

**Effect of Nutrient, Weed and Pest Management
Practices on Productivity of Field pea
[*Pisum sativum var. arvense.*]**

काशी हिन्दू
विश्वविद्यालय



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in

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Supervisor

Prof. R. S. Singh

Submitted by

Katkuri Sravani

**DEPARTMENT OF AGRONOMY
INSTITUTE OF AGRICULTURAL SCIENCES
BANARAS HINDU UNIVERSITY
VARANASI-221005
INDIA**

I.D. No. A-15019

2017

Enrolment No. 375656

Dr. Radhey Shyam Singh
Professor
Department of Agronomy
Mobile :+91-9451493750
E – mail: singhrs.bhu@gmail.com



Institute of Agricultural Sciences
Banaras Hindu University
Varanasi (U.P.)-221005 (India)

Ref. No.

Date.....

CERTIFICATE

To,
The Registrar (Academic)
Banaras Hindu University,
Varanasi - 221 005 (INDIA).

Through: The Head, Department of Agronomy,
Institute of Agricultural Sciences,
Banaras Hindu University, Varanasi.

Dear Sir,

I have great pleasure in forwarding the thesis entitled **“Effect Of Nutrient, Weed and Pest Management Practices on Productivity of Field pea [*Pisum sativum var. arvense*]”** submitted by **Ms. Katkuri Sravani, I.D. No. A-15019**, in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture) in Agronomy** from Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, (U.P.) and placing on record that she has completed the requisite residential requirements as contained in the statutes of the university.

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Forwarded by
Head

Yours faithfully

(R.S. Singh)
Supervisor

**“Effect of Nutrient, Weed And Pest Management Practices on
Productivity of Field pea [*Pisum sativum var. arvense.*]”**

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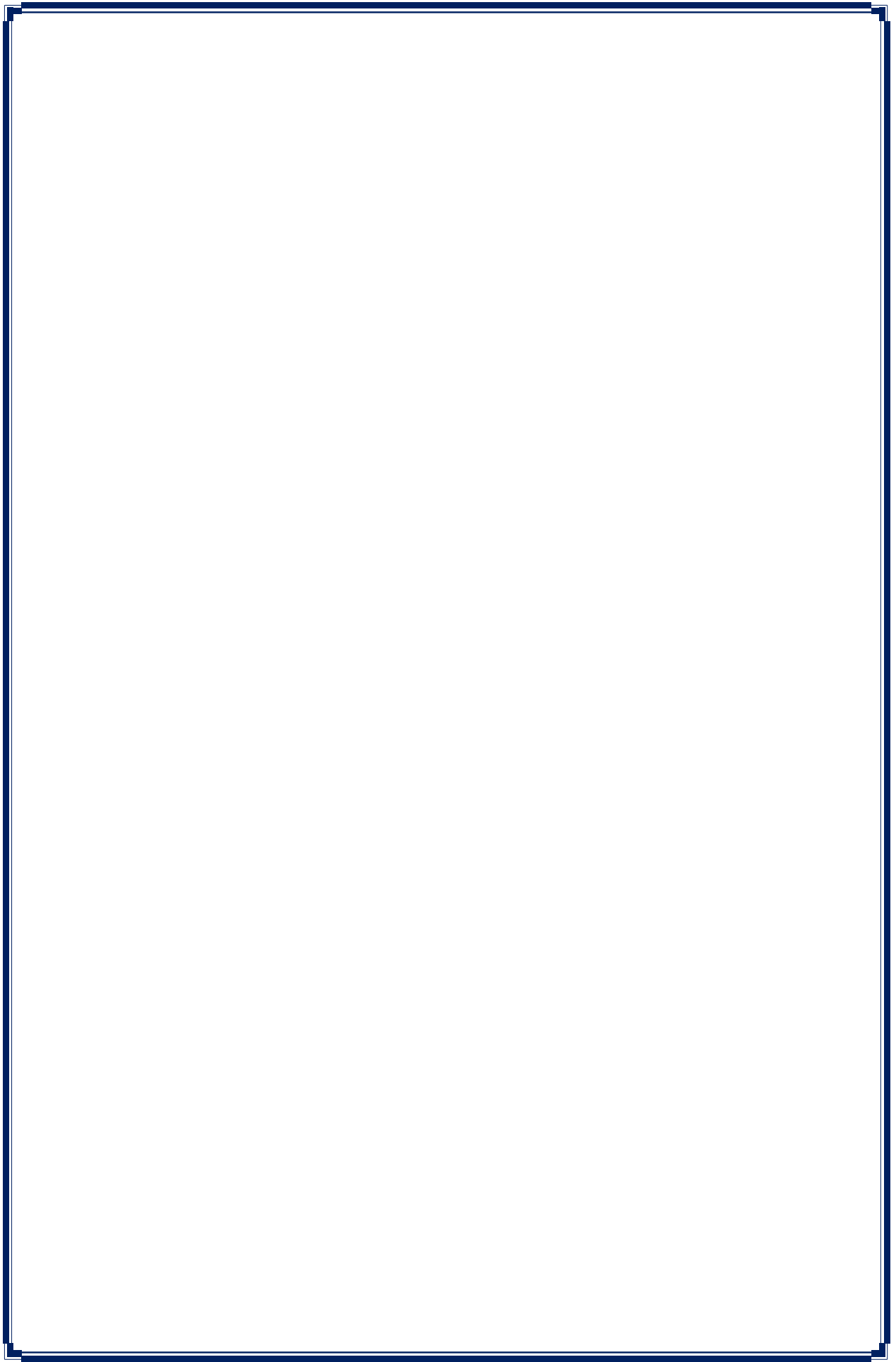
THESIS APPROVED BY ADVISORY COMMITTEE

Chairman and Supervisor : Prof. R.S. Singh
Professor
Department of Agronomy
Institute of Agricultural Sciences, BHU, Varanasi

Members : Prof. Yashwant Singh
Assistant Professor
Department of Agronomy
Institute of Agricultural Sciences, BHU, Varanasi

Members : Prof. Janardan Yadav
Assistant Professor
Department of Soil Science and Agricultural Chemistry
Institute of Agricultural Sciences, BHU, Varanasi

External Examiner :



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*I solicit the benediction for **LORD VISHWANATH** for my progress and prosperity.*

Date:

Place: Varanasi

(Katkuri Sravani)

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
/	:	Per
₹	:	Rupees
@	:	At the rate of
B:C	:	Benefit cost ratio
C.D.	:	Critical difference
cm	:	Centimeter
d. f.	:	Degree of freedom
DAP	:	Di ammonium phosphate
DAS	:	Days after sowing
dSm ⁻¹	:	Decisiemen per meter
e.g.	:	For example
EC	:	Electrical conductivity
<i>et al.</i>	:	And others
Fig.	:	Figure
g	:	Gram
ha	:	Hectare
HI	:	Harvest index
hrs	:	Hours
HW	:	Hand weeding
<i>i.e.</i>	:	Which is to say, in other words
kg	:	Kilogram(s)
l ha ⁻¹	:	Litre ha ⁻¹
lakh ha	:	Lakh hectares
M ha	:	Million hectare
M t	:	Million tonne
m ⁻²	:	Per square metre
Max	:	Maximum
Min	:	Minimum
N	:	Nitrogen
No. m ⁻²	:	Number per square metre
NS	:	Non-significant
SEm	:	Standard error of mean
t	:	Tones
<i>viz.</i>	:	Namely
WCE	:	Weed control efficiency
WI	:	Weed index

INTRODUCTION

Pulses have been essential for the development of agriculture over millennia and they are essential to any future scenario of sustainable global agriculture. The UN Food and Agriculture Organization declared 2016 the International Year of Pulses (IYP) to encourage connections throughout the food chain that would better utilize pulse based proteins, further global production of pulses, increase the efficiency of crop rotations, and address trade challenges.

Pulses are economically important crops for farmers, in both developing and developed countries. Pulses are traditionally mostly grown in developing countries, which contribute 70% of pulse production globally. Pulses, or grain legumes in general, are an indispensable source of supplementary protein to daily vegetarian diets; these are regarded as poor man's meal. India with its predominantly large vegetarian population in dietary habit has a distinction of being the world's largest producer cum consumer of grain legumes. The cultivation of pulses builds-up a mechanism to fix atmospheric nitrogen in their root nodules and thus meet their nitrogen requirements to a great extent. Apart from this pulses can be produced with a minimum use of resources and hence, it becomes less costly even than animal protein and in comparison with other vegetables, these are rich in protein which are less expensive and can be cultivated as an inter-crop and also as mixed crop.

Pulses are grown since ages in different parts of the world. Globally pulses are grown in 85.6 m.ha with a production of 77.6 mt (FAO, 2016), South Asia has the maximum acreage of 33.9 m.ha and highest production of 22.5 mt. Africa and Americas is the second and third largest grower of pulses after South Asia. Most important dietary pulses include chickpea, beans, lentil, green gram (mungbean), black gram (urdbean), field pea, pigeonpea, and cow pea. Soybean and groundnut are important oilseed legumes meeting ~35% of the global vegetable oil requirement and are also used as protein supplements.

India is the largest producer, largest consumer and the largest importer of pulses in the world. India accounts for over one third of the total world area and over 20 % of total world production. In India Pulses are grown in around 24-26 m.ha of area producing 17-19 mt of pulses annually. The total pulses production in India during 2012-13, was 18.34 mt (up by 7.31% over the previous year) which further increased by another 7.85% in 2013-14 with a production of 19.78 mt (FAOSTAT 2016).The acreage ranged from 20.35 (2000-01) to 23.99 m.ha (2014-15) and production varied from 11.08 (2000-01) to 18.45 mt (2014-15). The productivity has increased from 544 kg ha⁻¹ (2000-01) to 750 kg ha⁻¹ (2014-15).

The major pulses producing states are Madhya Pradesh (25%), Uttar Pradesh (13%), Maharashtra (12%), Rajasthan (11%), Andhra Pradesh (9%) and other states together (30%) during 2012-13. Several pulse crops including chickpea, pigeonpea, cowpea, mungbean, urdbean, lentil, French bean, horse gram, field pea, moth bean, lathyrus, etc are grown in one or the other part of India. However, the most important pulse crop grown here are chickpea (41%), pigeon pea (15%), urdbean (10%), mungbean (9%), cowpea (7%) lentil (5%) and field pea (5%).

Field pea (*Pisum sativum var. arvense*) is also known as ‘Dry peas’ is a cool-season legume crop that belongs to the Leguminosae. It provides a variety of vegetarian diet hence liked throughout the world. Field pea is an economically important grain legume oldest domesticated crop and is now grown in many countries for both human consumption and stock feed. It is mainly grown in tropical highlands and in many countries in temperate regions (Cousin, 1997; Messiaen *et al.*, 2006).

Field pea is the third most important pulse crop at global level, after dry bean and chick pea According to a recent FAO report, the major field pea growing country is Canada, followed by the Russian Federation, India, France and Australia (FAOSTAT, 2013). Canada rank first in area (20%) and production (35%) at Global level while china and France stand second for area and production respectively. India occupy 4th position in area (11.44 %)and 5th position in production (6.00%). Total world production of dry peas during 2012 was more than 10 mt, from a total area of almost 7m ha (FAOSTAT, 2013).

Field pea (*Pisum sativum* L.) is called 'Matar' in India. It is an important and third most popular rabi pulse of India after chick pea and lentil. It is grown as a winter vegetable in the plains of north India and as summer vegetable in hills, whereas vegetable types are also grown in cooler parts of southern India. It is mainly grown for tender green pods as a fresh vegetable and is a rich source of protein, calcium, phosphorous, iron and vitamins. According to FAO statistics, India is one of the largest producers of field pea in the world and stands at the 5th place in the list of major field pea producers next to France. The Indian production contributes to around 7% in the world's total produce with the production figures of 7.8 lakh tonnes. In India, field pea is grown on about 0.76 m.ha areas with an annual production of 0.84 mt showing productivity of $>1.1 \text{ t ha}^{-1}$ during 2012-13. Uttar Pradesh, Madhya Pradesh, Bihar, Maharashtra, Haryana and Rajasthan are major pea growing states in India. Uttar Pradesh is a major field pea producing state in India producing about 60% of the country's produce.

Field pea is one of the main sources of dietary protein for the majority of Indians. The productivity of this crop is highest among the pulses. Moreover, its high yield potential 3.5 t ha^{-1} through balanced fertilization envisages ample scope to increase its yields further (Anonymous 2009). Soil is the main source of plant nutrients. It supplies almost all of the essential nutrients to crop plants. Being a legume crop and has the inherent ability to obtain much of its nitrogen requirement from the atmosphere by forming a symbiotic relationship with Rhizobium bacteria in the soil (Schatz and Endres, 2009). Field pea ability to use the atmospheric nitrogen through biological nitrogen fixation (BNF) is economically sound and environmentally acceptable (Saikia and Jain, 2007). Thus apart from meeting its own nitrogen requirement, pea crop is known to add 50-60 kg residual nitrogen ha^{-1} in soil (Erman *et al.*, 2009). Phosphorus is known to play an important role in growth and development of the crop. The requirement of P, which is essential for root growth and nodulation, has to be largely fulfilled through inorganic fertilizers. Chemical fertilizers are needed to get good crop yields but their abuse and overuse can be harmful for the environment and their cost cannot make economic and profitable agricultural products (Bobade *et al.*, 1992). Bio fertilizers on the other hand are cost-effective and renewable source of plant nutrients to supplement the parts of chemical

fertilizers. Enhancing P availability to crop through phosphate-solubilising bacteria (PSB) holds promise in the present scenario of escalating prices of phosphatic fertilizers in the country and a general deficiency of P in Indian soils (Alagawadi and Gaur, 1988). Bio-fertilizers are known to play an important role in increasing availability of nitrogen and phosphorus besides improving biological fixation of atmospheric nitrogen and enhance phosphorus availability to crop (Bhat *et al.*, 2013). Therefore, The integration of bio fertilizers along with chemicals and FYM not only has a positive effect on the yield attributes of pea and gives highest net returns but also increasing soil fertility status and ecofriendly as well (Bhattarai *et al.* 2003). Introduction of efficient strains of *Rhizobium* in soil, which is poor in nitrogen, may help in boosting up production and consequently more nitrogen fixation. (Gill *et al.*, 1987).

There are several factors that affect the yield of field pea and competition by weeds is one of the major factors for reducing the yield and quality, both grassy as well as broad leaved weeds results in significant yield losses in this crop (Singh *et al.*, 1991). Weeds compete vigorously with the crop as field pea is a poor competitor with weeds especially during the first month after planting. The critical period for crop-weed competition in pea varies from 40-60 days after sowing (Bhyan *et al.*, 2004). The yield reductions are about 20 to 40% (Blackshaw and O'Donovan 1993). Good weed control is also very important in raising high-quality human edible pea. An integrated approach to weed control combines preventative and cultural measures (such as the use of clean, healthy seed, crop rotation, and seeding rates) with the effective use of herbicides. Sanitation, competition and rotation are the primary tools used to keep weeds from being a problem when growing field peas. Heavy weed infestations should be controlled by cultural or chemical measures prior to rotating into field pea, and prior to planting. Cultural measures include effective weed control by practice of hand weeding twice at 30 and 60 days after sowing. Maintaining good fertility is also an important aspect to effective weed management. This helps maximize vigour and the ability of field peas to compete with weeds. Controlling grassy weeds like wild oats and green foxtail can be achieved with an in-crop application of an effective herbicide. Removing weeds after 60 days of sowing did not improve the yield as the most critical period of crop weed competition is between 10

to 60 days of sowing. Thus the most critical period for weed management point of view is up to 40-50 days after sowing and thereafter, it can suppress the weeds by growing faster and forming crop canopy. As a chemical control of weeds, application of pre-emergence herbicides control the weed losses up to 50 days after sowing and post emergence herbicides may help in alleviating weed problem. Thus the practice of cultural measures along with chemical measures help in wide control of weeds in field.

Another factor responsible for low yields of field pea is insects and pest. However Pea crops have relatively few insect pests of economic importance, but the few that can affect pea plants must be monitored to prevent yield loss. The major insects which pose a threat to field peas are pea weevil, *Bruchus pisorum* L., pea aphid, *Acyrtosiphon pisum* (Harris), African bollworm, *Helicoverpa armigera* (Hubner) and adzuki bean beetle, *Callosobruchus chinensis* L. are reported to be the insect pests of field pea (Ali *et al.*, 2008). As a preventative measure, a seed treatment can help keep insect pressure to a minimum.

Keeping this in view, the present experiment entitled “Effect of nutrient, weed and pest management practices on productivity of field pea” was conducted during the crop season of 2015-16 with the following objectives:

1. To study the effect of management practices on growth and yield of field pea.
2. To estimate the uptake of N, P, K in field pea grain.
3. To find out the economics of different treatments.



REVIEW OF LITERATURE

Pea (*Pisum sativum* L. *arvense*) is an important grain legume crop in India and mostly cultivated during *rabi* season. The major reasons for its low yield are cultivation on marginal land, imbalanced fertilizer application, weed incidence and attack of diseases and insect pests. So to overcome this problem and increase the productivity of field pea proper management practices should be followed. The experiment was conducted to determine the effects of nutrient, weed and pest management practices on productivity of field pea.

In this chapter, an attempt has been made to review the available information on various aspects related to present study that is the effect of nutrient, weed and pest management practices on productivity of field pea. Due to paucity of research work on field pea, the concerned information on related legumes has also been included and presented under different sub headings.

1. Effect of Nutrient Management Practices on Crop Growth, Yield Attributes, Yield and economics of Field pea.
2. Effect of Weed management on growth and yield attributes and economics of Field pea.
3. Effect of Pest management on growth and yield attributes and economics of fieldpea.

2.1 Effect of Nutrient Management Practices on Crop Growth, Yield Attributes, Yield and Economics of Field pea

2.1.1. Growth, Yield and Yield attributes

Abdel-Ghaffar and Mohamed (1992) found that plant height of pea was significantly increased by seed inoculation. They found also that nodule number plant⁻¹ was significantly affected by *Rhizobium* inoculation.

Prasad and Maurya (1992) reported that growth and nodulation of pea plants during winter season significantly increased by *Rhizobium* inoculation of seeds.

Gheeth (1993) found that plant height; number of branches and nodules plant⁻¹ was increased markedly with *Rhizobium* inoculation treatment compared with uninoculation of pea plants.

El-Mansi *et al.* (2000) showed that seed inoculation with *Rhizobium* gave significantly higher values of pod number plant⁻¹ and total yield fed⁻¹ compared with check. In addition, El-Khatib (2003) mentioned that inoculation of pea seeds with biofertilizer *Rhizobium* significantly increased components of yield.

Sarg and Hassan (2003) reported that number of pods plant⁻¹, pod weight, yield plant⁻¹, yield fed⁻¹ and weight of 100 seeds were significantly increased by *Rhizobium* inoculation higher than the untreated one.

According to Tyagi (2003), the highest 14.93 q ha⁻¹ grain yield was recorded in composit culture of *Rhizobium*+ PSB which was significantly higher over both *Rhizobium* and PSB inoculated alone but at par with the single inoculum culture of *Rhizobium* and PSB treatment over the control.

Solieman *et al.* (2003) reported on pea plant, that inoculation of pea seeds with *Rhizobium* significantly increased plant height, number of branches plant⁻¹ compared to the un inoculated one.

In a report by Negi *et al.* (2006) it was revealed that the Biofertilizers *viz.*, *Rhizobium leguminosarum* + *Pseudomonas striata* increased the plant height significantly by 71.43 % over no inoculation. Weight of 100 pods significantly increased by biofertilizers *viz.*, *Rhizobium leguminosarum* + *Pseudomonas striata* by 17.14 % over no inoculation. The green pod yield was significantly increased with co-inoculation of *Rhizobium leguminosarum* + *Pseudomonas striata* by 52.04 %.

Negi *et al.* (2007) concluded that combine application of FYM + RDF and bio-fertilizers in vegetable pea recorded the significant values of yield and yield attributing characters, nitrogen, phosphorus, potassium uptake and harvest index.

Bansal (2009) conducted field study in *kharif* 2003, 2005 and 2006 at Agricultural Research Station, Durgapura, Jaipur revealed that presowing inoculation of mungbean seeds with different inoculants (*Rhizobium*, PGPR and PSB) alone or in combination, significantly increased the nodulation and grain yield over uninoculated control. Nodulation and grain yield was highest when seeds were inoculated with *Rhizobium* + PGPR + PSB followed by *Rhizobium* + PGPR and *Rhizobium* alone, in all the three *kharif* seasons (2003, 2005 & 2006) of experimentation. In pooled analysis also, combined inoculation mungbean seeds with *Rhizobium* + PGPR + PSB gave significantly highest grain yield (12.94 q ha⁻¹). It was at par with *Rhizobium* + PGPR with grain yield of 12.14 q ha⁻¹.

An experiment was carried out by Ganie *et al.* (2009) to establish the effect of bio-fertilizer inoculation and co-inoculation (interaction) of *Rhizobium*, *Azobacter* and phosphorus solubilising micro-organisms (PSM) on the growth and yield character of vegetable pea. Results of experiment indicated clearly that the co- inoculation of *Rhizobium*, *Azotobacter* and phosphorus solubilising microorganism (PSM) produced noticeably highest growth in terms of plant height, branches and also highest yield in the tune of number of pods plant⁻¹ (19.37), number of seeds pod⁻¹ (8.22) and yield of pods (74.25q ha⁻¹) in respect to the other treatments. Moreover, the co-inoculation of *Rhizobium* and phosphorus solubilising microorganism (PSM) also gave beneficial results.

Mishra *et al.* (2010) from the experiment of two consequent *rabi* seasons revealed that the combined application of 100% RDF and seed inoculation with *Rhizobium* +PSB+PGPR improved all the growth; yield attributes and yields of field pea. Maximum yield was obtained under 100% RDF when compared to 50% RDF and control respectively.

Rather *et al.* (2010) conducted a field experiment find out the effect of biofertilizers (*Rhizobium*, *Azotobacter* and phosphate solubilising bacteria (PSB)) application on growth, yield and economics of field pea (*Pisum sativum* L.). The Co inoculation of all the three bio-fertilizers *i.e.* *Rhizobium*, *Azotobacter* and PSB produced significantly higher growth characters as compared to absolute control and when inoculated them individually. The treatment comprising *Rhizobium*

+*Azotobacter* + PSB gave highest growth in terms of plant height (45.26 cm), number of branches plant⁻¹ (4.20), number of leaves plant⁻¹.

Jitender Kumar (2011) noted that yield and yield attributes like number of pods plant⁻¹, length of the pod and number of seeds pod⁻¹ in garden pea was influenced significantly by phosphorus fertilizer and *Rhizobium* inoculation. Maximum number of pods per plant, length of the pod and number of seeds pod⁻¹ were recorded with *Rhizobium* inoculation. Yield of mature green pods was significantly increased with the increased doses of phosphorus and *Rhizobium* inoculation, while minimum yield was observed under control.

Yadav and Yadav (2011) carried out an experiment at the Horticulture Farm (Asalpur), S.K.N. College of Agriculture, Jobner during the *rabi* season of 2005-06. The treatment comprised four levels of phosphorus (0, 20, 40 and 60 kg P/ ha) and biofertilizers (control, *Rhizobium*, PSB and *Rhizobium* + PSB) each, thereby making 16 treatment combinations. Higher number of pods plant⁻¹, grains pod⁻¹ and green pod yield resulted in seed inoculation with *Rhizobium*, PSB and *Rhizobium* + PSB significantly over no inoculation. Seed inoculated with *Rhizobium* + PSB increased the green pod yield by 16.8, 9.1 and 5.3 % over control, *Rhizobium* and PSB, respectively.

Kumari *et al.* (2012) reported that application of inorganic nutrients, biofertilizers and zinc to field pea produced the highest seed yield over the recommended inorganic nutrients. Seed inoculation with biofertilizers (*Rhizobium* +PSB+PGPR) along with 5 kg Zn ha⁻¹ markedly enhanced crop growth and yield attributes, seed (1498 kg/ha) and straw (2184 kg/ha) yield of field pea and soil fertility status. Net return and B: C ratios were also higher with bio fertilizers + zinc.

Khandelwal *et al.* (2012) observed that the combined application of *Rhizobium* and PSB to cowpea resulted in significantly higher yield and yield attributing characters.

Gangwar and Dubey (2012) reported that the application of RDF with one gram ammonium molybdate + *Rhizobium* + PSB, RDF with two gram ammonium

molybdate + one gram FeSO_4 + *Rhizobium* + PSB recorded the highest yield and yield attributes in chickpea.

Bhat *et al.* (2013) conducted field study to evaluate the response of field pea (*Pisum sativum* cv. Rachna) to levels of phosphorus and bio-fertilizers under sub-tropical conditions of Jammu. It was found that dual inoculation of *Rhizobium* + PSB recorded highest seed yield (15.01 q ha^{-1}) and stover yield (33.90 q ha^{-1}) as compared to control. Seed inoculation with *Rhizobium* or PSB alone remained at par with each other but significantly superior over control. Significant increase in seed and stover yield due to seed inoculation could be attributed to increased and balanced availability of both N and P in dual inoculation (*Rhizobium* + PSB). The synergistic effect of *Rhizobium* and PSB might have increased the growth, yield attributes and ultimately the yield due to increased nitrogenase activity and available P status of soil.

According to Patel *et al.* (2013) the maximum plant height (cm), No. of seed per pods was shown constantly by the treatment (*Rhizobium*+RDF of NPK) and maximum length of pods was observed under treatment - (PSB+ RDF of NPK), whereas minimum observed under treatment (RD of NPK). 100 Seed weight in the study on pea showed maximum seed weight is under treatment of PSB+ RDF of NPK. The maximum yield per plot was recorded under the trial treatment (PSB + *Rhizobium* + % NP and full dose of K), while the minimum yield was shown to be under treatment (RDF of NPK), length of pods.

Mishra (2014) found that application of NPK as a source of chemical fertilizer integrated with vermicompost and biofertilizers were found to be superior with regards to yield and yield-attributing characters over control and sole application of 100% recommended dose of chemical fertilizers. The pea plant can readily absorb and utilize the nutrients and express the highest value in all characters and finally the pod yield under combined application of organics and inorganics.

According to Kumar *et al.* (2014) application of *Rhizobium* and PSB supplemented by one-fourth quantity of NP fertilizers along with manurial treatments in *kharif* recorded higher grain yield of pea as compared to green manuring (residual effect) and half dose of N P along with *Rhizobium* +PSB and proved better than

application of FYM (20 t ha⁻¹) or vermi-compost (10 t ha⁻¹) combined with bio fertilizers (*Rhizobium* + PSB) in rabi without NP fertilizers.

Ms. Sarita Rani (2015) revealed that more number of pods plant⁻¹, number of grains pod⁻¹ and 100 grain weight produced with the combined application of RDF + *Rhizobium* + PSB + PGPR significantly being statistically at par with RDF, RDF + *Rhizobium*, RDF + *Rhizobium* + PSB and RDF + ZnSo₄. Similarly grain yield under different treatments varied from 1595-2931 kg ha⁻¹ and maximum in the RDF + *Rhizobium* + PSB + PGPR treatment with its significant superiority over rest of the treatments. The individual (*Rhizobium*) and combined application (*Rhizobium* + PSB and *Rhizobium* + PSB + PGPR) produced 132 kg ha⁻¹, 207 kg ha⁻¹ and 521 kg ha⁻¹ higher grain yield over the control.

Varsha Uikey *et al.* (2015) showed that there were significant influences in the growth and yield parameters. Maximum plant height were recorded under application of 10 t FYM ha⁻¹ + 45:75:60 kg ha⁻¹ NPK + Rz+PSB culture which was significantly superior over other treatments. It was followed by application of 20t FYM ha⁻¹ + 30:75:40 kg ha⁻¹ NPK + Rz+PSB culture. Minimum plant height was observed under control, which was significantly lower to other treatments.

Fozia Qureshi *et al.* (2015) in an experiment observed that with increasing levels of inorganic fertilizers increased growth, yield and yield attributing characters. Farm yard manure @ 20 t ha⁻¹ and *Rhizobium* inoculation significantly increased the plant height (cm), number of branches plant⁻¹, pod plant⁻¹, pod length (cm), seed pod⁻¹, test weight, dry matter production, seed and stover yield over control.

The application of phosphorus and sulphur in combination with PSB inoculation not only sustained the productivity of the crop but also improved the soil health. Application of 40 kg P ha⁻¹ and 30 kg S ha⁻¹ with PSB inoculation showed the highest yield as compared to other treatments. It not only increased the green pod yield of pea but also improved the quality of the green pea. (Adil *et al.*, 2015).

Abid *et al.* (2016) observed that besides, better nodulation and growth parameters, co-inoculation of *Rhizobium* and phosphate solubilising bacteria also significantly increased yield and yield contributing parameters i.e. number of grains

pod⁻¹, number of pods plant⁻¹, number of grains plant⁻¹, 100-grain weight and grain weight plant⁻¹ of peas over non inoculated control. These results are favoured by the outcomes of other researchers who observed the effects of inoculation on growth and yield of various legume crops (Mirza et al., 2007, Yadegari *et al.*, 2008, Zahir *et al.* 2010).

According to Desai *et al.* (2016) the yield attributes and yield viz., number of pods plant⁻¹, pod length, number of seeds pod⁻¹, 100-seed weight, seed yield were significantly higher under the treatment *Rhizobium* + PSB inoculation. Significantly higher protein content, available and uptake of nitrogen and phosphorus by seed were recorded with treatment *Rhizobium* + PSB inoculation.

Mukherjee, Dhiman (2016) accorded that the combined application of 75 % RDF + 25% N through vermicompost (@1.90 t ha⁻¹) and seed inoculation with *Rhizobium* + PSB improved all the growth, yield attributes and yields of field pea. Plant height, number of leaves plant⁻¹, number of branches plant⁻¹, number of nodules plant⁻¹, fresh and dry weight of nodule plant⁻¹ were significantly varied with various treatments and was maximum with full dose of RDF along with *Rhizobium* and PSB combination and showed parity with 75% RDF + vermicompost + *Rhizobium*+ PSB. Number of seeds pod⁻¹, number of pods plant⁻¹ and other yield attributing characters significantly more with 75% RDF + vermicompost + *Rhizobium* + PSB. Maximum grain yield was registered with full dose of RDF along with *Rhizobium* and PSB (26.74 q ha⁻¹) and remained at par with 75% RDF + vermicompost + *Rhizobium*+ PSB (25.08 q ha⁻¹). Increase in grain yield in the tune of 135.2 and 120.7 % more with RDF +*Rhizobium* + PSB and 75% RDF + vermicompost + *Rhizobium* + PSB, respectively over control.

2.1.2. Economics

The integration of biofertilizers along with chemical fertilizers and FYM not only has a positive effect on the yield attributes of pea, but also in the process leads to the highest net returns. The integrated application of chemical fertilizers in conjunction with manures and biofertilizers was the best option (Bhattarai *et al.* 2003).

Kumari *et al.* (2010) reported that superimposition of 50 per cent nitrogen through vermicompost over the recommended dose, along with the seed inoculation with bio-fertilizer (*Rhizobium* + PSB + PGPR) and application of Zn resulted in significantly higher, B:C, ratio in dwarf field pea.

Yadav and Yadav (2011) reported that significantly higher net returns of garden pea with inoculation of *Rhizobium* + PSB were recorded over rest of the biofertilizer treatments.

Varsha *et al.* (2015) reported that under the treatment combination 10t FYM / ha +45:75:60 kg /ha NPK + Rz+PSB culture with net return of Rs 135741.70 / ha and cost benefit ratio 1:6.78. Similarly Harikrishna *et al.* (2002) and Yadav and Luthra (2005) noted that.

Rakesh Kumar *et al.* (2015) revealed that the maximum gross return (Rs. 40738), net return (Rs. 28496) and B: C ratio (2.32) was recorded with the treatment of 100% RDF along with 50% RDN, which was significantly superior to other treatments. Among biofertilizers treatment, maximum gross return (Rs. 38141), net return (Rs. 26,505) and B: C ratio (2.24), production efficiency (10.33 kg day⁻¹ha⁻¹) and economic efficiency (Rs. 241.5 day⁻¹ with the treatment of biofertilizers along with Zn at 5 kg ha⁻¹) were recorded, which was significantly superior to other treatments.

2.2 Effect of weed management Practices on Crop Growth, Yield Attributes, Yield and Economics of Field pea

2.2.1 Crop Growth, Yield Attributes, Yield

Remarkable improvement in yield and yield attributes due to weed control treatments over weedy check was reported by Tripathi *et al.* (1991) and Ved Prakash *et al.* (2000).

Pandey *et al.* (2000) conducted a field experiments during *rabi* season in Uttar Pradesh, India, to evaluate the relative efficacy of herbicides in field pea and observed that highest plant height, number of pods plant⁻¹, grains pod⁻¹, pod length, pod weight

plant⁻¹ and shelling percentage were recorded under the repeated weeding treatment closely followed by pendimethalin at 0.5 kg ha⁻¹ + hand weeding at 45 DAS. Herbicides alone increased green pod yields by 55.9-75.9% over the weedy control. All the weed control treatments resulted in significantly higher green pod yield over the weedy control due to significant reductions in the density and dry weight of weeds.

Singh *et al.* (2001) conducted experiment in Punjab, India, during the winter seasons to test the efficacy of various herbicides for controlling weed in field pea under different planting systems. Application of pendimethalin at 0.50 kg ha⁻¹ + one hand weeding significantly reduced density and dry weight of weeds resulted highest grain yield of field pea over trifluralin at 0.75 kg ha⁻¹ + one hand weeding at 30 DAS trifluralin 1.25 kg ha⁻¹ and pendimethalin at 0.75 kg ha⁻¹.

Rana (2002) conducted field experiment in Himachal Pradesh, in sandy soil to investigate the effects of integrated weed management in pea cultivars. The treatments were pendimethalin, alachlor and metolachlor at 1.50 kg ha⁻¹ applied alone, or in combination with hand weeding (HW) at 1.50 and 0.75 kg ha⁻¹; and fluchloralin at 1.00 kg ha⁻¹ alone, and in combination with HW at 1.00 and 0.50 kg ha⁻¹; HW; and weedy control. Pendimethalin and fluchloralin were the most effective herbicides in controlling weeds in pea. Pendimethalin at 1.50 kg ha⁻¹ and fluchloralin at 1.00 kg ha⁻¹ increased pods plant⁻¹, seeds pods⁻¹ and yield significantly with equal magnitude.

Bhyan *et al.* (2004) conducted an experiment during the *rabi* seasons at Hisar, Haryana, India to evaluate the effect of weed competition on the quality of pea seeds. The treatments consisting of weed-free and weedy conditions for an initial period of 20, 40, 60, 80 and 100 days after sowing (DAS) were compared with weed free and weedy conditions until harvest. Seed yield increased with increasing weed free period up to 60 DAS. Weed removal after this period resulted in statistically similar seed yield to that of the season-long weed-free treatment.

Singh and Angiras (2004) conducted field experiment at Palampur, Himachal Pradesh, during the winter season to determine the efficacy of herbicides against weeds and their effects on the green pod yield of garden pea. The treatments

comprised: 1.0 kg alachlor, 1.5 kg pendimethalin, 0.75 and 1.0 kg fluchloralin, hand weeding at 30 days after sowing (DAS), hand weeding at 30 and 60 DAS, weed-free and weedy controls. All the treatments significantly reduced the dry matter accumulation of total weeds compared to the weedy control. Pendimethalin at 1.5 kg ha⁻¹ gave the highest number of pods plant⁻¹ (13.2) and pod yield (10.8 t ha⁻¹).

Govardhan *et al.* (2007) reported that pre-emergence applications of pendimethalin at 0.75 kg ha⁻¹, fluchloralin at 1.00 kg ha⁻¹ followed by HW at 30 DAS and 45 DAS. This treatment also recorded the maximum values of number of pods per plant (20.46), grain yield (21.40 q ha⁻¹).

Dawson *et al.* (2007) conducted the field experiment in Uttar Pradesh, in *rabi* season to evaluate the effect of different weed control methods on weed density, weed dry weight and pea. The treatments were pre-emergence application of pendimethalin at 0.75 kg ha⁻¹ alone, pre-emergence fluchloralin at 1.0 kg ha⁻¹ and herbicide + one hand weeding at 30 or 45 DAS. All treatments reduced the density and dry weight of monocot and dicot weeds and increased pod number plant and grain number pod⁻¹. Two hand weeding resulted in high yield (21.63 q ha⁻¹), which was statistically similar to the weed free control (22.50 q ha⁻¹). Pre-emergence fluchloralin at 1.0 kg ha⁻¹ combined with one hand weeding at 30 DAS resulted in a yield of 21.40 q ha⁻¹.

Pre-emergence application of pendimethalin 0.75 kg ha⁻¹ recorded significantly the highest branches plant⁻¹, pods plant⁻¹ and grain yield of field pea and it were at par with pendimethalin 0.50 kg ha⁻¹ + one hand weeding, pendimethalin 1.00 kg ha⁻¹, trifluralin 1.25 kg ha⁻¹ and two hand weeding (Buttar *et al.*, 2008).

Anil kumar *et al.* (2009) reported that maximum values for all the yield attributes were recorded more in plot kept weed free till harvest which resulted in significant improvement in yield over weedy plot upto 60, 90 days after sowing and upto harvest stage of crop.

The significantly higher values of pods plant⁻¹, seeds pod⁻¹, seed yield and test weight was recorded significantly in weed free condition over quizalofop, imazethapyr in field pea and it were at par with pendimethalin 1.0 kg ha⁻¹ (Chaudhary *et al.*, 2009).

Bhooshan and Singh (2014) observed that hand weeding at 25 DAS recorded significantly more number of pods per plant as compared to pendimethalin 1.0 kg ha⁻¹ applied as pre-emergence and weedy check. The HW 25 DAS treatment produced 13.2 and 21.5 % more pods plant⁻¹ over pendimethalin 1.0 kg ha⁻¹ PE and weedy check, respectively.

Shalini and Singh (2014) conducted an experiment to evaluate the efficacy of different herbicides on weed dynamics and seed yield of dwarf fieldpea. Weed control in fieldpea with pendimethalin 1.0 kg ha⁻¹ + imazethapyr 0.05 kg ha⁻¹ (POE, 30 DAS) and pendimethalin 1.0 kg ha⁻¹ (PE) + quizalofop ethyl 0.05 kg ha⁻¹ (POE, 30 DAS) produced 27.8 and 23.3 % more pods plant⁻¹ and 22.8 and 20.5 % more seeds pod⁻¹ as compared to weedy check.

Mathukia *et al.* (2015) revealed that different weed management practices exerted significant influence on growth and yield of field pea. The treatment T₁₁ (weed free) significantly enhanced growth and yield attributes *viz.*, plant height, plant spread, branches plant⁻¹, root nodules plant⁻¹, pods plant⁻¹, seeds pod⁻¹, seed weight plant⁻¹ and 100-seed weight and ultimately increased seed and stover yields, however it was found statistically at par with the treatments T₁₀ (HW and IC at 20 and 40 DAS), T₂ (Pendimethalin 0.75 kg ha⁻¹ as pre-emergence *fb* HW and IC at 30 DAS), T₄ (Oxyfluorfen 0.18 kg ha⁻¹ as pre-emergence *fb* HW and IC at 30 DAS) and T₈ (pendimethalin 0.75 kg ha⁻¹ as pre-emergence *fb* quizalofop 40 g ha⁻¹ as post-emergence at 25 DAS), whereas the treatment T₁₂ (unweeded check) registered significantly the lowest growth and yield of the crop.

According to Rana *et al.* (2015) weed control treatments brought about significant variation in green pod yield. All weed control treatments were significantly superior to weedy check in influencing green pod yield. Each of the herbicide at higher rate was superior to its lower rate in influencing green pod yield. Significantly highest green pod yield was obtained with imazethapyr at 150 g ha⁻¹ (40 DAS) in both the years. Hand weeding twice and imazethapyr at 100 g ha⁻¹ (40 DAS) being statistically similar with each other were the other superior treatments in influencing

green pod yield. All the post-emergent herbicidal treatments except quizalofop at 25 g ha⁻¹ were superior to standard pre-emergent herbicidal check (pendimethalin 1.5 kg ha⁻¹) in influencing green pod yield. Weeds in untreated check reduced pea pod yield by 56.8% over the best post-emergent herbicidal treatment in 2005-06 and 60.1% in 2006-07.

Mainpal Singh *et al.* (2016) in a study conducted for two years found that during both the years, all the yield attributes including number of branches plant⁻¹, pods plant⁻¹ and grains pod were influenced significantly by treatments with different weedy and weed free periods. Yield attributes increased with increase in weed-free duration and decreased with increase in weedy period. The yield attributes were highest in season-long weed-free period and at par with weed-free for initial 40 days or plots kept weedy only for initial 20 days. Yield attributes were adversely affected in plots where weed competition were allowed for longer than initial 20 days. This might be due to the shading effect caused by taller weeds like wild oat which reduced the availability of light for the photosynthesis and resulted in less number of yield attributes under weedy condition (Vasilakoglou and Dhima 2012). Akhter *et al.* (2009) also reported decrease in yield attributes of field pea under the reduced photosynthetically active radiation conditions.

According to patel *et al.* (2016) the fieldpea yield was recorded high in hand weeding twice 20 and 40 days after sowing. Among the herbicidal treatments, Pendimethalin + Imazethapyr @ 1.0 kg ha⁻¹ at pre emergence recorded higher seed yield (3475 kg ha⁻¹). However, this was at par with application of Pendimethalin + Imazethapyr @ 0.75 kg ha⁻¹ at pre emergence (3326 kg ha⁻¹) and Pendimethalin @ 1.0 kg ha⁻¹ as pre emergence (3319 kg ha⁻¹) and hand weeding twice at 20 and 40 DAS also recorded higher vine yield (4386 kg ha⁻¹) due to the weed free environment and less competition provides better growth to crop. Removal of weeds at early stage in the season reduced crop weed competition at the lowest possible limit and provided almost weed free environment. Due to controlling weeds, higher growth and yield parameters of field pea were probable reasons for higher seed yield in hand weeding twice at 20 and 40 days after sowing treatment.

Anil Kumar *et al.* (2016) observed that all weed control treatments were significantly superior to weedy check in influencing yield attributes and yield of peas. Among the treatments, weed free, pendimethalin 1000 g ha⁻¹ fb one HW (45 DAS), imazethapyr + imazamox 90 g ha⁻¹ (45 DAS) and imazethapyr + imazamox 60 g ha⁻¹ (45 DAS) being statistically at par with application of imazethapyr + pendimethalin 1200 g ha⁻¹ applied as pre-emergence and imazethapyr + pendimethalin 1000 g ha⁻¹ fb imazethapyr 100 g ha⁻¹ as post-emergence (45 DAS) resulted in significantly higher pods plant⁻¹. Significantly higher green pod yield was obtained in weed free situation followed by application of pendimethalin 1000 g ha⁻¹ fb one HW (45 DAS) and sequential application of pendimethalin 1000 g ha⁻¹ fb imazethapyr + imazamox 60 g ha⁻¹ (45 DAS) treatments.

Brijbhooshan *et al.* (2017) found that hand weeding done at 25 DAS, which was at par with pendimethalin 1.0 kg/ha recorded significantly higher total nitrogen uptake by field pea over weedy condition. One hand weeding done at 25 DAS produced significantly higher grain yield plant⁻¹ over remaining weed management treatments. The increase in yield under one hand weeding at 25 DAS was to the tune of 12.1 and 30.8 % over pendimethalin 1.0 kg a.i. ha⁻¹ applied as pre-emergence and weedy check, respectively.

2.2.2 Economics

Pendimethalin 0.5 kg ha⁻¹ followed by hand weeding at 45 DAS yielded 168 q ha⁻¹ which was as good as the repeated weeding treatment involving four weeding (171 q ha⁻¹) and gave the maximum additional net returns over the weedy control (40,708 Rs. ha⁻¹) (Pandey *et al.*, 2000).

Govardhan *et al.* (2007) reported that pendimethalin 0.75 kg ha⁻¹, followed by HW at 30 DAS yielded 21.40 q ha⁻¹, this treatment also recorded the maximum values of grain yield and benefit: cost ratio (1.80).

According to Peer *et al.* (2013) Pendimethalin 1.0 kg ha⁻¹ integrated with one hand weeding at 35 DAS (critical period of weed removal) is the most appropriate method for effective weed management and profitable cultivation of soybean.

Kaushik *et al.* (2014) from his results reported that the application of Pendimethalin 0.75 kg ha⁻¹ as pre emergence + 1 hand weeding at 25 DAS resulted in maximum net returns (Rs. 39,726 ha⁻¹).

Patel *et al.* (2016) reported that the benefit cost ratio (4.37) was higher under the treatment of Pendimethalin + Imazethapyr @ 1.0 kg ha⁻¹ at pre emergence and net return (Rs 90,550 ha⁻¹) was higher under the treatment of hand weeding twice at 20 and 40 DAS and followed by application of Pendimethalin + Imazethapyr @ 1.0 kg ha⁻¹ at pre emergence. The lowest BCR ratio was observed in Chlorimuron ethyl @ 4.0 g ha⁻¹ at pre plant incorporation (2.34).

2.3 Effect of pest management Practices on Crop Growth, Yield Attributes, Yield and Economics of Field pea

Dereje and Somsiri (2003) noticed that treating seeds with carbendazim improved seed yield by 13.2% and with iprodione by 12.5% by reducing the incidence of Ascochyta infection over the untreated control. Seed treatment with fungicides could be used as a component of integrated blight management in field pea production.

Among the insecticides treated, imidacloprid gave 100 per cent population reduction at five days after spraying. All other treatments *viz.*, acetamiprid (99.11%), acephate (98.97%), profenophos (98.93%) thiomethoxam (97.35%), NSKE (97.35%), endosulfan (96.95%) alphasmethrin (96.77%), and neem oil (91.41%) were found to be statistically at par with each other in managing this pest. (Harendra Singh and Saravanan, 2008).

According to Parihar *et al.* (2016). Seed treatment with fungicides (Carbendazim @ 2.5g kg⁻¹ seeds) is feasible and protects the seedlings from infection and ensures better plant stand.

The insecticides were found to be significantly superior over the control in managing the pest population. The order of efficacy was dimethoate > cypermethrin > chlorpyrifos > imidacloprid > acephate > endosulfan > emamectin benzoate >

control. Dimethoate (0.06%) gave lowest percent larval population after spraying. (Deepti, 2016)

Sharma *et al.* (2016) carried out Field experiments to evaluate the performance of four IPM modules against leaf miner and diseases like root rot/wilt and Ascochyta blight in Kullu valley of Himachal Pradesh during Rabi 2010-11 and 2011-12. The findings of two years experiments revealed that the IPM module (M₃) consisting of seed treatment by seed soaking in streptomycin @ 200 ppm followed by seed treatment with carbendazim (Bavistin 50 WP) @ 2.5g Kg⁻¹ seed succeeded by two foliar sprays with a mixture of lambda-cyhalothrin 5EC @ 0.8ml/L(0.04%) and carbendazim @ 0.1% (Bavistin 50 WP) at the 50% flowering of the crop (3.5 months of sowing, 3 week of March) and by the 2 spray of mixture of acetamiprid @ 0.005% (Polar 25 SP) and triadimefon @ 0.05% (Bayleton 2%) after 15 days of the first spray, was found to be most effective in minimizing the leaf infestation by leaf miner and root rot/wilt incidence with 85.1% and 98.2% reduction over control, respectively. It was also found that with these module the most economic resulting in highest mean marketable pod yield (138.6 q ha⁻¹) during the two years and maximum net returns of 21.7 per rupee spent. However, for the control of Ascochyta blight, module M₁ was found to be the most effective in minimizing the disease incidence with 68.8% reduction over the control.



MATERIALS AND METHODS

A field experiment was conducted entitled “**Effect of nutrient, weed and pest management practices on productivity of field pea [*Pisum sativum var. arvense*]**” during *rabi* season of 2015-16 at the Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The details of materials used and the techniques adopted during the course of study are presented briefly in this chapter.

3.1 Experimental Site

The experiment was conducted at the Agriculture Research farm of the Institute of Agricultural Sciences, Banaras Hindu University situated in the South-eastern part of Varanasi city at a distance of about 10 km from Varanasi cant railway station. Geographically, experimental site falls under sub-tropical zone of Indo-Gangetic plains and lies on the left bank of river Ganga. It is located on 25°18' N latitude, 83°03' E longitude and at an altitude of 77 meters above mean sea level. The predominant soil in the experimental field was homogenous in fertility having assured irrigation and other required facilities.

3.2 Climate and Weather

Varanasi is situated in the eastern part of U.P. experiences a sub-tropical climate, characterized by hot summer and cool winters. The region has a tropical moist sub-humid climate, characterized by strong seasonality with respect to temperature and precipitation. The year is divisible into a warm rainy season (July–September), a cool winter (November–February), and a hot summer (April–June). The normal period for the onset of monsoon in this region is the third week of June and which last upto the end of September or sometimes extends to the first week of October. However occasionally showers are also occur during winter. The summer is dry and hot with temperatures ranging between 35 and 45°C during the day. Warm

conditions (25–35°C) and high relative humidity (70–91%) prevail during the rainy season.

A standard week wise data on meteorological parameters were obtained from the meteorological observatory at the Agricultural Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi are presented in Table 3.1 and depicted in fig. 3.1.

Table 3.1: Mean standard Weekly meteorological parameters during crop season, (2015 to 2016)

Week No.	Month & Date	Rainfall mm	Temperature °C		R.H. %		Wind Speed km hr ⁻¹	Sunshine hours	Evaporation mm
			Max	Min	Max	Min			
45	Nov 05-11	0.0	30.6	18.6	89	49	0.8	5.7	2.6
46	12-18	0.0	30.4	16.6	89	40	1.8	7.6	2.5
47	19-25	0.0	28.7	16.2	90	49	0.7	4.4	1.4
48	26-02	0.0	28.4	17.2	86	53	1.1	4.3	2.1
49	Dec 03-09	0.8	24.6	14.8	93	62	1.0	2.2	1.4
50	10-16	0.0	22.7	11.4	92	56	2.6	3.7	1.5
51	17-23	0.0	22.0	8.2	91	43	1.5	3.8	1.4
52	24-31	0.0	22.8	8.0	82	37	2.5	5.4	1.6
1	Jan 1-7	0.0	24.3	9.6	94	47	4.2	2.5	1.2
2	8-14	0.0	25.0	10.7	85	45	1.9	5.9	1.7
3	15-21	7.7	19.0	11.0	94	69	1.9	0.6	0.9
4	22-28	0.0	21.7	7.2	85	43	2.0	5.2	1.6
5	29-04	0.0	24.7	11.9	79	50	2.0	6.5	2.1
6	Feb 05-11	0.0	24.5	9.6	83	52	2.3	6.3	2.2
7	12-18	2.4	27.1	13.5	85	57	1.7	6.3	2.2
8	19-25	0.0	28.6	14.9	77	44	4.0	8.5	3.6
9	26-03	0.0	29.9	16.2	85	51	1.4	6.4	2.7
10	Mar 04-10	19.2	30.9	17.9	77	46	2.4	7.6	3.3
11	1-17	16.2	28.9	16.6	73	51	3.5	6.4	3.6
12	18-24	0.0	33.6	17.3	61	26	3.8	9.6	4.6
13	25-31	0.0	35.5	18.4	58	34	2.0	9.0	4.6
14	April 01-07	0.0	38.3	23.1	63	26	3.5	7.9	5.9
15	08-14	0.0	39.2	22.3	42	19	5.0	8.4	7.9
16	15-21	0.0	41.4	23.9	35	22	4.3	8.7	8.4

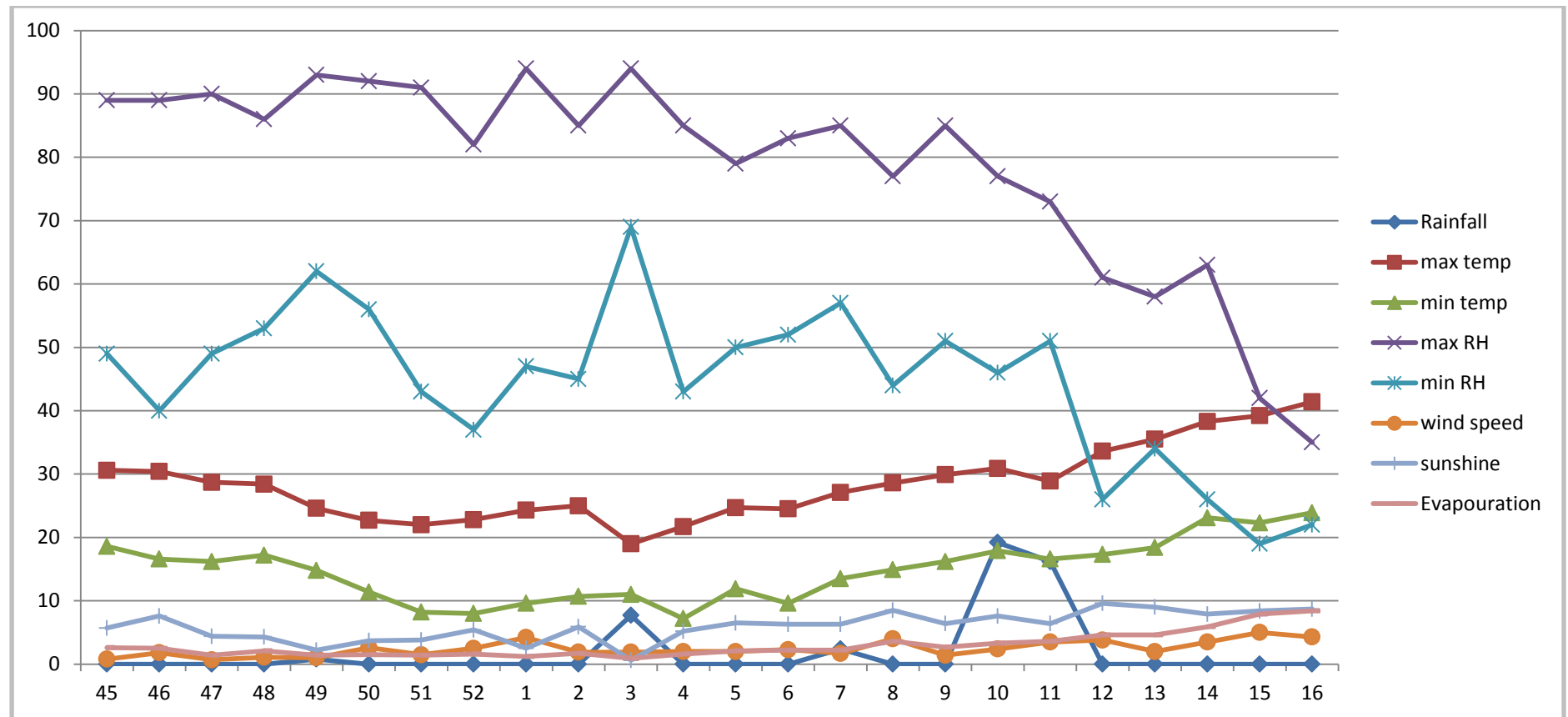


Fig. 3.1: Mean standard week-wise meteorological parameters during crop season (Nov 2015-Apr 2016)

The details of different meteorological parameters are given below:

3.2.1 Temperature (°C)

The weekly mean monthly maximum and minimum temperature during the experimental period ranged from 19.0 to 41.4°C and 7.2 to 23.9°C respectively. The maximum temperature was recorded 41.4⁰C in 16th standard week in the month of April and minimum temperature 7.2⁰C in the 4th standard week of January month in 2016.

3.2.2 Rainfall (mm)

The total rainfall during the period of investigation in the year 2015-2016 (19 Nov, 2015 to 15 April, 2016) was 46.3 mm. Maximum amount of rainfall i.e., 19.2 mm was recorded during the month of March in the experimental period.

3.2.3 Relative humidity (%)

The mean monthly maximum relative humidity varied from 35 to 94 percent and mean monthly minimum relative humidity varied from 19 to 62 percent during the period of experimentation.

3.2.4 Sunshine duration (hours)

The average duration of 5.57 hrs. of bright sunshine was recorded. The maximum and minimum monthly bright sunshine duration ranged between 9.6 and 0.6 hrs. respectively during the period of investigation.

3.2.5 Evaporation (mm)

The evaporation data recorded from United States Weather Bureau Class A open Pan Evaporimeter revealed that the monthly evaporation ranged from 0.9 to 8.4 mm day⁻¹ during the crop period.

3.3 Soil properties and nutrient analysis

Soil samples were collected before sowing of the crop randomly from the proposed plot. The soil samples were analysed for available nitrogen, phosphorus and potassium (Table 3.2).

Table 3.2: Mechanical and physico-chemical properties of soil of the experimental field

Soil Particular	Values	Method employed	Reference
Mechanical analysis			
Sand (%)	51.63	Hydrometer method	Bouyoucos (1962)
Silt (%)	26.92		
Clay (%)	20.34		
Textural class	Sandy loam	Textural triangle	Black <i>et al.</i> (1965)
Physical constant			
Bulk density (g cm ⁻³)	1.45		
Chemical Analyses			
i) Soil reaction (pH)	7.5	Glass electrode pH meter (1:2.5 soil and water suspension)	Jackson (1973)
ii) Electrical conductivity (dSm ⁻¹ at 25°C)	0.2	Sytronics electrical conductivity meter	Jackson (1973)
iii) Organic carbon (%)	0.32 %	Wet digestion Method, 1934	Walkley and black (1934)
iv) Available N (kg ha ⁻¹)	248.0 kg ha ⁻¹	Alkaline permanganate method	Subbiah and Asija (1956)
v) Available P ₂ O ₅ (kg ha ⁻¹)	14.38 kg ha ⁻¹	0.5 N NaHCO ₃ extractable	Olsen <i>et al.</i> (1954)
vi) Available K ₂ O (kg ha ⁻¹)	125.37 Kg ha ⁻¹	Ammonium acetate extractable flame photometer	Jackson (1973)

The alluvial soils of Indo-Gangetic plains in general are deep, flat, well drained with low available nitrogen and medium in available phosphorus and potassium. A composite soil sample was drawn randomly from the experimental area before sowing to a depth of 30cm. The soil was analyzed for physical and chemical properties. The soil textural class of the experimental site was sandy loam. Also soil was slightly alkaline (pH= 7.5), low in organic carbon status (0.32%), low in available nitrogen (248.0 kg ha⁻¹), medium in available phosphorus (14.38 kg ha⁻¹) and medium in available potassium (125.37 kg ha⁻¹). The values obtained along with the method of determination are given in Table 3.2. It is evident from the table that the soil of the experimental field is sandy loam in texture, slightly alkaline in reaction, low in nitrogen and medium in available phosphorus and potassium.

3.4 Cropping history

The production potential of the experimental field can be judged from the cropping history, the details of cropping history of the experimental field for past five years have been presented in Table 3.3:

Table 3.3: Cropping history of the experimental field

Year	Season	
	<i>Kharif</i>	<i>Rabi</i>
2011-2012	Summer mungbean	Field pea
2012-2013	Summer mungbean	Field pea
2013-2014	Summer mungbean	Field pea
2014-2015	Summer mungbean	Field pea
2015-2016	Summer mungbean	Field pea

It is quite apparent from the cropping history of the experiment site that the field has been continuously under pulse cropping sequence and its fertility set up has not been disturbed. Hence, as such the field is ideally suited for the experiment.

3.5 Experimental details

3.5.1 Experimental design and layout

The experiment was laid out in Randomized Block Design with factorial concept with three replications and 8 treatments ; Control (**T₁**); INM -RDF + Rhizobium + PSB (**T₂**); IWM -Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS(**T₃**); IPM-Seed treatment with fungicide (Bavistin) +disease and pest management as and when required (**T₄**); INM +IWM(**T₅**); INM +IPM(**T₆**); IWM +IPM(**T₇**); INM+ IWM +IPM(**T₈**)..The gross plot size was 3 m x 4 m=12 m². The whole field was divided into three blocks representing a replication and each replication consist of eight treatments of different combinations allocated randomly.

3.5.2 Details of layout

The detailed description of layout of the field in order to facilitate their reference in text is given in table

Table 3.4: Layout plan

Experimental design	Randomised complete block design
Treatment	8
Replications	3
Total no. Of plots	24
Block border	1m
Plot border	0.5m
Irrigation channel	1m
Gross plot size	3m x4m
Net plot size	2.4m x 3m
Spacing	30 x 10 cm

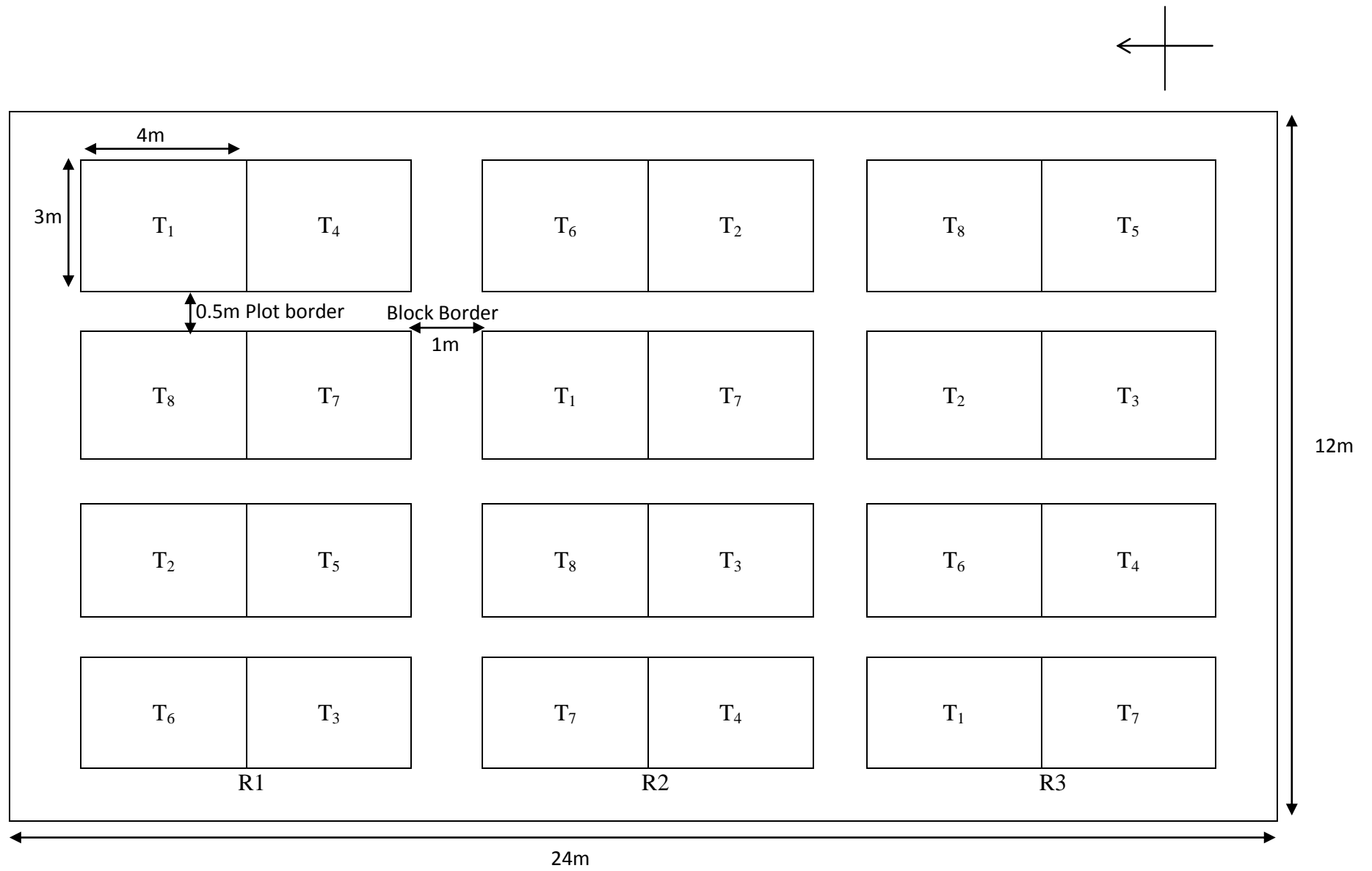


Fig. 3.2 Layout of Experimental plot

3.5.3 Treatments details:

The details of the treatments with corresponding symbols in order to facilitate their reference in the text is given in table 3.5

Table 3.5: Details of treatments

Treatments	Symbol
Control	T ₁ (C)
INM (RDF + Rhizobium + PSB)	T ₂ (INM)
IWM (Pendimethalin 1.0 kg ha ⁻¹ +1 hand weeding at 30 DAS)	T ₃ (IWM)
IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	T ₄ (IPM)
INM +IWM	T ₅ (INM +IWM)
INM +IPM	T ₆ (INM +IPM)
IWM +IPM	T ₇ (IWM +IPM)
INM + IWM + IPM	T ₈ (INM + IWM + IPM)

3.6.1 Description of variety used

HUDP-15 (Malaviya matar)

Cultivar HUDP-15 (Hindu University Dwarf pea-15) was developed at the Banaras Hindu University Varanasi in the year 1999. The colour of the seed is yellow with a maturity period of 125-130 days. The yield potential of the variety is about 30-35q ha⁻¹.

3.6.2 Source of Nutrients

Table 3.6: Source of nutrients

Elements	Source of fertilizer
Nitrogen	Di ammonium phosphate (DAP)
Phosphorus	Di ammonium phosphate (DAP)
Potassium	Muriate of potash (MOP)
Sulphur	Zinc sulphate (Znso4)

1. DAP

Diammonium phosphate (DAP) is the world's most widely used phosphorus (P) fertilizer. It is popular because of its relatively high nutrient content and its excellent physical properties and is produced by reacting calcium nitrate with mono-calcium phosphate and finally to di-ammonium phosphate. The average pH in solution is 7.5–8. The typical formulation is 18-46-0 (18% N, 46% P₂O₅, 0% K₂O).

2. MOP

Potassium chloride (commonly referred to as Muriate of Potash or MOP) is the most commonly used and cost-effective source of potassium in agriculture accounting for about 95% of all potash fertilisers used worldwide. Muriate of Potash (potassium chloride), 0-0-60-0-0, typically contains 60% potash. Its is highly soluble and can be easily mixed with other fertilizers.

3. Znso₄

Zinc sulfate is the most commonly used source of zinc in granular fertilizers because of its high solubility in water and its relatively low cost of production.

3.7 Field preparation and cultural operations

Details of field operation carried out for field pea during the period of investigation are summarized below and calendar of field operations are given in Table 3.7

Table 3.7: Schedule of field operations carried out during experiment

Operations	Date
1. Ploughing by cultivator	15/11/2015
2. Land preparation.	18/11/2015
3. Experimental layout	18/11/2015
4. Fertilizer application	19/11/2015
5. Allocation of treatment	19/11/2015
6. Sowing	19/11/2015
7. Thining	27/12/2015
8. Weeding (at 30 DAS)	27/12/2015
9. Harvesting	20/4/2016

3.7.1 Land preparation

The experimental field was ploughed by tractor drawn disc plough followed by cultivator and planking to provide good tilth. The gross experimental area was demarcated for the layout of the experiment and the plots were laid out as in the Fig. 3.2.

3.7.2 Seed treatment

Seed treatment is done with fungicide (Bavistin) and *Rhizobium leguminoceram*+*PSB* as per standard procedure and sown after drying. Seed is cleaned without any physical impurities like weed seeds, trash and other crop seeds.

3.7.3 Manures and fertilizer application

The application of recommended dose of nitrogen, phosphorus and potassium were given through DAP, Muriate of Potash (MOP) and sulphur at sowing time. Recommended dose of Fertilizer was @ 20-17-16-20 kg ha⁻¹ N, P, K and Znso₄ in furrows at the time of sowing.

3.7.4 Seed rate and sowing

Cleaned seed is used @ 120 kg ha⁻¹, in the furrows opened with help of spade at about 5 cm depth.

3.7.5 Weeding

The period from 30 to 60 days after sowing is most critical for competition with weeds. Weeding done manually at 30 days after sowing (DAS) as per the management practices.

3.7.6 Irrigation

Supplemental irrigations (5cm. each) were given two times at the time of pre flowering and grain filling stage.

3.7.7 Harvesting and threshing

The crop was harvested when the pod turned yellow and the grains were fully ripened. At the time of harvesting, at first, the border rows were harvested around the individual plots leaving only net plot. The crop from net plots was harvested, bundled separately and tagged.

3.8 Biometric observation of field pea

For recording biometric observations plant sample were taken at 30, 60, 90 DAS and at maturity. Five plants from each plot excluding sample and from border rows were selected randomly and tagged to be used for recording different growth characters and yield attributes and yield. However, for the dry matter accumulation, five plants were randomly selected from the sample rows (border plot area) at regular interval. Yield attributes and yield were studied after harvesting of the crops.

3.8.1 Growth components in field pea

3.8.1.1 Plant height (cm):

The heights of 5 randomly selected plants were measured at 30, 60 and 90 days after sowing (DAS) and at harvesting, plant height was measured from ground

level to tip of the plant. The average values were computed and expressed in centimetre (cm).

3.8.1.2 Number of branches plant⁻¹

The total number of branches was counted from the five tagged plants of each plot at 30, 60 and 90 DAS. The average number of branches per plant was worked out.

3.8.1.3 Dry matter accumulation plant⁻¹ (g)

Five plants from each plot were select randomly from sample row and cut from ground level at 30 DAS, 60DAS, 90DAS and at harvest. The plant samples (leaf + stem) were air dried firstly followed by oven at 70⁰ C for about 24 hours or more until a constant weight was obtained and then weighed and averaged for one plant.

3.8.2 Yield attributes of field pea

3.8.2.1 Number of pods plant⁻¹:

Five plants were selected at randomly from each plot at harvest and number of pods plant⁻¹ counted and expressed as average number of pods plant⁻¹.

3.8.2.2 Number of grains pod⁻¹:

Ten pods plant⁻¹ were collected from five sample plant from each treatment and were threshed, cleaned and the total numbers of seeds were counted. Average number of seeds pod⁻¹ was worked out.

3.8.2.3 100-seed weight (g)

A random sample of seeds was collected from the produce of each net plot, 100-seeds were counted and then weighed with the help of electronic weighing machine to get the seed weight. The weight was expressed in gram (g).

3.8.3 Yield of field pea crop

3.8.3.1 Grain yield (kg ha⁻¹):

Grain yield was recorded after threshing, winnowing, cleaning and drying. The produce of each net plot was threshed separately and weighed plot wise to work out seed yield. Then obtained values were converted into kg ha⁻¹.

3.8.3.2 Stalk yield (kg ha⁻¹):

It was calculated by subtracting the grain yield from the biological yield recorded per net plot and later on converted in kg ha⁻¹.

3.8.3.3 Harvest Index (%):

It is the economic yield expressed as percentage of biological yield and calculated as follows. It is expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.8.4 Weed control efficiency

Weed control efficiency was calculated at 30, 60 and 90 DAS using the formula (USDA/ICAR AICRPWC, 1988).

$$\text{DCM} = \frac{\text{DMC} - \text{DMT}}{\text{DMC}} \times 100$$

Where, DMC= dry matter production of weeds per unit area in unweeded check

DMT= dry matter production of weeds per unit area in the treatment to be compared

WCE= expressed in percentage

3.8.5 Quality (grain) analysis :

At harvest, the grain samples were collected from each plot for chemical estimation and the samples were dried in an oven at 70°C for 48 hours and then grain

material thus obtained was ground with the help of grinder and passed through 40 mesh sieve and preserved separately for determination of N, P and K content. The nutrient content was then estimated as per following methods.

3.8 Methods of plant chemical analysis

Analysis	Analytical Method	Reference
Total N	Micro Kjeldahl method	Jackson (1973)
Total P	Vanadomolybdo phosphoric acid yellow colour method	Jackson (1973)
Total K	Flame photometer method	Jackson (1973)

3.8.5.1 Nutrient content

3.8.5.1.1 Nitrogen estimation

The grain sample were analyzed separately for N content by Micro Kjeldhal method as described by Jackson, 1973 and the results were expressed on percent dry weight basis of the sample.

3.8.5.1.2 Phosphorous estimation

Phosphorous content (%) in grain was estimated by vanadomolybdo-phosphoric acid yellow colour method followed by spectrophotometric determination (Jackson, 1973). Total phosphorus content of grain and straw was multiplied by the respective dry matter yield to get the total phosphorus uptake (kg ha^{-1}) by plant materials.

3.8.5.1.3 Potassium estimation

The estimation of potassium content (%) in grain sample was done by adopting Flame photometer method (Jackson, 1973). Potassium content in grain and straw were multiplied by their respective dry matter yield to obtain total potassium uptake (kg ha^{-1}) by plant materials.

3.8.5.1.4 Protein content (%) and protein yield

Protein content in grain was obtained by multiplying the nitrogen content in grain with factor 6.25 (A.O.A.C., 1995). The protein yield (kg ha⁻¹) was obtained by the following formula:

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Protein content (\%)} \times \text{yield (kg ha}^{-1}\text{)}}{100}$$

3.8.5.2 Nutrient uptake

Nutrient uptake (N, P and K) by grain, stalk and total (grain + stalk) were calculated in kg ha⁻¹ from their corresponding yield and nutrient content by using formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{yield (kg ha}^{-1}\text{)}}{100}$$

3.9 Economics

The economics of different treatments was worked out by taking into consideration of all the expenses incurred. The cost of input and price of produce prevalent at the Agricultural Research Farm, Banaras Hindu University were taken into considerations for calculating economics of different treatments and expressed as net return and benefit cost ratio (B:C).

3.9.1 Gross returns (₹ ha⁻¹)

Gross returns was worked out by multiplying grain and straw yield with their prevailing market prices and expressed in ₹ ha⁻¹.

3.9.2 Net returns (₹ha⁻¹)

The net return was calculated as follows:

$$\text{Net returns (₹ha}^{-1}\text{)} = \text{Gross returns (₹ha}^{-1}\text{)} - \text{cost of cultivation (₹ha}^{-1}\text{)}$$

3.9.3 Benefit: cost ratio

The benefit: cost ratio was calculated as follows:

$$\text{Benefit: cost ratio (BCR)} = \text{Net returns (₹ha}^{-1}\text{)} / \text{cost of cultivation (₹ha}^{-1}\text{)}$$

3.10 Statistical analysis:

The observations recorded during the course of investigation were tabulated and analyzed statistically to draw a valid conclusion. The data were analyzed as per the standard procedure for “Analysis of Variance” (ANOVA) as described by Gomez and Gomez (1984). The significance of treatments was tested by ‘F’ test (Variance ratio). Standard error of mean was computed in all cases. The difference in the treatment mean were tested by using Critical Difference (CD) at 5% level of probability where ‘F’ test showed significant differences among means by the following formula:

$$\text{SEm} \pm = \frac{\sqrt{\text{ErrorMSS}}}{N}$$

Where ,

$$N = \frac{\text{Number of experimental unit}}{\text{Number of factor involved}}$$

$$\text{CD} = \sqrt{\frac{2 \times \text{error sum of square}}{N}} \times t(\text{error d.f. 5\%})$$

3.11 ANOVA Table

Source of variance	Degree of freedom	Sum of squares	Mean of squares	Cal. F Value	Tab.F Value
Replication	2				
Treatment	7				
Error	14				
Total	23				

The results have been presented in the tabular form and depicted in figure wherever necessary.



EXPERIMENTAL FINDINGS

The present investigation entitled “**Effect of nutrient, weed and pest management practices on productivity of field pea [*Pisum sativum var. arvense*]**” was conducted during *rabi* season of 2015-16 at the Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. In this chapter, an attempt has been made to assess degree of variation exhibited by the field pea crop at successive stages of growth and development due to the relative influence of different management practices. The observations pertaining to growth, yield attributes, yield and nutrient uptake of field pea recorded during the course of investigation were statistically analysed and significance of results verified and presented in this chapter with the help of tables and graphs whenever required.

4.1 Growth parameters

4.1.1 Plant height (cm)

The height of the plant is usually taken as convenient measure of plant vigour. Data on plant height recorded at 30, 60, 90 DAS and at harvest stages of field pea as influenced by different treatments are presented in Table 4.1 and Fig. 4.1. In general plant height increased with the advancement of crop growth and a rate of increase was recorded in the earlier stages of growth and thereafter, it slowed down. The maximum increase in plant height was recorded during 30 to 60 DAS.

Among the different treatments of experiment the maximum plant height was recorded significantly in the treatment consist of RDF + Rhizobium + PSB+ Pendimethalin 1.0 kg ha⁻¹ +1 hand weeding at 30 DAS+ Seed treatment with fungicide (Bavistin) +disease and pest management as and when required (INM + IWM + IPM) which was found statistically at a par with INM+IWM and significantly superior over other treatments. The lower plant height was recorded in control.

Table 4.1: Effect of nutrient, weed and pest management practices on Plant height (cm) at various growth stages of field pea

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T ₁ . Control	13.46	36.52	55.05	61.70
T ₂ . INM (RDF + <i>Rhizobium</i> + PSB)	14.40	39.68	63.68	69.47
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	14.38	38.16	59.07	69.45
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	13.49	37.22	58.02	66.26
T ₅ . INM +IWM	15.52	43.15	67.41	71.30
T ₆ . INM +IPM	14.87	40.43	64.19	70.54
T ₇ . IWM +IPM	14.55	40.24	63.95	70.45
T ₈ . INM + IWM + IPM	15.57	43.26	67.97	75.70
SEm ±	0.02	0.14	0.68	1.43
C.D. 5%	0.05	0.43	2.06	4.34

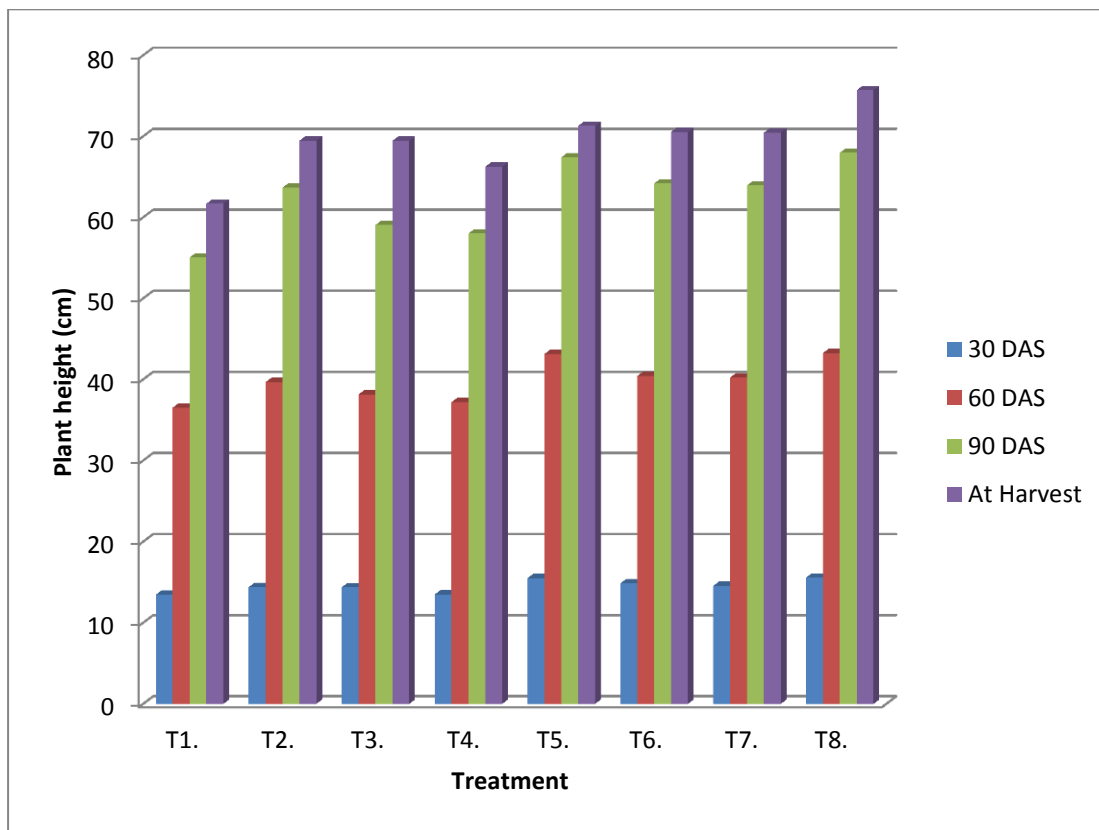


Fig. 4.1 Effect of nutrient, weed and pest management practices on Plant height (cm) at various growth stages of field pea

4.1.2 Number of branches plant⁻¹

The data on number of branches were recorded as influenced by management practices are presented in Table 4.2. Perusal of the data indicated that the number of branches per plant continue to increased, in general 30, 60, 90 DAS.

Among the different management practices significantly the highest branches plant⁻¹ was recorded in INM+IWM+IPM which was found statistically at par with INM+IWM. The lowest number of branches plant⁻¹ was recorded in the control.

4.1.3 Dry matter accumulation (g m⁻²)

The data recorded to dry matter production as influenced by various management practices are presented in Table 4.3 and Fig. 4.2. The results revealed that there was a gradual increase in the dry matter production plant with advancement in the age of the crop till harvest in all the treatments.

Data on dry matter production plant⁻¹ showed that there was a significant difference in dry matter production plant⁻¹ due to various management practices at all the stages of observation .It was revealed that significantly the highest dry matter production was recorded with treatment INM + IWM+ IPM was recorded maximum dry matter production followed by INM + IWM and INM + IPM at all the growth stages. Significantly the lowest dry matter production per plant was registered with control.

4.2 Yield and yield attributes

Data pertaining to yield attributes like number of pods plant⁻¹, number of seeds pod⁻¹, seed weight plant⁻¹ and 100- seed weight, grain yield (kg ha⁻¹), straw yield (kg ha⁻¹) and harvest index are presented in tables.(4.4, 4.5, 4.6, 4.7, 4.8, 4.9).

4.2.1 Number of pods plant⁻¹

The data pertaining to number of pods plant⁻¹ as influenced by different management practices are presented in Table 4.4.

Table 4.2. Effect of nutrient, weed and pest management practices on No. of branches plant⁻¹ at various growth stages of field pea

Treatments	30 DAS	60 DAS	90 DAS
T ₁ . Control	1.83	3.89	4.10
T ₂ . INM (RDF + Rhizobium + PSB)	2.15	4.55	4.51
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	2.07	4.07	4.32
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	1.89	3.90	4.14
T ₅ . INM +IWM	2.42	4.80	5.43
T ₆ . INM +IPM	2.30	4.75	4.81
T ₇ . IWM +IPM	2.20	4.66	4.76
T ₈ . INM + IWM + IPM	2.52	4.82	5.48
SEm ±	0.07	0.01	0.07
C.D. 5%	0.21	0.03	0.20

Table 4.3. Effect of nutrient, weed and pest management practices on dry matter production plant⁻¹ (g) at various growth stages of field pea

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T ₁ . Control	1.27	2.46	10.01	18.61
T ₂ . INM (RDF + Rhizobium + PSB)	1.53	2.78	13.15	23.26
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	1.50	2.54	11.97	22.97
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	1.35	2.49	10.86	18.96
T ₅ . INM +IWM	1.71	3.24	14.51	26.55
T ₆ . INM +IPM	1.69	2.91	14.05	26.09
T ₇ . IWM +IPM	1.65	2.87	13.75	24.95
T ₈ . INM + IWM + IPM	1.74	3.37	14.70	26.92
SEm ±	0.01	0.06	0.03	0.57
C.D. 5%	0.04	0.18	0.08	1.73

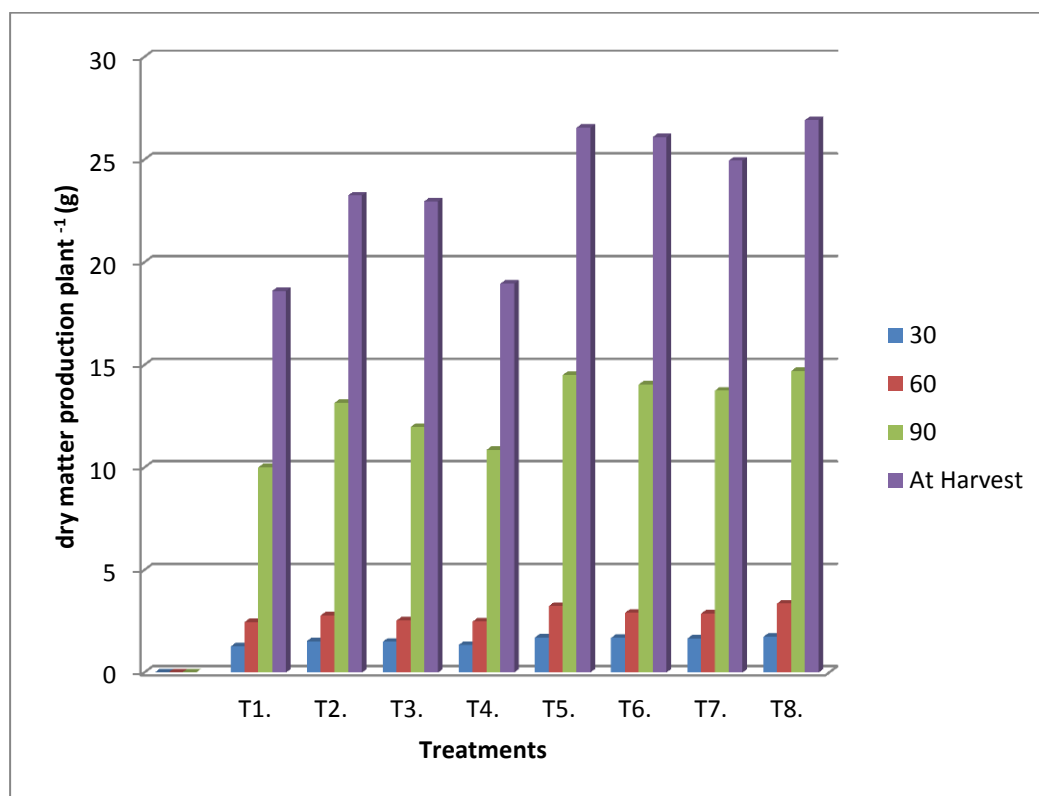


Fig. 4.2 Effect of nutrient, weed and pest management practices on dry matter production plant⁻¹ (g) at various growth stages of field pea

Table 4.4. Effect of nutrient, weed and pest management practices on no. of pods plant⁻¹ of fieldpea

Treatment	No. of pods plant⁻¹
T ₁ . Control	10.93
T ₂ . INM (RDF + Rhizobium + PSB)	12.73
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	12.10
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	11.93
T ₅ . INM +IWM	15.67
T ₆ . INM +IPM	14.57
T ₇ . IWM +IPM	13.60
T ₈ . INM + IWM + IPM	16.17
SEm ±	0.38
C.D. 5%	1.16

Among the different treatments maximum number of pods produced with the INM+IWM+IPM which was at par with the INM+IWM treatment. The lowest number of pods was recorded lowest in control.

4.2.2 Number of seeds pod⁻¹

The data recorded on number of seeds pod⁻¹ as influenced by nutrient, weed and pest management practices are given in table 4.5.

Among the different management practices data revealed that practices of INM + IWM + IPM significantly increased the number of grains pod⁻¹ and was found at par with INM + IWM. The management practices of INM + IWM and INM + IPM were recorded at par to each other. The lowest grain pod-1 found in control.

4.2.4 Test weight (g)

The data recorded on 100 seed weight as influenced by different treatments are presented in Table 4.6 and Fig. 4.3.

Among the different management practices maximum 100-seed weight recorded with INM+IWM+IPM than other treatments. The minimum 100-seed weight recorded in the control.

4.2.5 Grain yield (kg ha⁻¹)

The influence of different management practices on grain yield of field of pea are presented in Table 4.7 and Fig. 4.4.

The data revealed that, all the treatments influenced the grain yield. Among the treatment the maximum grain yield(1516.7 kg ha⁻¹) was recorded in combined management practices i.e. INM+IWM+IPM which was found statistically at par with INM+IWM superior over other treatments. The minimum grain yield was recorded with control.

4.2.6 Stalk yield (kg ha⁻¹)

The data on stalk yield of field pea as influenced by nutrient, weed and pest management practices are presented in table 4.8.

From the results it was revealed that straw yield was significantly influenced by the different management practices. Significantly maximum stalk yield produced with INM+IWM+IPM practices. The minimum stalk yield obtained with control.

4.2.7 Harvest index

The data on harvest index of fieldpea as influenced by nutrient, weed and pest management practices are presented in table 4.9. The maximum harvest index was recorded with INM + IWM + IPM treatment and which were found higher over all other treatments. Minimum harvest index recorded with control treatment.

4.3 Nutrient study

4.3.1 Nitrogen content (%) and its uptake (kg ha⁻¹) by crop

Data pertaining to nitrogen content (%) in grain, its uptake (kg ha⁻¹) of field pea influenced by nutrient, weed and pest management practices were presented in Table 4.10 and Fig. 4.5.

4.3.1.1 Nitrogen content (%) in grain and its uptake (kg ha⁻¹):

The nitrogen content (%) in grain and its uptake (kg ha⁻¹) were presented in Table 4.10 and Fig. 4.5 data revealed significant variation on different treatments in qualitative attributes of grain due to various management practices individually and combined.

All the treatments differ significantly to each other. The maximum nitrogen content and uptake were observed with INM + IWM + IPM practices followed by INM + IWM. The minimum nitrogen content and uptake were observed in control.

4.3.2 Phosphorus content (%) and its uptake (kg ha⁻¹) by crop

Data on phosphorus content (%) in grain, its uptake (kg ha⁻¹) were presented in Table 4.11.

4.3.2.1 Phosphorus content (%) in grain and its uptake (kg ha⁻¹)

Data on phosphorus content (%) in grain and its uptake (kg ha) shown in Table 4.11. All the treatments differ significantly to each other. The maximum phosphorous content and uptake were observed with INM + IWM + IPM followed by INM+IWM. The minimum phosphorous content and uptake were observed in control.

4.3.3 Potassium content (%) and its uptake (kg ha⁻¹) by crop

Potassium content (%) in grain and its uptake (kg h a⁻¹) are shown in Table 4.12.

4.3.3.1 Potassium content (%) in grain and its uptake (kg ha⁻¹)

Data on potassium content (%) in grain and its uptake (kg/ha) presented in Table 4.12.

All the treatments differ significantly to each other. The highest potassium content and uptake were recorded with application of integration of management practices *i.e* INM + IWM + IPM. Minimum removal of potassium by grain was recorded under control treatment.

4.4 Qualitative attributes

4.4.1 Protein content (%) and Yield (kg ha⁻¹)

The data on protein content (%) in grain are shown in Table 4.13 and Fig. 4.6

4.4.1.1 Protein content (%) in grain

The careful screening of the data revealed marked variation in the protein content of field pea grain. All the treatments differ significantly to each other. Maximum protein content (22.75 %) was noticed with the INM+IWM+IPM practices

applied followed by INM+IWM which was significantly superior over pest management practices and control. The minimum protein content (18.18 %) and yield (157.20 kg ha⁻¹) were observed in control.

4.5 Weed control efficiency

The data on weed control efficiency is shown in Table.4.14. Weed population and dry weight of weed at 60 DAS showed that maximum population and dry weight of weeds associated with control and minimum in weed management practices followed by NM+IPM. In case of WCE higher in WM followed NM+WM and minimum in NM followed by NM+IPM practices.

4.6 Economics

The data on economics of field pea cultivation under are given in Table 4.15. All the treatments differ significantly to each other. The gross return (91,002 Rs. ha⁻¹), net return (60,432 Rs. ha⁻¹) and benefit cost ratio (1.97) were observed highest with INM+IWM+IPM practice followed by INM+IWM practice whereas minimum gross return (51,882 Rs. ha⁻¹), net return (26,032 Rs. ha⁻¹) and benefit –cost ratio (1.00) were observed in control followed by individual pest management practices.

Table 4.5. Effect of nutrient, weed and pest management practices on No. of grains pod⁻¹ of field pea

Treatment	No. of grains pod⁻¹
T ₁ . Control	4.0
T ₂ . INM (RDF + Rhizobium + PSB)	4.3
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	4.2
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	4.0
T ₅ . INM +IWM	5.1
T ₆ . INM +IPM	4.9
T ₇ . IWM +IPM	4.8
T ₈ . INM + IWM + IPM	5.4
SEm ±	0.09
C.D. 5%	0.26

Table 4.6. Effect of nutrient, weed and pest management practices on 100 seed wt (g) of field pea

Treatment	100 seed wt (g)
T ₁ . Control	15.09
T ₂ . INM (RDF + Rhizobium + PSB)	16.16
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	16.08
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	16.00
T ₅ . INM +IWM	16.77
T ₆ . INM +IPM	16.58
T ₇ . IWM +IPM	16.40
T ₈ . INM + IWM + IPM	16.91
SEm ±	0.05
C.D. 5%	0.16

Table 4.7. Effect of nutrient, weed and pest management practices on grain yield (kg ha⁻¹) of fieldpea

Treatment	Grain yield (kg ha⁻¹)
T ₁ . Control	864.7
T ₂ . INM (RDF + Rhizobium + PSB)	979.3
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	951.6
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	916.7
T ₅ . INM +IWM	1322.1
T ₆ . INM +IPM	1140.0
T ₇ . IWM +IPM	1035.2
T ₈ . INM + IWM + IPM	1516.7
SEm ±	62.89
C.D. 5%	190.71

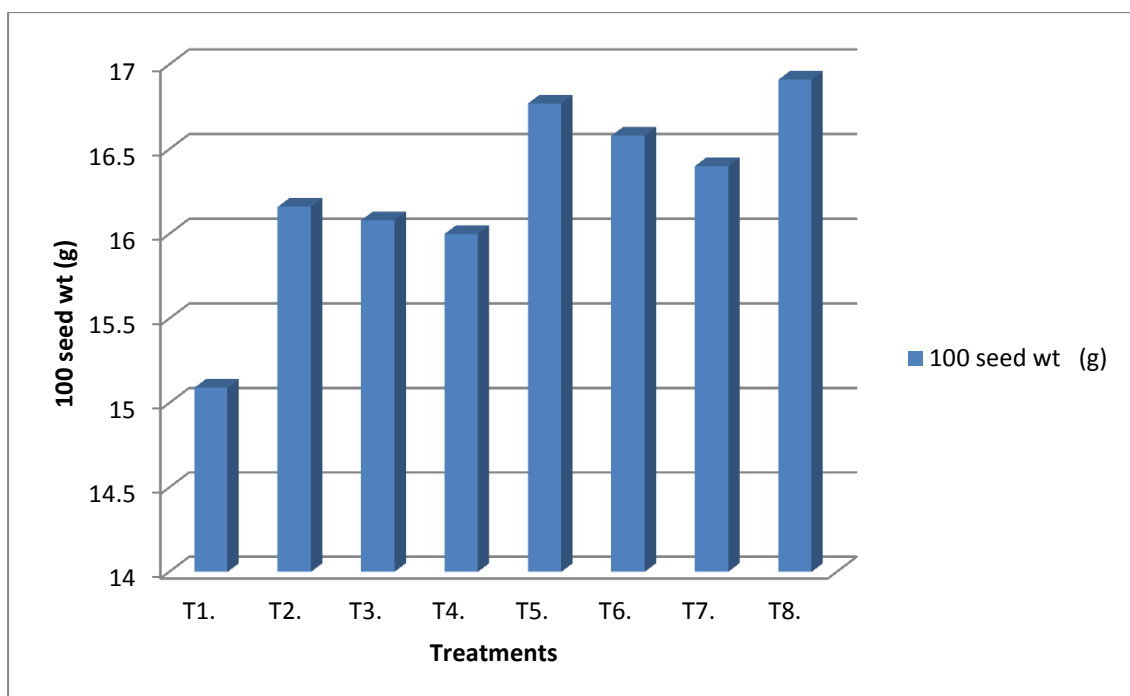


Fig. 4.3 Effect of nutrient, weed and pest management practices on 100 seed wt (g) of field pea

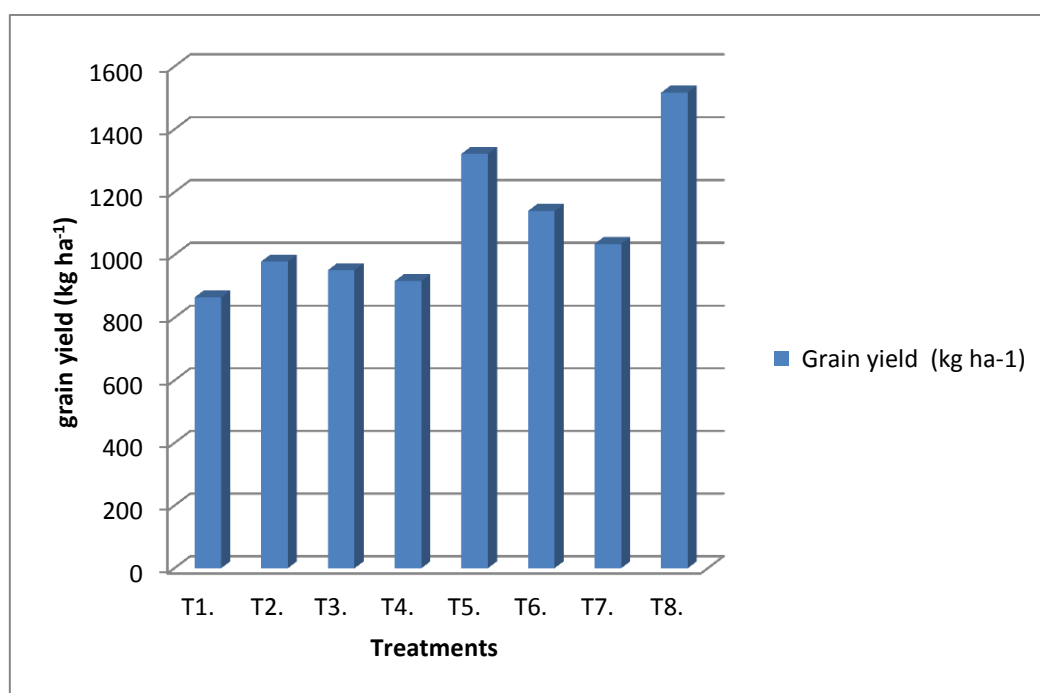


Fig. 4.4 Effect of nutrient, weed and pest management practices on grain yield (kg ha⁻¹) of fieldpea

Table 4.8. Effect of nutrient, weed and pest management practices on stalk yield (kg ha⁻¹) of field pea

Treatment	Stalk yield (kg ha⁻¹)
T ₁ . Control	4333.45
T ₂ . INM (RDF + Rhizobium + PSB)	4648.16
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	4638.09
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	4385.71
T ₅ . INM +IWM	4889.67
T ₆ . INM +IPM	4844.80
T ₇ . IWM +IPM	4713.26
T ₈ . INM + IWM + IPM	4919.27
SEm ±	10.56
C.D. 5%	32.01

Table 4.9. Effect of nutrient, weed and pest management practices on Harvest index of field pea

Treatment	Harvest Index
T ₁ . Control	16.61
T ₂ . INM (RDF + Rhizobium + PSB)	17.38
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	17.02
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	17.28
T ₅ . INM +IWM	21.27
T ₆ . INM +IPM	18.90
T ₇ . IWM +IPM	18.00
T ₈ . INM + IWM + IPM	23.52
SEm ±	0.84
C.D. 5%	2.54

Table 4.10. Effect of nutrient, weed and pest management practices on Nitrogen content (%) and Nitrogen uptake (kg ha^{-1}) in grain of field pea

Treatment	Nitrogen content (%)	Nitrogen uptake (kg ha^{-1})
T ₁ Control	2.91	25.16
T ₂ INM (RDF + Rhizobium + PSB)	3.03	29.67
T ₃ IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	2.97	28.26
T ₄ IPM (Seed treatment with fungicide +disease and pest management as and when required	2.93	26.85
T ₅ INM +IWM	3.60	47.59
T ₆ INM +IPM	3.31	37.73
T ₇ IWM +IPM	3.10	32.09
T ₈ INM + IWM + IPM	3.64	55.20
SEm \pm	0.01	1.01
C.D. 5%	0.04	3.07

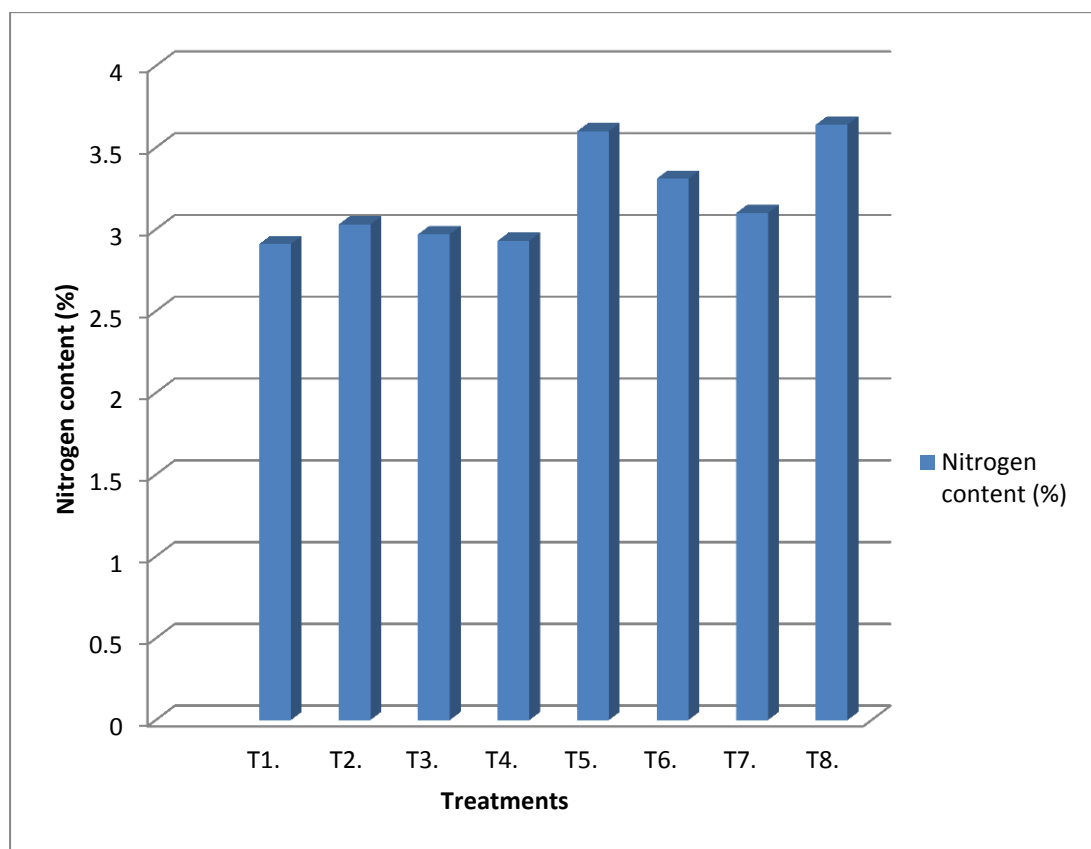


Fig. 4.5 Effect of nutrient, weed and pest management practices on Nitrogen content (%) in grain of field pea

Table 4.11. Effect of nutrient, weed and pest management practices on P content (%) and P uptake (kg ha⁻¹) in grain of fieldpea

Treatment	P content (%)	P uptake (kg ha⁻¹)
T ₁ . Control	0.20	1.75
T ₂ . INM (RDF + Rhizobium + PSB)	0.22	2.13
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	0.21	2.00
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	0.20	1.83
T ₅ . INM +IWM	0.24	3.18
T ₆ . INM +IPM	0.23	2.68
T ₇ . IWM +IPM	0.22	2.27
T ₈ . INM + IWM + IPM	0.25	3.75
SEm ±	0.003	0.17
C.D. 5%	0.009	0.51

Table 4.12. Effect of nutrient, weed and pest management practices on K content (%) and K uptake (kg ha⁻¹) in grain of fieldpea

Treatment	K content (%)	K uptake (kg ha⁻¹)
T ₁ . Control	1.03	8.94
T ₂ . INM (RDF + Rhizobium + PSB)	1.05	10.29
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	1.04	9.93
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	1.03	9.41
T ₅ . INM +IWM	1.06	14.06
T ₆ . INM +IPM	1.05	11.99
T ₇ . IWM +IPM	1.05	10.83
T ₈ . INM + IWM + IPM	1.07	16.19
SEm ±	0.004	0.65
C.D. 5%	0.012	1.96

Table 4.13. Effect of nutrient, weed and pest management practices on protein content (%) and Protein yield (kg ha⁻¹) in grain of field pea

Treatment	Protein content (%)	Protein yield (kg ha⁻¹)
T ₁ . Control	18.18	157.20
T ₂ . INM (RDF + Rhizobium + PSB)	18.93	185.38
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	18.56	176.61
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	18.31	167.84
T ₅ . INM +IWM	22.50	297.47
T ₆ . INM +IPM	20.68	235.75
T ₇ . IWM +IPM	19.37	200.51
T ₈ . INM + IWM + IPM	22.75	345.04
SEm ±	0.08	6.16
C.D. 5%	0.23	18.68

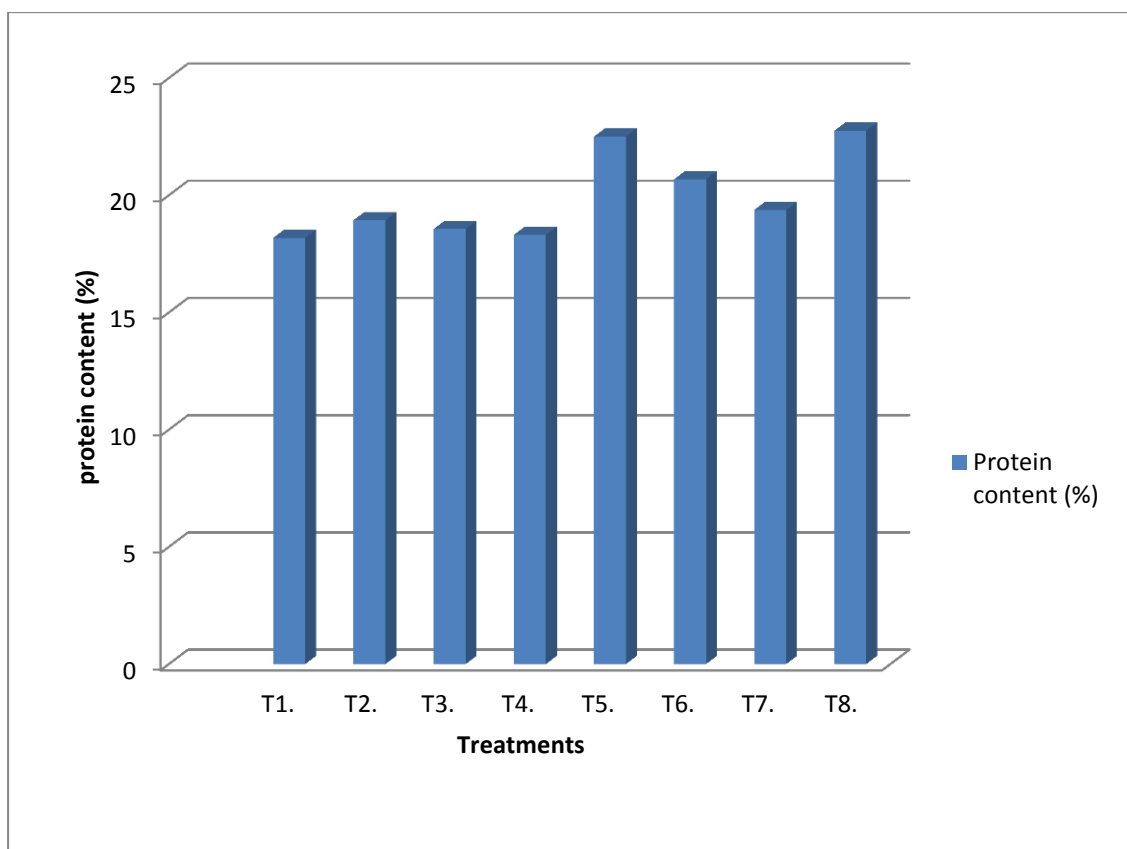


Fig. 4.6 Effect of nutrient, weed and pest management practices on protein content (%) in grain of field pea

Table 4.14. Effect of nutrient, weed and pest management practices on weed control efficiency

Treatment	Weed population (No/m²) at 60 DAS	Dry weight of weed biomass (g/m²) at 60 DAS	Weed control efficiency (WCE) (%)
T ₁ . Control	71.63	45.88	0.00
T ₂ . INM (RDF + Rhizobium + PSB)	69.81	35.89	21.77
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	20.89	21.67	52.76
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	67.54	44.35	3.33
T ₅ . INM +IWM	26.35	28.53	37.81
T ₆ . INM +IPM	64.56	31.70	30.91
T ₇ . IWM +IPM	21.46	23.78	48.16
T ₈ . INM + IWM + IPM	24.34	28.38	38.14
SEm ±	0.58	0.52	-
C.D. 5%	1.76	1.59	-

Table 4.15. Effect of nutrient, weed and pest management practices on economics (Gross return, Net return and benefit cost ratio) of field pea production

Treatments	Gross returns (Rs. ha⁻¹)	Net returns (Rs. ha⁻¹)	B:C ratio
T ₁ . Control	51,882	26,032	1.00
T ₂ . INM (RDF + Rhizobium + PSB)	58,758	31,238	1.135
T ₃ . IWM (Pendimethalin 1.0 kg/ha +1 hand weeding at 30 DAS)	57,096	29,606	1.07
T ₄ . IPM (Seed treatment with fungicide (Bavistin) +disease and pest management as and when required	55,002	27,742	1.01
T ₅ . INM +IWM	79,326	50,166	1.72
T ₆ . INM +IPM	68,400	39,470	1.36
T ₇ . IWM +IPM	62,112	33,212	1.15
T ₈ . INM + IWM + IPM	91,002	60,432	1.97
SEm ±	-	-	-
C.D. 5%	-	-	-



DISCUSSION

A field experiment was conducted entitled “**Effect of nutrient, weed and pest management practices on productivity of field pea [*Pisum sativum var. arvense*]**” during *rabi* season of 2015-16 at the Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The results obtained during the course of investigation are presented in the preceding chapter. In this chapter discussions are made on the results obtained with suitable evidences based on accessible literatures

The productivity of crop is the net result of the extent of successful completion of growth and developmental activities of individual plant. The crop depends upon the genetic potential of the cultivar and the environmental condition to which it is exposed during the course of its life cycle. However, under a given agro-climatic conditions exploitation of maximum yield potential is possible by altering the micro environment at optimum levels through certain agronomic manipulations. The most important one is that maximum response is obtained when nutrients are supplied at optimum levels at proper time and place, proper plant protection from weeds, pest and diseases.

Here in this chapter the effect of different treatments on various characters have been sought and significant findings of the investigation are discussed in terms of cause and effect relationship.

5.1 Effect of weather conditions on the growth and yield of crop:

Plants growing in natural environment subjected to various biotic and abiotic stresses were often prevent expressing their full genetic potential for production. The variation in weather parameters has pronounced effect on growth and development of the crop. Potential yield of every crop is achieved with the optimum air temperature,

relative humidity, vapour pressure and sunshine duration. Even slight deviation from the optimum range may adversely affect the crop growth and yield.

Field pea is basically a crop of cool region of the sub tropics. The meteorological data presented in Table 3.1 for the period of experiment indicated that, the weather conditions are more or less suitable for normal growth of the crop.

5.2 Effect of nutrient, weed and pest management practices on Growth attributes of fieldpea:

The growth parameters *viz.*, plant height, number of branches and dry matter production plant⁻¹ was continued to increase with the advancement in the age of crop irrespective of the different treatments. From the experimental findings it was observed that growth parameters like plant height, number of branches plant⁻¹, dry matter accumulation influenced by different practices. Among the different practices significantly maximum growth attribute were found with INM+IWM+IPM which was statistically at a par with INM+IWM and superior over other treatments. The maximum results in this treatment is due to the application RDF along with rhizobium+PSB, pendimethalin application + one hand weeding and which provide proper nutrients and weed control thus increasing the growth. Similar results were in conformity with findings of Prasad and Maurya (1992), Geetha (1993), El-Mansi *et al.* (2002), Tyagi. M. K.(2003), Soliemen *et al.* (2003), Rather *et al.*(2010).

5.3 Effect of nutrient, weed and pest management practices on yield attributes of fieldpea:

The data pertaining to the yield attributes like number of pod plant⁻¹, number of grains pod⁻¹, 100-seed weight, grain yield, straw yield was influenced by management practices. The maximum were increased with INM+IWM+IPM practices over the other practices.

The significantly highest grain and straw yield was achieved under treatment INM+IWM+IPM and INM+IWM respectively. Seed inoculation with *Rhizobium* +PSB along with RDF enhanced the crop growth and yield attributes due to balanced

availability of N and P. These results are in line with the findings of Kumari *et al.* (2012), Bhat *et al.* (2013).

With the application of pre-emergence pendimethalin along with one hand weeding at 30 DAS controls weed at growth stage of crop which reduce the crop weed competition and increase the yield by providing proper conditions. Similar results were reported by various researchers such as Singh *et al.* (2001), Pandey *et al.* (2000), Govardhan *et al.* (2007), Buttar *et al.* (2008).

The seed treatment bavistin improved seed yield by reducing the incidence of diseases over the untreated control. These results are in agreement with Dereje and Somsiri (2003).

5.4 Effect of nutrient, weed and pest management practices on N, P, K content and uptake of field pea:

Statistically analysed data on nutrient uptake revealed that differences in nutrient uptake were significantly influenced by different management practices. Under the treatment INM+IWM+IPM maximum nutrient uptake was observed due to less crop-weed competition for available nutrients.

Due to reduced weed infestation the weed competition with crop for nutrients reduced and nutrient availability to crop increased. The minimum nutrient uptake was reported in unweeded treatment due maximum crop-weed competition. The results are in accordance with findings of Brijbhooshan (2017).

5.5 Effect of nutrient, weed and pest management practices on quality parameter of fieldpea:

Significantly maximum protein content and protein yield was recorded under NM+WM+PM treatment. Protein quality depends on nitrogen efficiency of crop. Due to fertilizer application along with nitrogen fixation by *Rhizobium* inoculation the nitrogen content grain increased which results in increased grain yield as well as protein content. These results are summarised with the findings of Bhat *et al.* (2013), Desai *et al.* (2016).

5.6 Effect of management practices on weed attributes of field pea:

Weed dynamics

Maximum weed population and dry weight of weeds at 60 DAS was associated with control and minimum in weed management practices followed by INM+IPM. In case of WCE higher in IWM followed INM+IWM and minimum in INM *fb* INM+IPM. It might be due to application of pre applied herbicide followed by one hand weeding at 30DAS. Also better utilization of resources like nutrient, light and moisture. Whereas maximum weed population and dry weight of weeds in no herbicides applied treatment is and WCE is poor. Similar results were found with Singh *et al.* (2001), Singh and Angiras (2004), Dawson *et al.* (2007).

5.7 Effect of nutrient, weed and pest management practices on Effect on Economics

The cost of cultivation and gross return of field pea crop varied markedly by influence of different management practices which was ultimately influenced the overall net return and benefit: cost ratio. In treatment INM+IWM+IPM highest gross return, net return and B: C was observed. All these observation ultimately proved that in control and practising of only pest management practices without applying any other treatments had a significant effect in reducing the growth, yield, nutrient uptakes and economics.



SUMMARY AND CONCLUSION

The present investigation entitled “**Effect of nutrient, weed and pest management practices on productivity of field pea [*Pisum sativum var. arvense*]**” was carried out during *rabi* season of 2015-16 at the Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh with the following objectives:

1. To study the effect of management practices on growth and yield of field pea.
2. To estimate the uptake of N, P, K in field pea grain.
3. To find out the economics of different treatments.

The experiment was conducted with a field pea variety HUDP-15 which was laid in a randomised block design with three replications and eight treatments. The treatments include control plot, integrated nutrient management (INM), integrated weed management (IWM), integrated pest management (IPM) and combinations of INM+IWM, INM+IPM, IWM+IPM, INM+IWM+IPM practices. The soil of experimental field was sandy loam in texture, with slightly alkaline in reaction (pH 7.5).

In the present experiment consist of different management practices the nutrient management include recommended dose of fertilizers + *Rhizobium* + PSB, weed management include Pendimethalin 1.0 kg ha⁻¹ +1 hand weeding at 30 DAS and pest management include Seed treatment with fungicide(Bavistin) +disease and pest management as and when required.

During the period of experiment observation of growth *viz.*, plant height, crop dry matter accumulation, branches plant and nodule dry weight were recorded at 30, 60, 90 DAS and at harvest. The yield attributes *viz.*, pods plant⁻¹, grains pod⁻¹, seed index (100-grain weight), grain and straw yield, harvest index, protein content, protein yield, N, P and K content and their uptake were recorded after the crop harvest. The comparative economics of different treatments were also calculated.

The salient features of the result thus obtained are summarized below:

From the results it was observed that the growth parameters *viz.* Plant height, No. of branches plant⁻¹ and dry matter production were eminently influenced by different management practices. Maximum growth parameters significantly produced in treatment of INM+IWM+IPM which is statistically at a par with INM+IWM over other treatments.

Among the yield attributes *viz.* Number of pods plant⁻¹, grain pod⁻¹, 100-seed weight, grain yield, stalk yield and harvest index which are influenced by different management practices the highest values were observed with INM+IWM+IPM and lowest with control.

In the treatment INM+IWM+IPM significantly maximum grain yield and stalk yield was observed which was statistically at a par with INM+IWM treatment and lowest was observed in control.

The nutrient content and uptake of nitrogen, phosphorous and potassium in grain of the crop is influenced by different management practices. The highest nutrient content and uptake was observed in INM+IWM+IPM treatment which was at a par with INM+IWM treatment.

Quality parameter like protein content and yield was observed maximum with INM+IWM+IPM practice followed by INM+IWM practice.

It was recorded that maximum weed population and dry weight of weed was associated with control and minimum in weed management practices. Higher weed control efficiency observed in IWM followed by INM+IWM and lowest in INM followed by INM+IPM.

The maximum Gross returns, net returns and B:C ratio were observed in INM+IWM+IPM practice followed by INM+IWM practice.

Conclusion:

On the basis of results summarized above, it can be concluded that

Among all the management practices the maximum values for yield attributes, quality parameters, nutrient content, uptake and economics were observed in treatment with combination of nutrient, weed and pest management practices (INM+IWM+IPM).



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APPENDICES

Appendix I: cost of cultivation of field pea

S. No.	Particulars of operations	Input	Rate (₹)	Cost (₹ ha ⁻¹)
1	Field preparation			
	i) Ploughing and planking		300 hrs ⁻¹	900
2	Layout	4 labour for one day	290 labour ⁻¹ day ⁻¹	1160
3	Seed	120kg	145 kg ⁻¹	17400
4	Seed sowing	4 labour day ⁻¹	290 labour ⁻¹ day ⁻¹	1160
5	Harvesting	4 labour day ⁻¹	290 labour ⁻¹ day ⁻¹	1160
6	Threshing	4 labour day ⁻¹	290 labour ⁻¹ day ⁻¹	1160
7	Winnowing & bagging	4 labour day ⁻¹	290 labour ⁻¹ day ⁻¹	1160
8	Land revenue	6 month	300 annum ⁻¹	150
9	Interest on working capital	6 month	10 % annum ⁻¹	1600
Total				25,850

Appendix II: Gross return, net return and B: C ratio under different treatments.

Treatments	Cost of cultivation (₹ ha⁻¹)	Gross returns (₹ ha⁻¹)	Net returns (₹ ha⁻¹)	B:C ratio
T ₁	25,850	51,882	26,032	1.00
T ₂	27,520	58,758	31,238	1.135
T ₃	27,490	57,096	29,606	1.07
T ₄	27,260	55,002	27,742	1.01
T ₅	29,160	79,326	50,166	1.72
T ₆	28,930	68,400	39,470	1.36
T ₇	28,900	62,112	33,212	1.15
T ₈	30,570	91,002	60,432	1.97
SEm ±	-	-	-	-
C.D. 5%	-	-	-	-

