P1	25.723 c	21.027 c	945.0 c
P2	28.078 ab	23.211 ab	1025.1 b
P3	27.094 b	22.481 b	955.5 c
P4	29.069 a	24.003 a	1163.1 a
Cv %	4.61	4.30	11.46
LSD (0.05)	1.2398	0.9536	43.9

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 1% or 5% level of significance. Where, P_1 = 100% TSP (control), P_2 = 50% TSP+50% Vermicompost, P_3= 50% TSP+ 50% Mushroom spent compost , P_4= 50% Vermicompost + 50% Mushroom spent compost

Appendix X: Effect of different mulch materials on number of flower/plant, number of pod/plant, pod yield/ha of french bean

Mulch materials	Number of flower/plant	Number of pod /plant	Pod yield /ha (t)
Mo	25.388 c	21.098 c	10.987 c
M1	27.711 b	22.731 b	12.697 b
M2	29.375 a	24.213 a	14.336 a
CV %	4.61	4.30	12.65
LSD (0.05)	1.0737	0.8259	0.47

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, M_0 = No mulch (control) ,M_1 = White polythene mulch ,M_2 = Black polythene mulch

Appendix XI: Cost of production of french bean per hectare

A. Input cost (Tk./ha)

Treatments	Labour	Ploughing	Seed	Irrrigation	Pesticides	Mulch materials	Organic and inorganic Fertilizers						Sub-Total (A)
							Urea	TSP	MoP	Vermicompost	Mushroom spent compost	Cowdung	
P_1M_0	42000	11000	10000	10000	6000	0	3400	4400	3300	0	0	5000	95100
P_1M_1	43500	11000	10000	8000	6000	50000	3400	4400	3300	0	0	5000	144600
P_1M_2	32100	11000	10000	6000	6000	50000	3400	4400	3300	0	0	5000	131200
P_2M_0	42000	11000	10000	10000	6000	0	3400	2200	3300	18200	0	5000	111100
P_2M_1	43500	11000	10000	8000	6000	50000	3400	2200	3300	18200	0	5000	160600
P_2M_2	32100	11000	10000	6000	6000	50000	3400	2200	3300	18200	0	5000	147200
P_3M_0	42000	11000	10000	10000	6000	0	3400	2200	3300	0	25000	5000	117900
P_3M_1	43500	11000	10000	8000	6000	50000	3400	2200	3300	0	25000	5000	167400
P_3M_2	32100	11000	10000	6000	6000	50000	3400	2200	3300	0	25000	5000	154000
P_4M_0	42000	11000	10000	10000	6000	0	3400	0	3300	18200	25000	5000	133900
P_4M_1	43500	11000	10000	8000	6000	50000	3400	0	3300	18200	25000	5000	183400
P_4M_2	32100	11000	10000	6000	6000	50000	3400	0	3300	18200	25000	5000	170000

Here, P_1 = 100% TSP (control), P_2 = 50% tsp+50% Vermicompost, P_3= 50% TSP+ 50% Mushroom spent compost , P_4= 50% Vermicompost + 50% Mushroom spent compost,M_0 = No mulch (control) ,M_1 = White polythene mulch ,M_2 = Black polythene mulch.

Labour @300 tk/day/man, Urea@ 17 tk/kg, TSP@ 22 tk/kg, MoP@ 22 tk/kg, Vermicompost@14000 tk/ton, Mushroom spent compost @ 10000 tk/ton, Cowdung @1000 tk/ton

B. Overhead cost (Tk./ha)

Treatments	Miscellaneous cost (Tk.5% of the input cost)	Cost of lease for 4 months land rent (10% of total Tk.12,00000/year)	Interest of running capital for 12 month (Tk.12% of cost/year)	Sub-total Overhead cost (B)	Total cost of production [Input cost (A) +Overhead cost (B)]
P_1M_0	4755	40000	5706	50461	145561
P_1M_1	7230	40000	8676	55906	200506
P_1M_2	6560	40000	7872	54432	185632
P_2M_0	5555	40000	6666	52221	163321
P_2M_1	8030	40000	9636	57666	218266
P_2M_2	7360	40000	8832	56192	203392
P_3M_0	5895	40000	7074	52969	170869
P_3M_1	8370	40000	10044	58414	225814
P_3M_2	7950	40000	4540	52490	206490
P_4M_0	7700	40000	9240	56940	190840
P_4M_1	9170	40000	11004	60174	243574
P_4M_2	8500	40000	10200	58700	228700

Here, P_1 = 100% TSP (control), P_2 = 50% tsp+50% Vermicompost, P_3= 50% TSP+ 50% Mushroom spent compost , P_4= 50% Vermicompost + 50% Mushroom spent compost,M_0 = No mulch (control), M_1 = White polythene mulch ,M_2 = Black polythene mulch.