INTEGRATED NUTRIENT MANAGEMENT IN BABY CORN

(*Zea mays* L.)

by

NAMITHA V V

(2017-11-076)

THESIS

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2019

DECLARATION

I, hereby declare that this thesis entitled **"INTEGRATED NUTRIENT MANAGEMENT IN BABY CORN (*Zea mays* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associate ship, fellowship or other similar title, of any other University or Society.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

@	At the rate of
°C	Degree Celcius
%	Per cent
BCR	Benefit : cost ratio
CD (0.05)	Critical difference at 5 per cent level
cm	Centimetre
RBD	Randomized block design
dS m^{-1}	Deci Siemens per meter
EC	Electrical conductivity
et al.	Co- workers/ co-authors
Fig.	Figure
FYM	Farmyard manure
PM	Poultry manure
VC	Vermicompost
ha^{-1}	Per hectare
kg ha^{-1}	Kilogram per hectare
LAI	Leaf area index
DMP	Dry matter production
DAS	Days after sowing
DAE	Days after emergence
No.	Number
RH	Relative humidity
SEm	Standard error of means
t ha^{-1}	Tonnes per hectare
viz.,	Namely
INM	Integrated nutrient management
RDN	Recommended dose of nitrogen
RDF	Recommended dose of fertilizer
PGPR	Plant growth promoting rhizobacteria
N	Nitrogen
P	Phosphorus
K	Potassium

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INTRODUCTION

1. INTRODUCTION

Maize plays a significant role as food, feed and fodder in the global agricultural economy and is called the "Queen of Cereals" due to its higher yield potential. Even though it is not being extensively cultivated in Kerala, the maize products *viz*., corn starch, corn flakes, fresh cob, sweet corn and baby corn are widely consumed. The baby cob is the female inflorescence (ear) harvested within 2-3 days of silk emergence and is 6-7 cm long, unfertilized and yellow coloured (Saha *et al*., 2007). Baby corn is a good source of fibre and phosphorus. The sweet, succulent and delicious baby corn is a part of several preparations like soups, salads and Chinese foods. It is almost free from residual effects of pesticides and has great potential for domestic consumption and exports. Since the crop is harvested within 65 to 75 days after sowing (DAS), 3 or 4 crops could be raised in an year.

For successful crop production especially a heavy feeder crop like maize, scientific nutrient management assumes great importance. The application of chemical fertilizer may assist in obtaining maximum production of baby corn, but it may lead to hazardous effect on environmental health besides increasing production cost and impeding quality of produce which is mostly used in the raw or uncooked form. Meeting the nutrient requirement solely from the organic sources is not feasible in a crop like baby corn which completes its duration within a short span of time as there may be a delay in nutrient release from the organic sources. Hence, integrated nutrient management (INM) which encompasses the judicious application of fertilizers or manures from different sources appears to be the most suitable strategy for nutrient management in baby corn.

Organic manures are the natural products that increase the organic matter content in the soil and release plant nutrients in available form for the use of crop. These are the alternate sources to supplement the inorganic fertilizers and could also be used for substituting the chemical fertilizers under INM strategy. The nutrient substitution with organic sources is done on nitrogen (N) equivalent basis and the ratios or proportions at which the organic and inorganic sources are applied to supply a given quantity of nutrient N varies with the crop requirement and soil fertility status.

Poultry manure or poultry litter which is a popular organic manure in southern Kerala is a suitable alternative to chemical fertilizers. This organic manure is having higher mineralisation potential and quickly releases its nutrients for plant uptake and use (Smith,1950) and hence it is an ideal organic source for INM in short duration crops. Poultry manure contains all the essential plant nutrients and can provide a portion or whole of the plant nutrition when combined with other organic sources and inorganic fertilizers.

Vermicompost is an organic manure produced as vermicast by earthworms feeding on biological waste material and plant residues. It contains adequate quantities of major and minor nutrients essential for the plant growth. The nutrient content in vermicompost vary widely according to the waste materials used for its preparation. Vermicompost produced with heterogenous waste materials will have a wide range of nutrients and that with homogenous materials will contain only few nutrients. In addition to the nutrients, vermicompost also contains vitamins, enzymes and growth hormones. Combined application of vermicompost with chemical fertilizers therefore appears to be promising in crops like baby corn wherein the quality of produce is a major consideration.

Biofertilizers are preparations containing living microorganisms which helps in enhancing the soil fertility. These microbial fertilizers form an important component of INM practices as they supplement the chemical fertilizers, increase release of nutrients from the organic sources and encourages native microorganisms, thus promoting soil health besides reducing the cost of cultivation.

Though INM has been standardised and recommended for several crops in Kerala, it has not been tried out in baby corn which has gained recent attention. Thus the present study is proposed with the following objectives:

- To investigate the influence of INM practices on growth, yield, nutritive quality and storage life of baby corn
- To work out the economics of cultivation

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Baby corn has gained consumer preference especially in the urban areas of Kerala recently. Being highly nutritive, its quality is more important and can be enhanced through mineral nutrition. The hike in the price of chemical fertilizers has led to greater emphasis on integrated use of organic manures and biofertilizers along with chemical fertilizers. Integrated nutrient management is the judicious combination of different source of organics, inorganics and biofertilizers that helps to enhance soil fertility and farm productivity without impairing the soil nutrient status (Kumar *et al.*, 2008). Many investigators have explained the importance and benefits of partly substituting nutrients through organic sources under INM strategy which not only reduces the quantity of costly chemical fertilisers, but also favourably influences the quality of produce and soil health.

In this chapter, a detailed review of research work done on the effect of N substitution through organic manures such as poultry manure and vermicompost and added benefits of using biofertilizers in integrated nutrient management have been presented.

2.1 EFFECT OF N SUBSTITUTION THROUGH POULTRY MANURE

Application of poultry manure provides increased availability of phosphorus (P) (More and Ghonshikar, 1988) by the formation of a soluble complex with organic manures that promote P uptake in maize (Das *et al.,* 1991).

2.1.1. Effect of N substitution through poultry manure on growth attributes

Integrating poultry manure with N fertilizer was found to be favourably influencing the growth attributes of maize. Maravi (2006) conducted a trial on the INM in maize (*Zea mays*) and reported increased plant height, leaves per plant, leaf area index (LAI) and dry weight per plant when applied with 75 per cent Recommended Dose of Fertilizers (RDF) ie.100:60:40 kg NPK ha^{-1}, along with

50 per cent N through poultry manure. Kumar *et al.* (2008) reported that application of 120 kg urea along with 30 kg poultry manure produced the tallest plant, highest number of leaves and maximum dry weight of maize. Choudhari (2012) recorded increased growth attributes *viz.*, plant height, number of leaves per plant, dry matter production (DMP), LAI and growth rates such as absolute growth rate, crop growth rate, relative growth rate, net assimilation rate, leaf area duration, specific leaf weight, specific leaf area and leaf area ratio with the application of 1.5 t ha^{-1} of poultry manure along with 100 per cent of RDF (100:50:25 NPK ha^{-1}) in maize. Iqbal *et al.* (2014) conducted an experiment to evaluate the effect of integrated N management in maize during rabi season and reported that taller plants and higher number of leaves per plant were produced with the application of 75 per cent N from urea and 25 per cent N from poultry manure. As reported by Nagavani and Subbian (2014) in hybrid maize, there was a significant increase in growth parameters *viz.*, plant height, LAI with the application of 50 per cent RDF through poultry manure and 50 per cent RDF through inorganic fertilizers (150:75:75kg NPK ha^{-1}). Recently Wailare and Kesarwani (2017) reported that application of 5 t ha^{-1} poultry manure and 50 per cent RDF (120:60:40 NPK kg ha^{-1}) recorded significantly higher leaf area in maize.

Substituting nutrient N with poultry manure was found have positive influence on specialty maize crops like baby corn and sweet corn. In an INM trial on baby corn, Kumar (2006) reported that tallest plants with highest LAI and highest DMP were registered with 100 per cent N through fertilizer, which were however on par with 75 per cent N through fertilizer along with 25 per cent N through poultry manure or sheep manure or farmyard manure (FYM). Pinjari (2007) suggested that with the application of 75 per cent recommended dose of nitrogen (RDN) along with 25 per cent N as poultry manure, taller plants, maximum number of functional leaves and maximum DMP per plant were recorded in sweet corn.

2.1.2 Effect of N substitution through poultry manure on yield attributes and yield

Substituting nutrient N through organic sources is reported to have positive effect on baby corn and sweet corn yield. Kumar (2006) reported that the highest baby corn yield (dehusked) and green fodder yield were obtained with 100 per cent N through fertilizer, which were however comparable with 75 per cent N through fertilizer along with 25 per cent N through poultry manure or sheep manure or FYM. Pinjari (2007) pointed out that in sweet corn, when 75 per cent RDN along with 25 per cent N as poultry manure was given, significantly higher cob length, cob girth, grains per cob, number of cobs per plant, weight per cob, cob yield, green fodder and total biological yield were recorded with RDF as 225:60:60kg NPK ha^{-1}. According to Hekmat and Abraham (2016), application of poultry manure as a nutrient source in baby corn produced higher cob girth, number of cobs per plant, cob length without husk and cob weight without husk. The highest cob yield and green fodder yield in this trial was obtained with application poultry @ 4615.30 kg ha^{-1}.

Substituting nutrient N through poultry manure was found to influence the maize yield by several workers. Application of 10 t ha^{-1} of poultry manure along with RDF (150:75:37.5 kg NPK ha^{-1} in three split doses) recorded longer and heavier maize cobs with greater diameter during the kharif season in Karnataka as reported by Chandrashekara *et al.* (2000). A study conducted by Channabasavanna *et al.* (2002) revealed that an increase in the seed yield of maize was recorded with 4 t ha^{-1} of poultry manure along with 75 per cent NPK. Studies conducted by Khaliq *et al.* (2004) in corn suggested that more number of cobs per plant (1.22), number of grains per cob (484.65), maximum corn grain yield (5.98 t ha^{-1}) and the highest harvest index (HI) of 26.06 per cent were recorded from plots fertilized with proportion of 100 kg N ha^{-1} as urea and 100 kg N ha^{-1} as poultry manure. Maravi (2006) conducted a trial on the INM of maize (*Zea mays*) and recorded maximum grain yield, HI and seed: straw ratio with 75 per cent RDF (100:60:40 kg NPK ha^{-1}) along with 50 per cent N as poultry manure. As reported by Kumar *et al.* (2008), the highest number of cobs per plant, length of cob, number of grains per cob, grain yield and test weight in maize were obtained with the application of 30 kg N through poultry manure in addition to 120 kg N through urea. In another study, Choudhari (2012) recorded maximum cob length, cob girth, number of grain rows per cob, number of grains per row, cob weight, grain weight per plant, grain yield and HI with the application of 1.5 t ha^{-1} of poultry manure along with 100 per cent of RDF (100:50:25 NPK ha^{-1}) in maize. Wailare and Kesarwani (2017) reported that the application of 5 t ha^{-1} poultry manure and 50 per cent RDF (120:60:40 NPK kg ha^{-1}) recorded significantly higher stover yield of maize.

2.1.3 Effect of N substitution through poultry manure on nutrient content and uptake

According to Ogunbanjo *et al.* (2007), higher yield and yield attributes of maize were obtained with the poultry manure application due to higher mineralization potential of poultry manure enabling it to actively and quickly release its nutrients for plant uptake and use. Pinjari (2007) reported that in sweet corn, P content in the leaves, stem, grain, cob sheath and cob axis was higher with 100 per cent N as poultry manure. However, the P uptake was higher with 50 per cent RDN with 50 per cent N as poultry manure. According to Choudhari (2012), N, P and potassium (K) content in the maize leaves at 30, 60 and 90 DAS were significantly higher with the application of 1.5 t ha^{-1} of poultry manure along with 100 per cent of RDF (100:50:25 kg NPK ha^{-1}). The increased uptake of N, P and K in maize with the application of 125 per cent RDF (120:60:40 kg NPK ha^{-1}) along with 50 per cent N as poultry manure, recorded higher content of nutrients in the grain and stover (Vaisakhi, 2012). Similar trend was observed in case of micronutrients *viz.*, iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) in this study.

2.1.4 Effect of N substitution through poultry manure on shelf life and quality

Nitrogen substitution through poultry manure was found to have positive effect on storage life and quality of baby corn. Kumar (2006) reported that the total soluble sugar (TSS) in the baby corn was the highest under 100 per cent N dose through poultry manure which was statistically on par with 100 per cent N dose (150:75:40 kg NPK ha^{-1}) through FYM or sheep manure or 25 per cent N through fertilizer with 75 per cent N through sheep manure or FYM or poultry manure. In another study on baby corn hybrid G-5414, the highest protein, starch, carbohydrate, reducing and non reducing sugar were obtained with RDF (150:75:40 kg NPK ha^{-1}) followed by poultry manure application (Ashalatha, 2009).

2.1.5 Effect of N substitution through poultry manure on soil properties

Several researchers have reported the influence of N substitution through poultry manure in maize crop on soil properties. Pinjari (2007) reported that the available soil P and K contents after sweet corn cultivation under lateritic soil of Konkan were superior with 100 per cent N substitution through poultry manure followed by 50 per cent RDN along with 50 per cent N as poultry manure where the RDF was 225: 60: 60 kg NPK ha^{-1}. As reported by Choudhari (2012), significantly higher available N, P and K status of soil after harvest of the maize crop were recorded when 1.5 t ha^{-1} of poultry manure along with 100 per cent of RDF was applied (100:50:25 kg NPK ha^{-1}). In another investigation, Vaisakhi (2012) reported that the highest available N, K and other cationic micronutrients (Fe, Mn, Zn, Cu) status of soil were recorded with the application of 125 per cent RDN along with 50 per cent N as poultry manure in maize. But the P availability was the highest at 100 per cent RDN with 50 per cent N as poultry manure where the RDF was 120:60:40 kg NPK ha^{-1}. Wailare and Kesarwani (2017) reported that in maize, application of 5t ha^{-1} poultry manure and 50 per cent RDF recorded an increase in available soil N status. The P availability and soil organic carbon content in this trial were found to be the highest with application of 5 t ha^{-1} poultry manure along with RDF (120:60:40 NPK kg ha^{-1}).

2.1.6 Effect of N substitution through poultry manure on economics of cultivation

Nitrogen substitution through poultry manure favourably influenced the economics of cultivation of maize crop as reported by several workers. Maravi (2006) reported the highest net returns was obtained with the application of 75 per cent RDF (100:60:40 kg NPK ha^{-1}) along with 50 per cent N substitution through poultry manure in maize. Kumar *et al.* (2008) analysed the economics of maize cultivation and found that the highest net profit and benefit: cost ratio(BCR) were obtained with the application of 120 kg N supplied through urea along with 30 kg N supplied through poultry manure. In another study, significantly higher gross returns, net returns and BCR were recorded in maize crop, when 1.5 t ha^{-1} of poultry manure along with 100 per cent of RDF as 100:50:25 kg NPK ha^{-1} (Choudhari, 2012). Vaisakhi (2012) reported higher gross returns in maize with 125 per cent RDF (120:60:40 kg NPK ha^{-1}) along with 50 per cent N as poultry manure. According to Iqbal *et al.*(2014), the net income and BCR of maize cultivation were the highest with the application of 75 per cent N from urea and 25 per cent N from poultry manure. Nagavani and Subbian (2014) observed that in maize, application of 50 per cent RDF and 50 per cent RDF through poultry manure recorded higher gross and net returns.

The INM in specialty corns with poultry manure as an organic source was found to influence the economics of cultivation. The gross and net returns in sweet corn cultivation were higher under 75 per cent RDN along with 25 per cent N as poultry manure where the RDF was 225:60:60 kg NPK ha^{-1} (Pinjari, 2007). According to Ashalatha (2009), the highest gross return, net return and BCR were obtained under RDF (150:75:40 kg NPK ha^{-1}) followed by poultry manure application in baby corn.

2.2 EFFECT OF N SUBSTITUTION THROUGH VERMICOMPOST

Vermicompost is an organic manure which is aerobically degraded, after the chemical disintegration has taken place in the gut of worms by enzyme activity (Kale *et al.*, 1992).

2.2.1 Effect of N substitution through vermicompost on growth attributes

The biometric characters of the maize crop was found to be influenced with the application of vermicompost as a source of N along with chemical fertilizers in integrated nutrient management.

Khadtare *et al.* (2006) reported that taller plants were produced in sweet corn under RDF (150:50:0 kg NPK ha^{-1}) which was closely followed by 75 per cent RDN and 25 per cent N through vermicompost. Louraduraj (2006) reported that the combined application of 100 per cent recommended NPK along with 5 t ha^{-1} vermicompost significantly increased the plant height, dry matter accumulation and LAI in maize compared to lower doses. In a field study carried out by Kannan *et al.* (2013) during rabi season on maize, it was reported that the application of vermicompost @ 5 t ha^{-1} along with RDF (120:60:00 kg NPK ha^{-1}) significantly increased the plant height and leaf area.

2.2.2 Effect of N substitution through vermicompost on yield attributes and yield

Combined application of vermicompost and chemical fertilizers was found to influence yield attributes and yield of baby corn.

Dadarwal (2008) reported that addition of vermicompost with inorganic fertilizers was effective in increasing the green cob yield in baby corn. According to Keerthi *et al.* (2013), baby corn crop produced a cob yield of 21.17 t ha^{-1} when treated with of vermiwash thrice at 20, 35 and 50 DAS along with 180:75:60 kg NPK ha^{-1}. However, this was found to be at par with the same amount of fertilizer with 30 t ha^{-1} of vermicompost. In an investigation conducted by Sharma and Banik (2014) in baby corn, the cob yield and green fodder yield were found to be superior with the application of 10 t ha^{-1} of vermicompost with 150 per cent of RDF (150:60:60 kg NPK ha^{-1}). Shivran *et al.* (2015) reported that the application of 25 per cent N as vermicompost with the remaining 75 per cent N as chemical fertilizer in baby corn resulted in the highest green cob yield of 2414 kg ha^{-1} and fodder yield of 19389 kg ha^{-1}. Sharma and Banik (2016) observed that among different INM practices in baby corn, maximum dehusked cob yield (0.81t ha^{-1}) and green fodder yield (16.25 t ha^{-1}) were obtained with the application of 30 per cent N through vermicompost along with 75 per cent RDF (150:60:60 kg NPK ha^{-1}).

2.2.3 Effect of N substitution through vermicompost on nutrient content and uptake

Favourable influence of N substitution through vermicompost on nutrient content and uptake by baby corn has been reported by some of the recent workers. Aravinth *et al.* (2011) reported that application of 5 t ha^{-1} of vermicompost along with RDF produced maximum uptake of NPK in baby corn. Keerthi *et al.* (2013) observed that the N, P and K uptake by the baby corn cobs were superior with the application of vermiwash thrice at 20, 35 and 50 DAS along with 180:75:60 kg NPK ha^{-1} and it was found to be on par with the application of 30 kg N ha^{-1} through vermicompost with the same dose of fertilizers. The nutrient content and uptake of baby corn were found to be superior with the application of chemical fertilizer @ 75 per cent of N and vermicompost @ 25 per cent N on equivalent basis (Shivran *et al.*, 2015). According to Sharma and Banik (2016), application of 75 per cent RDN with 30 per cent of N through vermicompost produced maximum N uptake in baby corn.

2.2.4 Effect of N substitution through vermicompost on soil properties

Soil properties are often found to be influenced by N substitution through vermicompost as organic source in baby corn and grain corn cultivation. Sharma and Banik (2014) reported that the soil chemical properties *viz.*, available N, P, K and organic carbon content were found to be higher when applied with vermicompost 10 t ha^{-1} combined with 150:60:60 kg NPK ha^{-1} in baby corn. According to Keerthi *et al.*(2013), application of 180:75:60 kg NPK ha^{-1} in baby corn along with the application of vermiwash at 20, 35 and 50 DAS increased the N, P and K content in the soil. This was on par with the application of same amount of chemical fertilizer and 30 kg N ha^{-1} through vermicompost. In another experiment on baby corn, Shivran *et al.* (2015) reported that the available nutrient status of N, P and K were found to be higher in soil after the application of half the dose of N through chemical fertilizer and remaining half as vermicompost.

Basavaraju (2007) suggested the availability of P, K, and sulphur (S) were maximum when maize crop was supplied with 50 per cent RDF (150:75:37.5 kg NPK ha^{-1}) along with 50 per cent N through vermicompost. Pawar and Patil (2007) recorded a significant increase in organic carbon, available N, P and K status after the harvest of maize with the application of 5 t ha^{-1} vermicompost along with 100 per cent RDF (120:60:40 kg NPK ha^{-1}) compared with lower levels. Singh and Nepalia (2009) reported that the application of vermicompost @ 5 t ha^{-1} with 100 per cent RDF in maize improved the organic carbon content, N and P status of soil in southern Rajasthan. An investigation conducted by Yadav (2015) on the effect of INM on maize suggested that the availability of N, P, K, Zn, Mn, Fe and Cu were found to be the highest with 100 per cent RDF (90:40:40 kg NPK ha^{-1}) along with vermicompost @ 4 t ha^{-1} compared to lower doses. The study also reported the highest aggregates, porosity and hydraulic conductivity of soil with the above rate of application.

2.2.5 Effect of N substitution through vermicompost on economics of cultivation

Favourable effect of N substitution through vermicompost under INM in maize has been reported by a few workers. The highest net monitory return and BCR (4.52) were obtained with the application of RDF (150:50:0 kg NPK ha^{-1}) followed by 75 per cent RDF along with 25 per cent N through vermicompost in sweet corn (Khadtare *et al*., 2006). Shivran *et al.* (2015) reported that the treatment combination of one third dose of N as vermicompost with two third dose of N through chemical fertilizer produced maximum gross return and BCR in baby corn cultivation. Yadav (2015) recorded significantly higher net returns and BCR with 100 per cent RDF (90:40:40 kg NPK ha^{-1}) along with vermicompost @ 4 t ha^{-1} in maize.

2.3 EFFECT OF BIOFERTILIZERS AS NUTRIENT SOURCE IN INTEGRATED NUTRIENT MANAGEMENT

Baby corn being a high value crop, quality is important than quantity and integration of organic and biofertilizers along with chemical fertilizers hence assumes significance.

2.3.1 Effect of biofertilizers on growth attributes

Favourable effects of biofertilizers on growth characteristics of baby corn have been reported by some of the researchers.

Studies conducted by Thavaprakaash *et al.* (2005) indicated that combined application of 50 per cent NPK (RDF- 150:60:40 kg ha^{-1}) with 50 per cent poultry manure and bio-fertilizers (*Azospirillum* and phosphobacteria @ 2 kg ha^{-1} resulted in taller plants, higher LAI and DMP during late *rabi* season in baby corn. Rao *et al.* (2009) reported that there was significant increase in plant height, number of leaves per plant and DMP in baby corn with the application of 90 kg ha^{-1} of N as urea and 30 kg N ha^{-1} through the seed inoculation with *Azospirillum.* According to Jinjala *et al.* (2016), taller plants were produced in baby corn when 100 per cent RDF was supplied along with biofertilizers (*Azotobacter* and phosphate solubilizing bacteria) application. Study conducted by Joshy (2016) in baby corn revealed that the plants were taller (67 cm) at 25 DAS in the plots treated with 100 per cent NPK along with *Azotobacter* and *Azospirillum* which was on par with 100 per cent NPK, 50 per cent NPK, 75 per cent NPK with *Azotobacter* and *Azospirillum* and 50 per cent NPK with seed treatment of *Azotobacter* and *Azospirillum*. In this study, the dry matter accumulation at 25 DAS was the highest with 75 per cent NPK with *Azotobacter* and *Azospirillum,* while at 50 DAS and at harvest it was the highest with the application of 100 per cent NPK with *Azotobacter* and *Azospirillum.* The LAI was significantly higher at 50 DAS and harvest under the application of 100 per cent NPK along with *Azotobacter* and *Azospirillum.*

2.3.2 Effect of biofertilizers on yield attributes and yield

Inclusion of biofertilizers as nutrient source in INM was found to produce positive effects on yield attributes and yield of baby corn.

Studies conducted by Datta and Banik (1997) suggested that the ability of *Azospirillum* to fix atmospheric N and to secrete growth promoting substance along with the bacterial action of phosphobacteria enhanced the yield attributing characters and yield of baby corn. Thavaprakaash *et al.* (2005) reported that application of 50 per cent NPK (RDF- 150:60:40 kg ha^{-1}) with 50 per cent poultry manure and biofertilizers (*Azospirillum* and phosphobacteria @ 2 kg ha^{-1} during the late rabi season in baby corn produced longer, thicker and heavier cobs and higher cob yield. Rao *et al.* (2009) reported that the application of 90 kg ha^{-1} of N as urea and 30 kg N ha^{-1} through the seed inoculation with *Azospirillum,* produced maximum number of cobs per plant, cob yield (2205 kg ha^{-1}) and green fodder yield (264.60 kg ha^{-1}) in baby corn. According to Sharma and Banik (2014) the highest dehusked cob yield (0.77 t ha^{-1}) and green fodder yield (20.23 t ha^{-1}) were produced in baby corn when treated with 100 per cent RDF (150:60:60 kg ha^{-1}) along with biofertilizers *viz.* AMF and *Azospirillum.* Jinjala *et al.* (2016) reported that there was a significant increase in the cob length, cob girth, cob weight with and without husk and green fodder yield in baby corn under 100 per cent RDF along with biofertilizers (*Azotobacter* and phosphate solubilizing bacteria). According to Joshi (2016), the highest length (8.9 cm), girth (4.8 cm), cob yield (413 kg ha^{-1}) and green fodder yield (2188.9 kg ha^{-1}) were obtained in baby corn with the application of 100 per cent NPK combined with application of *Azotobacter* and *Azospirillum.* Study conducted by Kavya (2017) indicated that the application of 50 per cent P and 100 per cent NK with mycorrhizal biofertilizer @ 500 g ha^{-1} (soil drenching) twice (20 DAS and 50 DAS) produced maximum fresh weight, dry matter, number of cobs, cob length, cob girth and yield in baby corn.

2.3.3 Effect of biofertilizers on nutrient content and uptake

The highest nutrient uptake of N, P and K was observed in baby corn when treated with 50 per cent RDF(150:60:40 kg NPK ha^{-1}) and remaining 50 per cent nutrients through poultry manure along with biofertilizers (*Azospirillum* and phosphobacteria @ 2 kg ha^{-1} during summer season (Thavaprakaash *et al.*,2005). According to Sharma and Banik (2014), application of AMF, *Azospirillum* and 150 per cent of RDF (150:60:60 kg NPK ha^{-1}) resulted in the highest nutrient uptake in baby corn. Joshi (2016) observed that baby corn treated with 100 per cent NPK along with *Azotobacter* and *Azospirillum* produced the highest N, P and K content. Kavya (2017) reported that the highest plant nutrient content in baby corn was obtained when applied with 100 per cent NPK and mycorrhizal biofertilizer @ 10 g kg^{-1} as seed treatment at 20 DAS while at 50 DAS, the highest values were found to be with the treatment 50 per cent P + 100 per cent NK with mycorrhizal biofertilizer @ 500 g ha^{-1} (soil drenching).

2.3.4 Effect of biofertilizers on shelf life and quality

Joshi (2016) reported that maximum TSS content (9.6 per cent) and protein content (11.5 per cent) were obtained with the application of 75 per cent NPK with *Azotobacter* and *Azospirillum.* Sensory evaluation was also conducted in this study to know the preference of people and found that baby corn produced with the application of 100 per cent NPK in combination with *Azotobacter* and *Azospirillum* were extremely liked by 80 per cent because of the sweetness and juiciness and liked very much by 20 per cent. Kavya (2017) conducted sensory evaluation of baby corn both before and after cooking. The results showed that the colour, appearance and absence of defect differed significantly between the treatments. Higher sensory values for these observations were obtained under the application of mycorrhizal biofertilizer @ 500 g ha^{-1} along with 100 per cent NK and 50 per cent P. Aroma, appearance and absence of defects were higher for the same treatment after cooking. The minimum values are recorded for 100 per cent NPK (100:60:75 kg NPK ha^{-1}). The highest TSS content (10.27 ^{0}B) and keeping quality were also observed for the same treatment.

2.3.5 Effect of biofertilizers on soil properties

Lowest bulk density, highest infiltration rate, high organic carbon content and highest availability of N, P and K were observed when 25 per cent RDF (30:15:15 kg NPK ha^{-1}) was applied along with biofertilizers (*Azotobacter* and phosphate solubilising bacteria), compost and green manuring in maize (Kalhapure *et al.,* 2013). As reported by Sharma and Banik (2014), higher values of residual soil fertility *viz.* available N (138.21 kg ha^{-1}), P (16.60 kg ha^{-1}) and K (170.83 kg ha^{-1}) were observed when treated with 150 per cent of RDF (150:60:60 kg NPK ha^{-1}) along with AMF and *Azospirillum* in baby corn. Joshi (2016) reported that in baby corn, the available N (282.3 kg ha^{-1}) and K (239 kg ha^{-1}) contents were higher with application of 100 per cent NPK with *Azotobacter* and *Azospirillum*. Available P content (29 kg ha^{-1}) was superior with the application of 75 per cent NPK with *Azotobacter* and *Azospirillum*. In this trial, the highest organic carbon content (0.71 per cent) was obtained under 100 per cent NPK with *Azotobacter* and *Azospirillum* followed by 75 per cent NPK with *Azotobacter* and *Azospirillum.* Kavya (2017) reported that the application of 50 per cent P, 100 per cent N and 500 g ha^{-1} of mycorrhizal biofertilizer produced significantly higher available NPK (439.04, 47.67 and 275 kg ha^{-1} respectively) content in the soil after the harvest of baby corn.

2.3.6 Effect of biofertilizers on economics of cultivation

Biofertilizers when used as a nutrient source in INM is reported to be producing more economic benefits. Kalhapure *et al.* (2013) reported that gross returns, net returns and BCR were significantly higher in maize with 25 per cent RDF (30:15:15 kg NPK ha^{-1}) along with biofertilizers (*Azotobacter* and Phosphate solubilising bacteria) and green manuring with sunhemp and compost. Joshi (2016) reported the highest gross returns, net returns and net return per day under 100 per cent NPK with *Azotobacter* and *Azospirillum* and it was on par with 100 per cent NPK alone and 75 per cent NPK with *Azotobacter* and *Azospirillum* in baby corn. Application of 150 per cent of RDF (150:60:60 kg NPK ha^{-1}) with AMF and *Azospirillum* resulted in maximum net returns and BCR under baby corn cultivation (Sharma and Banik, 2014). According to Jinjala *et al.* (2016), application of 100 per cent RDF with *Azotobacter* and phosphate solubilizing bacteria in baby corn produced maximum gross return, net return and BCR. Kavya (2017) reported that application of 100 per cent NK, 50 per cent P and mycorrhizal biofertilizer @ of 500 g ha^{-1} at 20 and 50 DAS produced higher gross returns, net returns and BCR in baby corn cultivation

Investigations done by various researchers have indicated the benefits of substitution of nutrient N through organic sources which is an important practice under INM in baby corn and importance of including biofertilizers in its nutrient management for getting additional benefits.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiment entitled "Integrated nutrient management in baby corn (*Zea mays* L.)" was conducted at College of Agriculture, Vellayani, Thiruvananthapuram during February to April 2018 in order to investigate the influence of INM practices on growth, yield, nutritive quality, storage life and economics of cultivation of baby corn. The details of materials used and methods followed are presented in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was conducted in block D of Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram. The experimental site was located at $08^{0}25'46.85''$ N latitude and $076^{0}59'17.16''$ E longitude and at an altitude of 40m above mean sea level.

3.1.1 Soil

Composite soil sample was taken from the field before the experiment and analysed for its mechanical composition and chemical properties. The soil was sandy clay loam belonging to the order Oxisol. The mechanical composition and chemical properties of soil are given in Table 2 and Table 3 respectively.

3.1.2 Climate and season

The experiment was conducted during February to April 2018 and a warm humid climate prevailed over the experimental site. The standard week wise weather data on minimum and maximum temperature, relative humidity, bright sunshine hours and total rainfall during the cropping period were collected from the class B Agromet Observatory of Department of Agricultural Meteorology, College of Agriculture, Vellayani and are given in Appendix I and graphically presented in Fig 1.

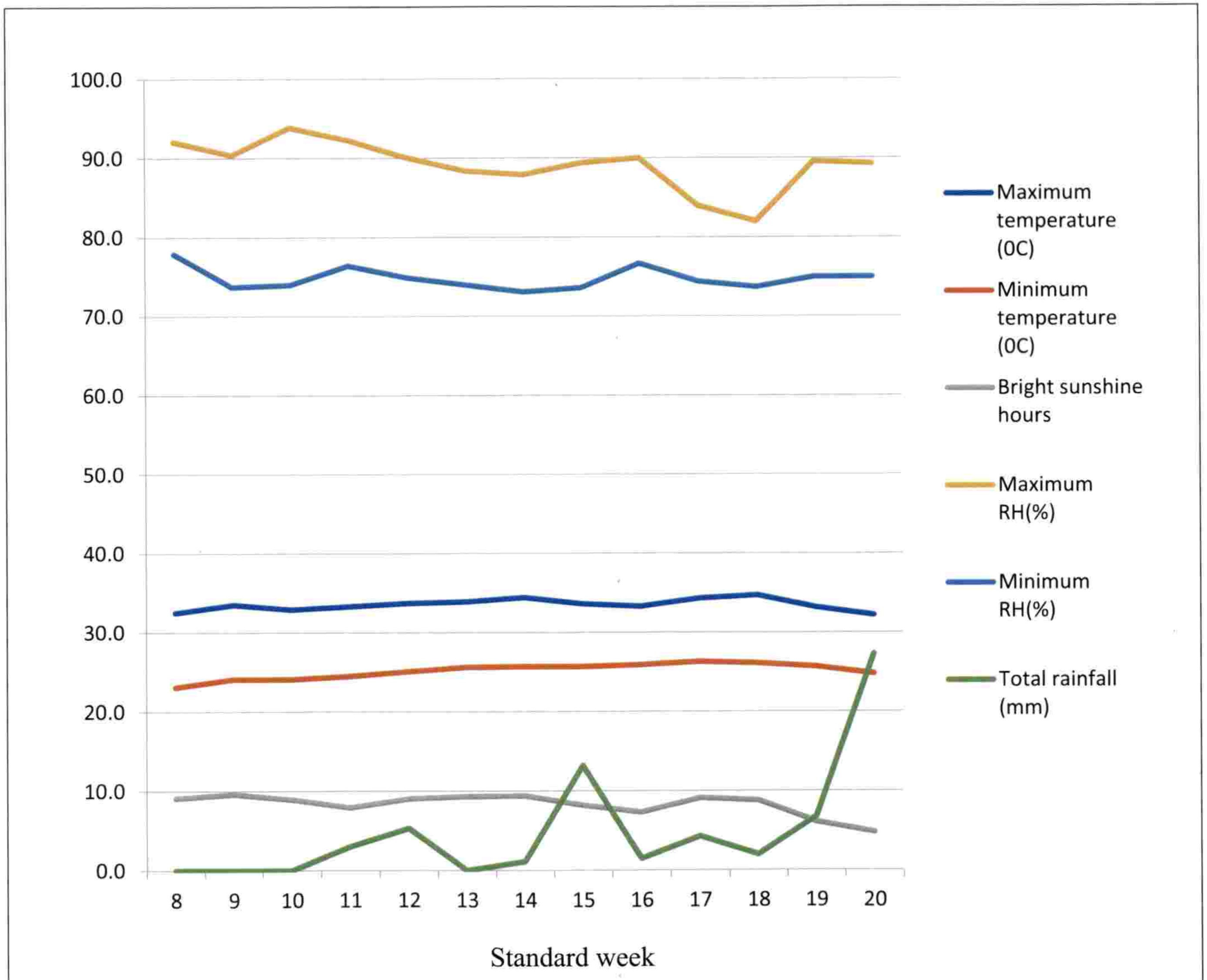


Fig 1. Weather data during the cropping period (February- May 2018)

The mean maximum temperature ranged between 31.7 °C to 34.7 °C and mean minimum temperature ranged between 22.8°C to 26.3°C, mean maximum relative humidity ranged between 82.0 per cent to 94.6 per cent and mean minimum relative humidity ranged between 72.6 per cent to 77.9 per cent. A total rainfall of 178.6 mm was received during the cropping season in 23 days.

3.1.3 Previous cropping history of experimental plot

Cassava was the previous crop of the experimental field.

3.2 MATERIALS

3.2.1 Crop and variety

Baby corn (*Zea mays* L.) is a 6-7 cm long, unfertilized, yellow coloured, young ear of corn plant harvested within 2-3 days of silking (Saha *et al*., 2007). The baby corn variety G-5414 was selected for the experiment which is a hybrid having 55-65 days duration. The variety has uniform sized grains that are creamy or light yellow in colour and was released from Syngenta Seeds Co. Ltd.

3.2.2 Manures

Well decomposed FYM, poultry manure and vermicompost were used as the sources of organic manure in the experiment. The nutrient content of the manures are given in Table 1.

Table 1. Nutrient content of organic manures, per cent

Organic manure	N	P	K
Farm yard manure	0.52	0.63	0.33
Poultry manure	1.87	1.08	2.04
Vermicompost	1.31	1.21	1.55

Table 2. Mechanical composition of the soil of the experimental site

Sl. No.	Fractions	Content (per cent)	Method used
1	Sand	47.44	Bouyoucos hydrometer method (Bouyoucos, 1962)
2	Silt	23.85	
3	Clay	27.81	

Table 3. Chemical properties of the soil of the experimental site

Parameter	Content	Rating	Method used
Soil reaction (pH)	5.07	Strongly acidic	1:2.5 soil solution ratio using pH meter with glass electrode (Jackson, 1973)
Electrical conductivity (dSm^{-1})	0.26	Safe	Digital conductivity meter (Jackson, 1973)
Organic carbon (per cent)	1.35	Medium	Walkley and Black rapid titration method (Jackson, 1973)
Available N ($kg\ ha^{-1}$)	301.06	Medium	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P ($kg\ ha^{-1}$)	96.21	High	Bray colorimetric method (Jackson, 1973)
Available K ($kg\ ha^{-1}$)	225.30	High	Ammonium acetate method (Jackson, 1973)
Available Fe ($mg\ kg^{-1}$)	20.70	Deficient	0.1 M HCL extraction and Atomic Absorption Spectrophotometry (Osiname *et al.*, 1973)
Available Mn ($mg\ kg^{-1}$)	6.00	Deficient	
Available Zn ($mg\ kg^{-1}$)	8.60	Sufficient	
Available Cu ($mg\ kg^{-1}$)	14.80	Sufficient	

3.2.3 Fertilizers

Urea (46 per cent N), Rajphos (20 per cent P_2O_5) and Muriate of potash (60 per cent K_2O) were used as sources of chemical fertilizer for N, P and K respectively.

3.2.4 Biofertilizer

PGPR-1 supplied from the Department of Agricultural Microbiology, College of Agriculture, Vellayani, was used as the biofertilizer, it is a consortium of *Azospirillum lipoferum, Azotobacter chroococcum, Bacillus megaterium* and *Bacillus sporothermodurans.*

3.3 METHODS

3.3.1 Design and Layout

Design : Randomised Block Design

Treatments : (4x2)+1

Replications : 3

Gross plot size: 4.5 m x 4.0 m

Net plot size : 3.60 m x 3.60 m

Variety : G-5414

3.3.1.1 Treatments

N substitution with organic sources (S)

s_1 - 25 % N substitution through poultry manure

s_2 - 25 % N substitution through vermicompost

s_3 -12.5 % N substitution through poultry manure + 12.5 % N substitution through vermicompost

s_4- 25 % N substitution through poultry manure + 25 % N substitution through vermicompost.

Biofertilizer (B)

b_0- Without biofertilizer

b_1- PGPR-1 (seed treatment + soil application)

Control

c - 135 : 65: 45 kg NPK ha^{-1}

Treatment combinations

s_1b_0 s_2b_0 s_3b_0 s_4b_0

s_1b_1 s_2b_1 s_3b_1 s_4b_1

The layout of the field experiment is given in Fig. 2.

3.3.2 Crop Management

3.3.2.1 Land preparation

The experimental area was ploughed with the help of a power tiller and the clods were crushed and brought to fine tilth using a cultivator. Bunds were taken to separate the experimental area into individual plots. Ridges and furrows were formed at a spacing of 45 cm between two ridges.

3.3.2.2 Sowing

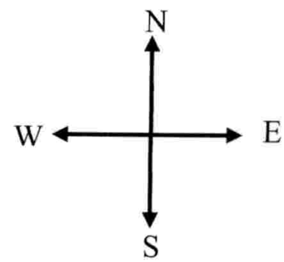
Seeds were dibbled @ of 28 kg ha^{-1} on the ridges taken at 45 cm apart at a spacing of 20 cm between the plants.

3.3.2.3 Application of biofertilizer

Seeds were moistened and treated with PGPR-1 @ 30g kg^{-1} and dried in shade for 15 minutes as per the treatment. Soil application of PGPR-1 @ 110 g m^{-2} area (mixture of dry cowdung and PGPR-1 in 50:1 proportion) was done at the time of sowing and 15 DAS.

3.3.2.4 Weeding and earthing up

In each plot, weeding and earthing up were carried out at 21 and 45 DAS.



Replication 1	Replication 2	Replication 3
s_1b_0	s_3b_1	s_2b_0
s_1b_1	s_4b_0	s_2b_1
s_2b_0	s_4b_1	s_1b_0
s_2b_1	s_3b_0	s_1b_1
s_3b_0	s_1b_1	s_4b_0
s_3b_1	s_2b_0	c
s_4b_0	s_2b_1	s_4b_1
s_4b_1	c	s_3b_0
c	s_1b_0	s_3b_1

Fig 2: Lay out of experiment

Plate 1: General view of experimental plot

3.3.2.5 Irrigation

Irrigation was given on the day of sowing and subsequently at three days interval.

3.3.2.6 De-tasseling

To avoid pollination followed by fertilization, the male inflorescence (tassel) of all the plants in each plot was removed at 40-45 DAS.

3.3.2.7 Harvest

Small, unfertilized cobs were hand-picked at 2-3 days of silk emergence.

3.4 OBSERVATIONS

3.4.1 Growth and growth attributes

Five plants were selected and tagged from each plot as observational plants and from these plants observations were taken and the average was worked out.

3.4.1.1 Plant height

The plant height was taken from the ground level to the uppermost fully opened leaf upto the flowering stage and after flowering stage plant height was recorded from the ground level to the basal end of tassel, at 15 days after emergence (DAE), 30 DAE and 45 DAE and expressed in cm.

3.4.1.2 Leaves per plant

Number of fully expanded and functional leaves was counted at 15, 30 and 45 DAE.


Plate 2: Baby corn at 30 DAS


Plate 3: Tasseling stage


Plate 4: Silking stage


Plate 5: Harvesting of baby corn

3.4.1.3 Leaf area index

The length and width of fully opened leaf lamina was taken and the LAI was calculated as per the formula suggested by Balakrishnan *et al*. (1987) at 15, 30 and 45 DAE.

$$LAI = \frac{L \times B \times K \times N}{\text{Plant spacing(cm)}}$$

L= leaf length

B= leaf breadth

N= total number of leaves per plant

K= constant (0.796)

3.4.1.4 Days to 50 per cent tasseling

Number of days was counted when 50 per cent of plants reached tasselling stage from the date of sowing.

3.4.1.5 Days to 50 per cent silking

Number of days was counted when 50 per cent of plants reached silking stage from the date of sowing.

3.4.1.6 Days to maturity

Number of days taken by the plants to reach the harvestable maturity of the cob was noted.

3.4.1.7 Days to harvest from tasseling

Number of days taken from tassel emergence to reach the harvestable maturity of the cob was noted.

3.4.1.8 Number of harvests

Number of times the cob was harvested from each plot was noted.

3.4.1.9 Dry matter production

The sample plants were uprooted after the final harvest of the cob, shade dried and then oven dried at 60 $\pm$ 5^0c till a constant weight was attained and total DMP was calculated and expressed in t ha^{-1}.

3.4.2 Yield attributes and yield

From the five selected plants in each plot, observations were taken and average was worked out.

3.4.2.1 Cobs per plant

Number of cobs produced per plant was counted from the observational plants and the average value was expressed as number of cobs per plant.

3.4.2.2 Cob length

After removing the husk (dehusking), length was measured from base to the tip of the cob and expressed in cm.

3.4.2.3 Cob girth

The girth of the dehusked cob was measured using a thread and expressed in cm.

3.4.2.4 Cob weight with husk

Weight of the unhusked cob from the five sample plants were measured and the mean was calculated and expressed as g per plant and g per cob.

3.4.2.5 Cob yield with husk

Total yield of the cob (with husk) obtained from each plot was recorded and expressed as t ha^{-1}.

3.4.2.6 Marketable cob yield

Weight of the cob was recorded after removing the outer two to three layers of the husk and expressed in t ha^{-1}.

3.4.2.7 Cob- corn ratio

The ratio between weight of the cob (husked) to the weight of the corn (dehusked) was calculated.

3.4.2.8 Green stover yield

After completion of the final picking, the green stover was cut from each plot and expressed in t ha^{-1}.

3.4.3 Pest and disease incidence

The plants were observed for the attack of pest and disease incidences.

3.5 PLANT ANALYSIS

3.5.1 Chlorophyll content

The chlorophyll content of fresh leaf sample was estimated using the method suggested by Yoshida *et al.* (1976) at 25 and 45 DAS and expressed in mg g^{-1} of leaf tissue.

3.5.2 Crude protein content

The N contents of both cob and stover were estimated and then multiplied by a factor of 6.25 to obtain the crude protein content (Simpson *et al.*, 1965) and expressed in percentage.

Plate 6: Baby cob with husk

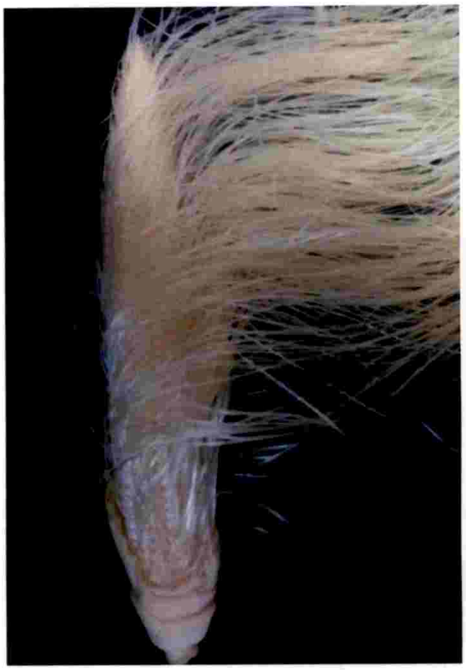


Plate 7: Baby cob with silk

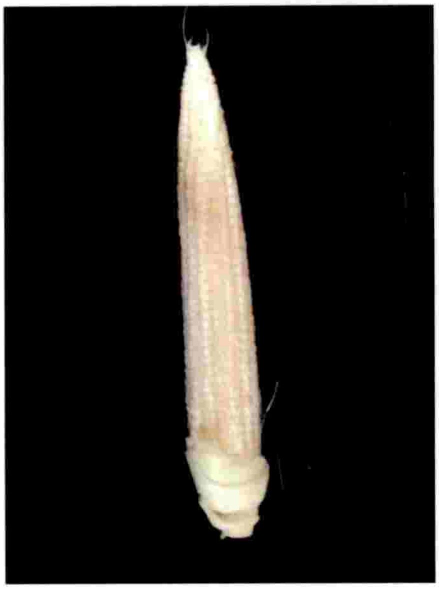


Plate 8: Marketable baby cob

3.5.3 Crude fibre content

Crude fibre contents of cob and stover were estimated as per the method suggested by Sadasivam and Manickam (1996) and expressed in percentage.

3.5.4 Starch content

Starch content of the cob was estimated by using Antrone reagent following the procedure given by Sadasivam and Manickam (1996).

3.5.5 Total soluble sugar

Hand refractometer was used for the measurement of total soluble sugar of the cob (Shobha *et al.*, 2010).

3.5.6 Reducing sugar

The reducing sugar content of the cob was estimated using Fehling solution A and Fehling solution B and expressed in percentage (Sadasivam and Manickam, 1996).

3.5.7 Ascorbic acid

Ascorbic acid content of the fresh cob was estimated using the method suggested by Sadasivam and Manickam (1996) and expressed in mg $100g^{-1}$ of tissue.

3.5.8 Uptake of N, P and K

3.5.8.1 Uptake of nitrogen

The N content was analysed by using the modified microckjeldahl method suggested by Jackson (1973). The N content was then multiplied with total DMP to obtain the uptake and expressed in kg ha^{-1}.

3.5.8.2 Uptake of phosphorus

The P content was analysed by vanadomolybdate phosphoric yellow colour method (Piper, 1966) and the uptake was determined by multiplying it with total DMP.

3.5.8.3 Uptake of potassium

The K content was analysed by using flame photometer method and the uptake was determined by multiplying it with total DMP (Piper, 1966).

3.6 ORGANOLEPTIC STUDY

Organoleptic study was conducted by sensory evaluation using nine point hedonic scale (Appendix II). The cob was salted and kept for 3 minutes and then steam boiled for 5 minutes. The hedonic scale rating was applied for the parameters such as appearance, colour, taste, flavor, texture and overall acceptability. The scoring was done at the Food science laboratory of College of Agriculture, Vellayani by a panel of judges. The judges were requested to taste the samples and mark their scores based on their likeness in the score card (Appendix II).

3.7 SHELF LIFE STUDY

The fresh cob from the sample plants were kept at room temperature. In order to assess the keeping quality of the cobs, the overall visual quality, moisture loss and sensory parameters were analysed on 3^{rd} day and 6^{th} day of storage.

3.8 SOIL ANALYSIS

Representative soil samples were collected from the plot before and after the crop and the samples were analysed.

3.8.1 pH

The pH of the soil sample was found out by diluting with water in the ratio 1:2.5 and analysing using pH meter (Jackson, 1973).

3.8.2 Electrical conductivity

Electrical conductivity of soil sample was found out using conductivity meter (Jackson, 1973).

3.8.3 Organic carbon

Organic carbon content was estimated using Walkley and Black Rapid titration method (Jackson, 1973) and expressed in percentage.

3.8.4 Available nitrogen

Available N content of soil sample was analysed using alkaline permanganate method suggested by Subbiah and Asija (1956) and expressed in kg ha^{-1}.

3.8.5 Available phosphorus

Available P content of soil sample was analysed by using Bray colorimetric method (Jackson, 1973) and expressed as P in kg ha^{-1}.

3.8.6 Available potassium

Available K content was estimated by extracting the soil sample with neutral normal ammonium acetate and estimated using flame photometer (Jackson, 1973) and expressed as K in kg ha^{-1}.

3.8.7 Micronutrient analysis

The content Fe, Mn, Zn and Cu in the soil sample were analysed using Atomic Absorption Spectrophotometry (Osiname *et al.*, 1973)

3.9 ECONOMIC ANALYSIS

3.9.1 Net income

Cost of cultivation was deducted from gross returns to obtain the net income

Net income (₹ ha^{-1}) = gross returns (₹ ha^{-1}) - cost of cultivation (₹ ha^{-1})

3.9.2 Benefit :cost ratio

The benefit-cost ratio (BCR)was worked out by using the following formula

$$\text{B:C Ratio} = \frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

3.10STATISTICAL ANALYSIS

Data generated were statistically analysed using analysis of variance technique (ANOVA), suggested by Panse and Sukhatme (1985) as applied to randomised block design. The significance was tested using f test (Snecdeore and Cochran, 1967). Critical difference was worked out at 5 per cent level of probability, wherever the treatment differences were found significant. For the organoleptic and shelf life studies, Kruskal Wallis test was adopted to get the mean rank values for all the treatments at 5 per cent level of significance. The significance of treatment mean *vs* control mean was tested by calculating the f value. The f value was calculated by subtracting factorial sum of squares from treatment sum of squares and then dividing with error sum of squares.

RESULTS

4. RESULTS

The project entitled "Integrated nutrient management in baby corn (*Zea mays* L.)" was conducted at College of Agriculture, Vellayani, Thiruvananthapuram during February to April 2018. The main objective of the study was to investigate the influence of INM practices on growth, yield, nutritive quality, storage life and economics of cultivation of baby corn. The results of the experiments are presented in this chapter.

4.1 GROWTH AND GROWTH ATTRIBUTES

4.1.1 Plant height

The main effect and interaction effect of INM practices on plant height of baby corn at 15, 30 and 45 DAE are given in Table 4.

Nitrogen substitution with organic sources did not influence the plant height at 15, 30 or 45 DAE.

Application of biofertilizer however had significant effect on the plant height at 15 and 45 DAE though there was no significant effect at 30 DAE. Application of biofertilizer (PGPR-1) produced taller plants at 15 DAE (14.64 cm) and 45 DAE (107.93 cm) which was found to be superior to the plant height produced without biofertilizer application or b_0 (12.23 cm and 101.57 cm at 15 and 45 DAE respectively).

The S x B interaction significantly influenced the plant height only at 45 DAE. The treatment s_3b_1 (12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1 along with 75 per cent RDN) resulted in significantly higher plant height (112.18 cm) compared to s_1b_1 (100.49 cm), s_3b_0 (98.49 cm) and s_2b_0 (97.90 cm). The treatment s_3b_1 was also found to be on par with s_4b_1 (110.05 cm), s_2b_1 (108.93 cm), s_1b_0 (105.77 cm) and s_4b_0 (104.13 cm) and these treatments were also on par with each other with respect to plant height. Among the interaction effects, shorter plants were produced (97.90 cm) with s_2b_0 treatment (25 per cent N substitution through vermicompost + 75 per cent RDN without biofertilizer).

Table 4. Effect of N substitution with organic sources, biofertilizer and their interaction on plant height of baby corn, cm.

Treatments	Plant height		
	15 DAE	30 DAE	45 DAE
N substitution with organic sources (S)			
s_1 (25 % N through PM)	13.76	63.35	103.13
s_2 (25 % N through VC)	13.59	61.57	103.41
s_3 (12.5% N through PM + 12.5 % N through VC)	13.17	67.20	105.34
s_4 (25% N through PM + 25 % N through VC)	13.23	64.05	107.09
SEm (±)	1.08	3.78	1.99
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	12.23	61.02	101.57
b_1 (PGPR-1 seed treatment + soil application)	14.64	67.07	107.93
SEm (±)	0.77	2.67	1.41
CD (0.05)	2.360	NS	4.318
S x B interaction			
s_1b_0	13.58	64.55	105.77
s_1b_1	13.93	62.15	100.49
s_2b_0	12.34	59.78	97.90
s_2b_1	14.84	63.37	108.93
s_3b_0	10.00	59.35	98.49
s_3b_1	16.34	75.06	112.18
s_4b_0	12.99	60.39	104.13
s_4b_1	13.46	67.70	110.05
SEm (±)	1.54	5.35	2.82
CD (0.05)	NS	NS	8.635
Treatment mean	13.44	64.04	104.74
Control mean	14.44	76.35	111.98
Treatment *vs*. Control	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

While comparing the treatments with control (135: 65: 45 kg NPK ha^{-1} through chemical fertilizers) it was observed that there was no significant difference between the treatments and control in the case of plant height at 15, 30 or 45 DAE.

4.1.2 Leaves per plant

Results of the influence of main effects and interaction effect of integrated management practices on number of leaves per plant in baby corn at 15, 30 and 45 DAE are shown in Table 5.

The number of leaves per plant was not significantly affected by N substitution with organic sources at 15, 30 or 45 DAE of the crop.

Biofertilizer application had significant influence on the number of leaves per plant only at 45 DAE. Higher number of leaves per plant (11.7) was observed in the case of b_1 (PGPR-1 seed treatment and soil application) compared to no biofertilizer application or b_0 (11.37).

The S x B interaction had no significant effect on the number of leaves per plant during any stage of observation. The treatments and control (135: 65: 45 kg NPK ha^{-1} through chemical fertilizers) did not show any significant variation with respect to leaves per plant.

4.1.3 Leaf area index

Influence of N substitution with organic sources and biofertilizer on LAI of baby corn at 15, 30 and 45 DAE are presented in Table 6.

The main effect of N substitution with organic sources could not significantly influence the LAI at any of the stage of observation.

Significantly higher LAI of 2.61 was obtained with biofertilizer treatment compared to no biofertilizer application (2.19) at 30 DAE.

Table 5. Effect of N substitution with organic sources, biofertilizer and their interaction on leaves per plant of baby corn.

Treatments	Leaves per plant		
	15 DAE	30 DAE	45 DAE
N substitution with organic sources (S)			
s_1 (25 % N through PM)	5.80	7.96	11.57
s_2 (25 % N through VC)	5.83	8.42	11.47
s_3 (12.5% N through PM + 12.5 % N through VC)	5.57	8.88	11.60
s_4 (25% N through PM + 25 % N through VC)	5.80	8.38	11.50
SEm (±)	0.39	0.39	0.09
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	5.73	8.50	11.37
b_1 (PGPR-1 seed treatment + soil application)	5.77	8.31	11.70
SEm (±)	0.28	0.28	0.06
CD (0.05)	NS	NS	0.202
S x B interaction			
s_1b_0	5.47	8.50	11.47
s_1b_1	6.13	7.42	11.67
s_2b_0	5.53	7.92	11.40
s_2b_1	6.13	8.92	11.53
s_3b_0	6.53	9.17	11.33
s_3b_1	4.60	8.58	11.87
s_4b_0	5.40	8.42	11.27
s_4b_1	6.20	8.33	11.73
SEm (±)	0.55	0.56	0.13
CD (0.05)	NS	NS	NS
Treatment mean	5.75	8.41	11.53
Control mean	6.40	8.58	11.67
Treatment *vs*. Control	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

Table 6. Effect of N substitution with organic sources, biofertilizer and their interaction on leaf area index of baby corn.

Treatments	Leaf area index		
	15 DAE	30 DAE	45 DAE
N substitution with organic sources (S)			
s_1 (25 % N through PM)	0.34	2.42	4.56
s_2 (25 % N through VC)	0.33	2.53	4.67
s_3 (12.5% N through PM + 12.5 % N through VC)	0.32	2.37	5.18
s_4 (25% N through PM + 25 % N through VC)	0.42	2.30	5.14
SEm (±)	0.04	0.18	0.24
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	0.33	2.19	4.77
b_1 (PGPR-1 seed treatment + soil application)	0.37	2.61	5.00
SEm (±)	0.03	0.14	0.17
CD (0.05)	NS	0.388	NS
S x B interaction			
s_1b_0	0.32	2.29	4.45
s_1b_1	0.35	2.55	4.67
s_2b_0	0.25	2.10	4.49
s_2b_1	0.40	2.95	4.84
s_3b_0	0.34	2.03	5.01
s_3b_1	0.29	2.70	5.34
s_4b_0	0.38	2.35	5.13
s_4b_1	0.45	2.25	5.14
SEm (±)	0.05	0.25	0.33
CD (0.05)	NS	NS	NS
Treatment mean	0.35	2.40	4.88
Control mean	0.45	2.50	5.31
Treatment *vs*. Control	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

Leaf area index was not significantly affected by the interaction (S x B) and there was no significant difference between the LAI of treatment plants and control plants at all stages of observation.

4.1.4 Days to 50 per cent tasseling

The result on the effect of N substitution with organic sources, biofertilizer and their interaction on days to 50 per cent tasseling is indicated in Table 7.

The main effect of N substitution with organic sources and biofertilizer did not have any effect on the duration taken by the plants to reach 50 per cent tasseling.

The S x B interaction had significant influence on days to 50 per cent tasseling. The treatment s_2b_0 (25 per cent N substitution through vermicompost + 75 per cent RDN through chemical fertilizer) was found to take greater number of days (47.67 days) for 50 per cent tasseling which was found to be on par with all other treatments except s_4b_0 and s_3b_1 which required significantly less number of days (46 and 45.67 days respectively) than s_2b_0.

There was no significant difference between treatments and control with respect to days to 50 per cent tasseling.

4.1.5 Days to 50 per cent silking

Table 7 represents the results of days to 50 per cent silking under the influence of main effects and interaction effect of the treatments.

The main effects or their interaction could not significantly influence the days taken by the plants to reach 50 per cent silking. The treatments and the control did not differ each other in the case of days to 50 per cent silking.

4.1.6 Days to maturity

The effect of INM practices on the days to maturity is given in Table 7.

Table 7. Effect of N substitution with organic sources, biofertilizer and their interaction on days to 50 per cent tasseling, days to 50 per cent silking and days to maturity of baby corn.

Treatments	Days to 50 per cent tasseling	Days to 50 per cent silking	Days to maturity
N substitution with organic sources (S)			
s_1 (25 % N through PM)	46.83	49.33	52.33
s_2 (25 % N through VC)	47.00	48.83	52.67
s_3 (12.5% N through PM + 12.5 % N through VC)	46.17	49.00	52.17
s_4 (25% N through PM + 25 % N through VC)	46.50	48.83	52.50
SEm (±)	0.33	0.41	0.46
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	46.67	49.17	52.67
b_1 (PGPR-1 seed treatment + soil application)	46.58	48.83	52.17
SEm (±)	0.23	0.29	0.33
CD (0.05)	NS	NS	NS
S x B interaction			
s_1b_0	46.33	49.00	51.67
s_1b_1	47.33	49.67	53.00
s_2b_0	47.67	49.67	53.33
s_2b_1	46.33	48.00	52.00
s_3b_0	46.67	49.33	53.00
s_3b_1	45.67	48.67	51.33
s_4b_0	46.00	48.67	52.67
s_4b_1	47.00	49.00	52.33
SEm (±)	0.46	0.58	0.65
CD (0.05)	1.418	NS	NS
Treatment mean	46.62	49.00	52.42
Control mean	46.00	48.00	51.00
Treatment *vs*. Control	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

The main effects or interaction could not significantly influence the days to maturity of the crop. There was no significant difference between treatments and the control with respect to number of days taken for crop maturity.

4.1.7 Days to harvest from tasseling

The results of the influence of main effects and their interaction on days to harvest from tasseling are indicated in Table 8.

None of the treatments could significantly affect the days to harvest from tasseling. The treatment plants and control plants also did not significantly differ each other with respect to days to harvest from tasseling.

4.1.8 Number of harvests

The effect of N substitution with organic sources, biofertilizer and their interaction on the number of harvests is given in Table 8.

It was observed that three harvests were taken from each plot irrespective of the treatments.

4.1.9 Dry matter production at harvest

The results of the influence of main and interaction effects of INM practices on DMP of baby corn at harvest are indicated in Table 9.

Nitrogen substitution with organic sources did not significantly influence the DMP at harvest.

Application of biofertilizer could however influence the DMP of the plants at harvest. The highest DMP (18.2 t ha^{-1}) was recorded with b_1 (PGPR-1 seed treatment + soil application) which was superior to without biofertilizer treatment (16.7 t ha^{-1}).

The S x B interaction significantly influenced the DMP of the crop at harvesting stage. The s_3b_1 treatment (75 per cent RDN +12.5 per cent N substitution through

Table 8. Effect of N substitution with organic sources, biofertilizer and their interaction on days to harvest and number of harvests of baby corn.

Treatments	Days to harvest from tasseling	Number of harvests*
N substitution with organic sources (S)		
s_1 (25 % N through PM)	6.17	3
s_2 (25 % N through VC)	5.83	3
s_3 (12.5% N through PM + 12.5 % N through VC)	6.50	3
s_4 (25% N through PM + 25 % N through VC)	6.33	3
SEm (±)	0.32	-
CD (0.05)	NS	-
Biofertilizer (B)		
b_0 (Without biofertilizer)	6.25	3
b_1 (PGPR-1 seed treatment + soil application)	6.17	3
SEm (±)	0.23	-
CD (0.05)	NS	-
S x B interaction		
s_1b_0	6.33	3
s_1b_1	6.33	3
s_2b_0	6.33	3
s_2b_1	6.00	3
s_3b_0	6.67	3
s_3b_1	6.00	3
s_4b_0	6.67	3
s_4b_1	6.00	3
SEm (±)	0.46	-
CD (0.05)	NS	-
Treatment mean	6.29	3
Control mean	5.67	3
Treatment *vs.* Control	NS	NS

PM- Poultry manure, VC- Vermicompos *statistically not analysed

Table 9. Effect of N substitution with organic sources, biofertilizer and their interaction on dry matter production of baby corn at harvest, t ha^{-1}.

Treatments	Dry matter production at harvest
N substitution with organic sources (S)	
s_1 (25 % N through PM)	16.29
s_2 (25 % N through VC)	17.59
s_3 (12.5% N through PM + 12.5 % N through VC)	17.70
s_4 (25% N through PM + 25 % N through VC)	18.22
SEm (±)	0.567
CD (0.05)	NS
Biofertilizer (B)	
b_0 (Without biofertilizer)	16.70
b_1 (PGPR-1 seed treatment + soil application)	18.20
SEm (±)	0.40
CD (0.05)	1.225
S x B interaction	
s_1b_0	14.03
s_1b_1	18.55
s_2b_0	18.17
s_2b_1	17.00
s_3b_0	15.47
s_3b_1	19.94
s_4b_0	19.13
s_4b_1	17.32
SEm (±)	0.76
CD (0.05)	2.289
Treatment mean	17.45
Control mean	18.16
Treatment *vs*. Control	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) produced significantly higher DMP (19.94 t ha^{-1}) compared to s_4b_1 (17.32 t ha^{-1}), s_2b_1 (17 t ha^{-1}), s_3b_0 (15.47 t ha^{-1}) and s_1b_0 (14.03 t ha^{-1}). However, it was found to be on par with s_4b_0 (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost), s_1b_1 (75 per cent RDN + 25 per cent N substitution through poultry manure + PGPR-1) and s_2b_0 (75 per cent RDN + 25 per cent N substitution through vermicompost), which resulted in a DMP of 19.13, 18.55 and 18.17 t ha^{-1} respectively.

The treatments and the control (135: 65: 45 kg NPK ha^{-1} through chemical fertilizers) did not vary significantly with respect to DMP.

4.2 YIELD ATTRIBUTES AND YIELD

4.2.1 Cobs per plant

The data on the number of cobs per plant as influenced by N substitution with organic sources, biofertilizer and their interaction is presented in Table 10.

The number of cobs per plant was unaffected by N substitution with organic sources or biofertilizer application and their interaction. However, the crop was observed to produce three cobs per plant uniformly in all the treatments including the control.

4.2.2 Cob length

The influence of N substitution with organic sources, biofertilizer and their interaction on cob length of baby corn are given in Table 10.

It was observed that the cob length was not significantly influenced either by main effects or their interaction. Treatments and the control also had the same effect on cob length.

Table 10. Effect of N substitution with organic sources, biofertilizer and their interaction on cobs per plant, cob length and cob girth of baby corn.

Treatments	Cobs per plant*	Cob length (cm)	Cob girth (cm)
N substitution with organic sources (S)			
s_1 (25 % N through PM)	3	11.12	5.31
s_2 (25 % N through VC)	3	10.90	5.24
s_3 (12.5% N through PM + 12.5 % N through VC)	3	11.37	5.35
s_4 (25% N through PM + 25 % N through VC)	3	10.72	5.28
SEm (±)	-	0.38	0.06
CD (0.05)	-	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	3	10.78	5.26
b_1 (PGPR-1 seed treatment + soil application)	3	11.27	5.33
SEm (±)	-	0.27	0.05
CD (0.05)	-	NS	NS
S x B interaction			
s_1b_0	3	10.93	5.32
s_1b_1	3	11.31	5.30
s_2b_0	3	10.70	5.16
s_2b_1	3	11.10	5.32
s_3b_0	3	10.81	5.31
s_3b_1	3	11.93	5.39
s_4b_0	3	10.72	5.27
s_4b_1	3	10.73	5.29
SEm (±)	-	0.53	0.09
CD (0.05)	-	NS	NS
Treatment mean	3	11.03	5.29
Control mean	3	11.19	5.36
Treatment *vs*. Control	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant *statistically not analysed

4.2.3 Cob girth

The results of the influence of main effects and their interaction effect on cob girth are furnished in Table 10.

The main effects or their interaction did not affect the cob girth of baby corn. There was no difference between the treatments and control with respect to cob girth.

4.2.4 Cob weight with husk

The data on cob weight with husk as influenced by N substitution with organic sources, biofertilizer and their interaction is given in Table 11.

Nitrogen substitution with organic sources could not influence the cob weight with husk per plant or per cob.

Application of biofertilizer (PGPR- 1) was found to have a significant influence on the cob weight with husk. Significantly higher cob weight with husk (244.33 g per plant and 81.44 g per cob) was obtained with b_1 (PGPR-1 seed treatment and soil application) and than b_0 (without biofertilizer) which produced a cob weight with husk of 236.25 g per plant and 78.80 g per cob.

The S x B interaction was found to have a significant influence on the cob weight with husk, both in terms of g per plant and g per cob. The treatment s_3b_1 (75 per cent RDN +12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) produced significantly higher cob weight (255.33 g per plant and 85.11 g per cob) but was on par with s_2b_1 (243.67 g per plant and 81.22 g per cob).

There was no significant variation between cob weight with husk produced by the treatments and control (135: 65: 45 kg NPK ha^{-1} through chemical fertilizers).

Table 11. Effect of N substitution with organic sources, biofertilizer and their interaction on cob weight and cob yield with husk of baby corn.

Treatments	Cob weight with husk (g per plant)	Cob weight with husk (g per cob)	Cob yield with husk (t ha^{-1})
N substitution with organic sources (S)			
s_1 (25 % N through PM)	240.50	80.27	21.48
s_2 (25 % N through VC)	237.00	79.00	21.97
s_3 (12.5% N through PM + 12.5 % N through VC)	245.50	81.83	22.92
s_4 (25% N through PM + 25 % N through VC)	238.17	79.39	20.30
SEm (±)	2.93	0.95	0.76
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	236.25	78.80	21.00
b_1 (PGPR-1 seed treatment + soil application)	244.33	81.44	22.33
SEm (±)	2.07	0.67	0.54
CD (0.05)	6.352	2.066	NS
S x B interaction			
s_1b_0	238.33	79.44	19.99
s_1b_1	242.67	80.89	22.97
s_2b_0	230.33	76.78	21.17
s_2b_1	243.67	81.22	22.76
s_3b_0	235.67	78.55	21.10
s_3b_1	255.33	85.11	24.74
s_4b_0	240.67	80.22	21.75
s_4b_1	235.67	78.55	18.84
SEm (±)	4.15	1.34	1.07
CD (0.05)	12.704	4.133	3.274
Treatment mean	240.29	80.09	21.66
Control mean	247.33	82.44	21.67
Treatment *vs*. Control	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

4.2.5 Cob yield with husk

The data on cob yield with husk as influenced by the N substitution with organic sources, biofertilizer and their interaction are indicated in Table 11.

Cob yield with husk was not influenced by the N substitution with organic sources and the biofertilizer application.

The S x B interaction was however found to be significant with respect to cob yield with husk. The s_3b_1 (75 per cent RDN +12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) produced significantly higher cob yield with husk (24.74 t ha^{-1}) compared to s_2b_0 (21.17 t ha^{-1}), s_3b_0 (21.1 t ha^{-1}), s_1b_0 (19.99 t ha^{-1}) and s_4b_1 (18.84 t ha^{-1}) and was on par with s_1b_1, s_2b_1 and s_4b_0 which produced a cob yield with husk of 22.97, 22.76 and 21.75 t ha^{-1} respectively.

The treatments and control did vary each other in case of cob yield with husk of baby corn.

4.2.6 Marketable cob yield

The results of the influence of main effects of INM treatments and their interaction on the marketable cob yield of baby corn are furnished in Table 12.

Nitrogen substitution with organic sources did not influence the marketable cob yield. However, it was significantly affected by biofertilizer application. The biofertilizer treatment with PGPR-1 (b_1) produced significantly higher marketable cob yield (5.82 t ha^{-1}) than the treatment without biofertilizer application (b_0) which produced a marketable cob yield of 4.89 t ha^{-1} only.

The S x B interaction produced significant effect on the marketable cob yield of baby corn. Among the different interactions, the highest marketable cob yield (6.79 t ha^{-1}) was produced by s_2b_1 (75 per cent RDN + 25 per cent N substitution

Table 12. Effect of N substitution with organic sources, biofertilizer and their interaction on marketable cob yield and cob-corn ratio of baby corn.

Treatments	Marketable cob yield (t ha^{-1})	Cob-corn ratio
N substitution with organic sources (S)		
s_1 (25 % N through PM)	5.32	4.07
s_2 (25 % N through VC)	5.72	4.42
s_3 (12.5% N through PM + 12.5 % N through VC)	5.53	4.09
s_4 (25% N through PM + 25 % N through VC)	4.85	4.34
SEm (±)	0.30	0.24
CD (0.05)	NS	NS
Biofertilizer (B)		
b_0 (Without biofertilizer)	4.89	4.39
b_1 (PGPR-1 seed treatment + soil application)	5.82	4.06
SEm (±)	0.21	0.18
CD (0.05)	0.643	NS
S x B interaction		
s_1b_0	4.67	4.27
s_1b_1	5.96	3.87
s_2b_0	4.64	4.63
s_2b_1	6.79	4.20
s_3b_0	4.94	4.35
s_3b_1	6.13	3.82
s_4b_0	5.30	4.32
s_4b_1	4.40	4.36
SEm (±)	0.42	0.34
CD (0.05)	1.285	NS
Treatment mean	5.35	4.23
Control mean	6.03	3.58
Treatment *vs*. Control	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

through vermicompost + PGPR-1) which was superior to all other treatments except s_3b_1 (6.13 t ha^{-1}) and s_1b_1 (5.96 t ha^{-1}) which had an on par relationship with s_2b_1.

There was no significant variation between treatments and control (135: 65: 45 kg NPK ha^{-1} through chemical fertilizers) with respect to marketable cob yield. However, the control also produced a high of marketable cob yield of 6.03 t ha^{-1}.

4.2.7 Cob-corn ratio

The effect of N substitution with organic sources, biofertilizers and their interaction on the cob - corn ratio are presented in Table 12.

The main effects of INM practices or their interaction had no influence on cob -corn ratio of baby corn. The treatments and control also had the same effect on cob - corn ratio.

4.2.8 Green stover yield

The data on green stover yield as influenced by the N substitution with organic sources, biofertilizer and their interactions are indicated in Table 13.

The main effects or the interaction effect of the INM practices could not influence the green stover yield of baby corn at harvest. There was no significant difference between control and treatments with respect to green stover yield.

4.3 PEST AND DISEASE INCIDENCE

There was no attack of pest, but the incidence of disease (sheath blight) was observed during the crop growing season. The disease was managed by spraying Bavisitin @ 2 g L^{-1} in all the treatment plots.

Table 13. Effect of N substitution with organic sources, biofertilizer and their interaction on green stover yield of baby corn, t ha^{-1}.

Treatments	Green stover yield
N substitution with organic sources (S)	
s_1 (25 % N through PM)	29.68
s_2 (25 % N through VC)	30.22
s_3 (12.5% N through PM + 12.5 % N through VC)	31.47
s_4 (25% N through PM + 25 % N through VC)	30.34
SEm (±)	1.54
CD (0.05)	NS
Biofertilizer (B)	
b_0 (Without biofertilizer)	29.54
b_1 (PGPR-1 seed treatment + soil application)	31.31
SEm (±)	1.09
CD (0.05)	NS
S x B interaction	
s_1b_0	28.03
s_1b_1	31.33
s_2b_0	30.45
s_2b_1	29.99
s_3b_0	28.99
s_3b_1	33.95
s_4b_0	30.70
s_4b_1	29.98
SEm (±)	2.17
CD (0.05)	NS
Treatment mean	30.43
Control mean	31.67
Treatment *vs*. Control	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

4.4 PLANT ANALYSIS

4.4.1 Chlorophyll content

The data on the chlorophyll content as influenced by the N substitution with organic sources, biofertilizer and their interaction are furnished in Table 14.

No significant effect was produced by the treatments or their interaction on the chlorophyll content of the plant leaves at 25 and 45 DAS. The treatments and the control produced the same effect on chlorophyll content at both 25 and 45 DAS.

4.4.2 Crude protein content

The data on the crude protein content in cob and stover as influenced by the N substitution with organic sources, biofertilizer and their interaction are presented in Table 15.

Neither the main effects of INM practices or their interaction could influence the crude protein content of both cob and stover of baby corn. The treatments and the control had the same effect on crude protein content of cob and stover.

4.4.3 Crude fibre content

The influence of N substitution with organic sources, biofertilizer and their interaction on the crude fibre content of baby corn cob and stover are shown in Table 15.

It was observed that the crude fibre content of both cob and stover was not significantly influenced by main effects or their interactions. The treatments did not vary from the control in its effect on crude fibre content.

Table 14. Effect of N substitution with organic sources, biofertilizer and their interaction on chlorophyll content of baby corn, mg g^{-1}.

Treatments	Chlorophyll content	
	25 DAS	45 DAS
N substitution with organic sources (S)		
s_1 (25 % N through PM)	0.63	1.64
s_2 (25 % N through VC)	0.60	1.77
s_3 (12.5% N through PM + 12.5 % N through VC)	0.69	1.33
s_4 (25% N through PM + 25 % N through VC)	0.63	1.43
SEm (±)	0.069	0.167
CD (0.05)	NS	NS
Biofertilizer (B)		
b_0 (Without biofertilizer)	0.62	1.61
b_1 (PGPR-1 seed treatment + soil application)	0.65	1.47
SEm (±)	0.048	0.118
CD (0.05)	NS	NS
S x B interaction		
s_1b_0	0.68	1.80
s_1b_1	0.58	1.48
s_2b_0	0.57	1.78
s_2b_1	0.63	1.76
s_3b_0	0.61	1.28
s_3b_1	0.77	1.37
s_4b_0	0.64	1.58
s_4b_1	0.62	1.26
SEm (±)	0.094	0.231
CD (0.05)	NS	NS
Treatment mean	0.64	1.54
Control mean	0.56	1.71
Treatment *vs*. Control	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

Table 15. Effect of N substitution with organic sources, biofertilizer and their interaction on crude protein and crude fibre content of baby corn, per cent.

Treatments	Crude protein content		Crude fibre content	
	Cob	Stover	Cob	Stover
N substitution with organic sources (S)				
s_1 (25 % N through PM)	13.83	7.58	6.25	27.82
s_2 (25 % N through VC)	13.36	7.23	6.57	26.55
s_3 (12.5% N through PM + 12.5 % N through VC)	14.12	8.58	6.10	30.10
s_4 (25% N through PM + 25 % N through VC)	13.70	7.29	6.27	31.83
SEm (±)	0.541	0.437	0.385	1.373
CD (0.05)	NS	NS	NS	NS
Biofertilizer (B)				
b_0 (Without biofertilizer)	14.12	7.90	6.11	29.59
b_1 (PGPR-1 seed treatment + soil application)	13.39	7.44	6.48	28.56
SEm (±)	0.383	0.309	0.272	0.971
CD (0.05)	NS	NS	NS	NS
S x B interaction				
s_1b_0	14.00	7.82	6.20	31.30
s_1b_1	13.65	7.35	6.30	24.33
s_2b_0	13.53	7.35	6.70	26.50
s_2b_1	13.18	7.12	6.43	26.60
s_3b_0	14.35	8.87	5.47	29.93
s_3b_1	13.88	8.28	6.73	30.27
s_4b_0	14.58	7.58	6.07	30.63
s_4b_1	12.83	7.00	6.47	33.03
SEm (±)	0.765	0.618	0.545	1.942
CD (0.05)	NS	NS	NS	NS
Treatment mean	13.75	7.67	6.30	29.07
Control mean	13.18	8.05	6.83	27.90
Treatment *vs*. Control	NS	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

4.4.4 Starch content

The result on the effect of INM practices on starch content of cob is given in Table 16.

The starch content of cob was not significantly influenced by the main effects or their interaction. The treatments and the control had the same effect on starch content of cob.

4.4.5 Total soluble sugar content

The data on the effect of INM practices on the total soluble sugar content of the baby corn cob is indicated in Table 16.

Nitrogen substitution with organic sources did not significantly influence the total soluble sugar content of cob.

Application of biofertilizer (b_1) had significant effect on the total soluble sugar content. Significantly higher sugar content (6.86 °Brix) was obtained by seed treatment and soil application of biofertilizer PGPR-1 compared to b_0 (without biofertilizer) which could produce a total soluble sugar content of 6.28 °Brix only.

The S x B interaction had no significant influence on total soluble sugar content. The INM treatments and the control produced similar effect on total soluble sugar content of baby corn.

4.4.6 Reducing sugar content

Effect of N substitution with organic sources, biofertilizer and their interaction on reducing sugar content in the cob are shown in Table 16.

Nitrogen substitution with organic sources did not significantly influence the reducing sugar content of cob.

Table 16. Effect of N substitution with organic sources, biofertilizer and their interaction on starch content, total soluble sugar, reducing sugar and ascorbic acid content of baby corn cob.

Treatments	Starch content (%)	Total soluble sugar (^{0}B)	Reducing sugar (%)	Ascorbic acid (mg g^{-1})
N substitution with organic sources (S)				
s_1 (25 % N through PM)	6.63	6.43	2.49	8.67
s_2 (25 % N through VC)	7.59	6.56	2.63	10.67
s_3 (12.5% N through PM + 12.5 % N through VC)	7.16	6.67	2.76	9.56
s_4 (25% N through PM + 25 % N through VC)	7.71	6.62	2.63	8.67
SEm (±)	0.39	0.12	0.24	0.50
CD (0.05)	NS	NS	NS	1.522
Biofertilizer (B)				
b_0 (Without biofertilizer)	6.97	6.28	2.36	8.78
b_1 (PGPR-1 seed treatment + soil application)	7.57	6.86	2.89	10.00
SEm (±)	0.27	0.08	0.17	0.35
CD (0.05)	NS	0.258	0.526	1.076
S x B interaction				
s_1b_0	6.25	6.23	2.09	8.44
s_1b_1	7.00	6.63	2.90	8.89
s_2b_0	7.36	6.33	2.39	9.78
s_2b_1	7.82	6.78	2.87	11.56
s_3b_0	6.66	6.43	2.75	8.89
s_3b_1	7.67	6.90	2.76	10.22
s_4b_0	7.61	6.13	2.23	8.00
s_4b_1	7.80	7.11	3.02	9.33
SEm (±)	0.54	0.17	0.34	0.70
CD (0.05)	NS	NS	NS	NS
Treatment mean	7.27	6.57	2.62	9.39
Control mean	7.49	6.67	2.91	9.33
Treatment *vs*. Control	NS	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

However, the biofertilizer application with PGPR-1 produced significantly higher reducing sugar content of cob (2.89 per cent) in comparison with no biofertilizer treatment (2.36 per cent).

Reducing sugar content of cob was unaffected by the interaction effect. The treatments and control did not significantly vary with respect to reducing sugar content of cob.

4.4.7 Ascorbic acid content

Influence of N substitution with organic sources, biofertilizer and their interactions on ascorbic acid content of the cob is given in Table 16.

The N substitution with organic sources had a significant effect on the ascorbic acid content of the cob. Among different treatments, the s_2 (25 per cent N substitution through vermicompost) produced significantly higher ascorbic acid content (10.67 mg g^{-1}) than s_1 (25 per dent N through poultry manure) or s_4 (25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost) which could produce an ascorbic acid content of 8.67 mg g^{-1} only. The s_2 treatment which produced the highest ascorbic acid content was however found to be on par with the s_3 treatment (12.5 per cent N through poultry manure + 12.5 per cent N through vermicompost) which produced a content of 9.56 mg g^{-1} ascorbic acid which in turn did not vary from s_1 or s_4.

Application of biofertilizer (PGPR-1) produced significantly higher ascorbic acid content of 10 mg g^{-1} compared no biofertilizer application or b_0 (8.78 mg g^{-1}).

The S x B interaction could not influence the ascorbic acid content of the cob. The ascorbic acid content produced by the treatments did not statistically differ from that produced by the control.

4.4.8 Uptake of N, P and K

The results on the effect of INM practices and their interaction on uptake of N, P and K are presented in Table 17.

4.4.8.1 Uptake of N

The main effects or their interaction could not significantly influence the uptake of N. The treatments and the control did not vary significantly with respect to the N uptake of baby corn.

4.4.8.2 Uptake of P

The P uptake was not significantly influenced by the effect of N substitution, biofertilizer and their interaction. The treatments and the control did not statistically differ in the case of P uptake.

4.4.8.3 Uptake of K

The main effects of INM practices did not influence the uptake of K in baby corn. The K uptake was, however, affected by the S x B interaction. The highest K uptake of 291.59 kg ha^{-1} was recorded with s_3b_1 which was superior to s_3b_0 but was however on par with all other interactions such as s_2b_0, s_1b_1, s_4b_1, s_2b_1, s_1b_0 and s_4b_0. The treatments and the control had same effect on uptake of K.

4.5 ORGANOLEPTIC STUDY

4.5.1 Appearance

The data recorded with respect to the effect of INM practices on the appearance of fresh baby corn cob are presented in Table 18.

The sensory evaluation revealed that the mean rank value for appearance ranged between 102.8 to 179. The highest mean rank value (MRV) of 179 and mean rank score of 8.56 for appearance of fresh cob were obtained for s_4b_0 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through

Table 17. Effect of N substitution with organic sources, biofertilizer and their interaction on N, P and K uptake by baby corn, kg ha^{-1}.

Treatments	N uptake	P uptake	K uptake
N substitution with organic sources (S)			
s_1 (25 % N through PM)	195.70	31.58	242.84
s_2 (25 % N through VC)	204.37	29.50	263.82
s_3 (12.5% N through PM + 12.5 % N through VC)	241.54	33.15	244.20
s_4 (25% N through PM + 25 % N through VC)	213.19	33.79	239.44
SEm (±)	13.58	2.71	15.58
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	210.09	32.39	239.01
b_1 (PGPR-1 seed treatment + soil application)	217.31	31.62	256.14
SEm (±)	9.60	1.92	11.02
CD (0.05)	NS	NS	NS
S x B interaction			
s_1b_0	173.78	29.15	238.11
s_1b_1	217.62	34.00	247.57
s_2b_0	214.99	31.98	288.83
s_2b_1	193.76	27.02	238.82
s_3b_0	219.56	30.57	196.80
s_3b_1	263.52	35.73	291.59
s_4b_0	232.02	32.72	232.30
s_4b_1	194.35	34.87	246.58
SEm (±)	19.20	3.84	22.04
CD (0.05)	NS	NS	67.489
Treatment mean	213.70	32.00	247.58
Control mean	234.25	30.67	256.37
Treatment *vs.* Control	NS	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

vermicompost) which was significantly higher than that of control (MRV 125), s_3b_0 (MRV 116.9), s_3b_1 (MRV 115.4), s_1b_0 (MRV 113.9) and s_1b_1 (MRV 102.8). The treatment s_4b_0 was however on par with s_2b_1 (MRV 166.4), s_2b_0 (MRV 155.9) and s_4b_1 (MRV 144.2) in its effect on appearance of fresh baby corn cob.

4.5.2 Colour

The results of the organoleptic study on colour of the fresh baby corn cob as influenced by the INM practices are shown in Table 18.

The INM practices could significantly influence the colour of fresh baby corn cob. The mean rank value for colour ranged between 89.85 to 182.55. Significantly higher MRV (182.55) with a mean score of 8.3 was registered for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) compared to the treatments s_4b_0 (MRV 138.45), s_3b_1 (MRV 128.1), s_3b_0 (MRV 115.05) and s_1b_0 (MRV 103.35) but was on par with s_2b_0 (MRV 160.5), s_2b_1 (MRV 155.35) and control (MRV 150.15). The treatment s_2b_0 however statistically did not differ from s_2b_1, control, s_4b_0 and s_3b_1 with respect to MRV of colour of fresh cob. The lowest mean rank value (89.85) was obtained for s_1b_1 (75 per cent RDN + 25 per cent N substitution through poultry manure + PGPR-1) which secured a mean score of 7.3 only in the organoleptic study.

4.5.3 Flavour

The data on the flavor of fresh baby corn cob as influenced by INM practices are indicated in Table 18.

As per the flavour evaluation, the mean rank value for flavour ranged from 107.75 to 186.5. The MRV and the score were significantly higher (186.5 and 8.3 respectively) for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) when compared

Table 18. Effect of integrated nutrient management on sensory parameters of fresh baby corn cob.

Treatment	Appearance		Colour		Flavour		Taste		Texture		Overall acceptability	
	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV
s_1b_0	7.90	113.90	7.60	103.35	8.00	155.00	7.70	116.30	7.50	112.00	7.50	114.00
s_1b_1	7.83	102.80	7.30	89.85	7.90	145.25	7.80	118.55	7.60	123.60	7.60	126.70
s_2b_0	8.24	155.90	8.10	160.50	7.60	111.50	7.50	85.25	7.90	152.60	7.80	144.40
s_2b_1	8.45	166.40	8.10	155.35	8.10	167.00	8.30	173.90	8.00	167.10	7.80	148.25
s_3b_0	8.00	116.90	7.70	115.05	7.50	107.75	7.80	118.55	7.40	114.30	7.70	130.78
s_3b_1	7.91	115.40	7.80	128.10	7.60	111.50	8.30	173.90	7.00	78.20	7.70	152.47
s_4b_0	8.56	179.00	7.90	138.45	7.70	123.50	7.70	107.75	7.50	118.95	7.40	109.45
s_4b_1	7.94	144.20	8.30	182.55	8.30	186.50	8.40	184.70	8.30	196.10	7.90	164.80
C	7.92	125.00	8.00	150.15	7.60	111.50	8.00	140.60	7.80	143.90	7.60	129.33
K value	34.73*		47.70*		65.66*		60.27*		44.67*		17.99*	
CD (0.05)	34.82											

(MS – Mean score, MRV - Mean rank value) *significant at 5%

to s_1b_1 (MRV 145.25), s_4b_0 (MRV 123.5), control (MRV 111.5), s_2b_0 (MRV 111.5)and s_3b_1 (MRV 111.5) but did not vary from s_2b_1 (MRV 167) and s_1b_0 (MRV 155).

4.5.4 Taste

The data pertaining to the effect INM practices on the taste of fresh baby corn cob are presented in Table 18.

The taste of the fresh baby corn cob was assessed in the organoleptic study and was found to be significantly influenced by the treatments. The mean rank value for taste ranged between 85.25 to 184.7. Higher mean rank value (184.7) was obtained for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) which was significantly superior to that of control (MRV 140.6), s_1b_1 (MRV 118.55), s_3b_0 (MRV 118.55), s_1b_0 (MRV 116.3) and s_4b_0 (MRV 107.75). The s_4b_1 was however found to be on par with s_2b_1 or s_3b_1 (MRV 173.9).

4.5.5 Texture

The result of the effects of INM practices on the texture parameter of fresh baby corn cob is recorded in Table 18.

The treatment s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) exhibited the highest mean rank value (196.1) and mean score (8.3) that was statistically superior to the treatments s_2b_0 (MRV 152.6), control (MRV 143.9), s_1b_1 (MRV 123.6), s_4b_0 (MRV 118.95), s_3b_0 (MRV 114.3) and s_1b_0 (MRV 112) and was on par with s_2b_1 (MRV 167.1) which in turn did not vary from s_2b_0 and control.

4.5.6 Overall acceptability

The overall acceptability of fresh baby corn cob under the influence of INM practices is indicated in Table 18.

The overall mean rank value for different treatments ranged from 109.45 to 164.8. As indicated by the table, the highest mean rank value (164.8) and mean score (7.9) were secured by s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) which was statistically superior to the value recorded with the control (MRV 129.33), s_1b_1 (MRV 126.7), s_1b_0 (MRV 114) and was on par with s_3b_1 (MRV 152.47), s_2b_1 (MRV 148.25), s_2b_0 (MRV 144.4) and s_3b_0 (MRV 130.78).

4.6 SHELF LIFE OF COB

4.6.1 Overall visual quality (OVQ)

The data on the effect of INM practices on OVQ of baby corn cob at 3rd and 6th day of storage are presented in Table 19.

The treatments could significantly influence the overall visual quality of baby corn cob on both 3rd and 6th day of storage. Significantly higher OVQ was observed for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) on 3rd day (mean rank 187.7 and mean score 7.8), which was significantly higher than the values recorded with treatments s_3b_1 (MRV 138.5), s_1b_1 (MRV 132.95), s_4b_0 (MRV 130.7), s_2b_0 (MRV 123.2), s_1b_0 (MRV 119.6) and control (MRV 117.65) and was on par with the treatment s_2b_1 (MRV 153.5) which in turn did not vary from the control treatment and s_3b_1.

On the 6th day of storage, significantly high mean rank value (161.42) for OVQ was obtained for s_3b_1 (75 per cent RDN+ 12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) compared to control (MRV 121.58) and s_3b_0 which produced the lowest mean rank (102.42) but was on par with s_2b_0 (MRV 159.67) and s_1b_0 (MRV 148.33), followed by s_4b_1 (MRV 137.5), s_4b_0 (MRV 132.5), s_1b_1 (MRV 128.17) and s_2b_1 (MRV 127.92).

Table 19. Effect of integrated nutrient management on overall visual quality of baby corn cob on 3rd and 6th day of storage

Treatment	Overall visual quality			
	3rd day		6th day	
	MS	MRV	MS	MRV
s_1b_0	7.10	119.60	7.27	148.33
s_1b_1	7.30	132.95	7.00	128.17
s_2b_0	7.20	123.20	7.40	159.67
s_2b_1	7.50	153.50	7.00	127.92
s_3b_0	7.00	115.70	6.67	102.42
s_3b_1	7.30	138.50	7.40	161.42
s_4b_0	7.30	130.70	7.07	132.50
s_4b_1	7.80	187.70	7.07	137.50
C	7.10	117.65	6.90	121.58
K value	24.41*		15.61*	
CD (0.05)	34.82			

(MS – Mean score, MRV - mean rank value) *significant at 5%

4.6.2 Moisture loss

The results on the effect of INM practices on moisture loss from baby corn cob on the 3rd and 6th day of storage are given in Table 20.

The main effects or interaction effects of the treatments could not influence the moisture loss from baby corn under storage conditions on the 3rd and the 6th day. The treatments and control also did not vary significantly with respect to their effect on moisture loss under storage.

4.6.3 Sensory parameters during storage

4.6.3.1 Appearance

The appearance of baby corn cob at 3rd and 6th day of storage as influenced by the INM practices are indicated in Table 21 and 22 respectively.

On the 3rd day of storage, the highest mean rank value (171.37) and mean score (7.83) were recorded for s_4b_0 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost) which was superior to s_1b_1 (MRV 132.77), s_3b_1 (MRV 124.52), s_1b_0 (MRV 123.72), s_3b_0 (MRV 119.63) and was found to be on par with s_2b_0 (MRV 150.87), s_4b_1 (MRV 145.82) and s_2b_1 (MRV 140.1). The treatment s_2b_0 was however on par with all the other treatments except control. The lowest mean rank value (110.72) was obtained for the control treatment (135:65:45 kg NPK ha^{-1} through chemical fertilizers).

The appearance of baby corn cob was not significantly affected by the treatments on the 6th day of storage.

4.6.3.2 Colour

The data on the effect of INM practices on the colour of baby corn cob at 3rd and 6th day of storage are presented in Table 21 and 22 respectively.

Table 20. Effect of N substitution with organic sources, biofertilizer and their interaction on moisture loss from baby corn cob on 3rd and 6th day of storage, per cent

Treatments	Moisture loss	
	3rd day	6th day
N substitution with organic sources (S)		
s_1 (25 % N through PM)	17.45	21.08
s_2 (25 % N through VC)	17.39	20.54
s_3 (12.5% N through PM + 12.5 % N through VC)	18.67	21.27
s_4 (25% N through PM + 25 % N through VC)	17.89	21.54
SEm (±)	2.437	2.533
CD (0.05)	NS	NS
Biofertilizer (B)		
b_0 (Without biofertilizer)	17.95	21.32
b_1 (PGPR-1 seed treatment + soil application)	17.75	20.90
SEm (±)	1.723	1.791
CD (0.05)	NS	NS
S x B interaction		
s_1b_0	19.58	23.03
s_1b_1	15.32	19.14
s_2b_0	15.61	18.77
s_2b_1	19.18	22.30
s_3b_0	19.51	22.06
s_3b_1	17.83	20.48
s_4b_0	17.11	21.39
s_4b_1	18.67	21.68
SEm (±)	3.446	3.582
CD (0.05)	NS	NS
Treatment mean	17.85	21.11
Control mean	17.76	20.47
Treatment *vs*. Control	NS	NS

PM- Poultry manure, VC- Vermicompost, NS- Not significant

Significant differences in the colour of baby corn cob was observed under the influence of INM practices only on the 3rd day of storage. The highest mean rank value (169.6) was recorded with s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1), which is was superior to the control (MRV 128.95), s_2b_1 (MRV 126.38), s_4b_0 (MRV 118.71) and was on par with s_1b_1(MRV 149.68), s_3b_1 (MRV 147.78) and s_1b_0 (MRV 135.2). Colour of baby corn cob was however, found to be unaffected by the treatments on the 6th day of storage under ambient condition.

4.6.3.3 Taste

The data on the effect of INM practices on the taste of baby corn at 3rd and 6th day of storage are given in Table 21 and 22 respectively.

The taste of the cob was influenced by the treatments on both 3rd and the 6th day of storage. On the 3rd day of storage, the highest mean rank value (165.5) and the mean score (7.67) was obtained for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) which was significantly higher than the control (MRV 121.05), s_1b_0 (MRV 119.35), s_3b_0 (MRV 105.65) and s_2b_0 (MRV 97.85). The treatment s_4b_1 was however on par with s_3b_1 (75 per cent RDN +12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1), s_2b_1 (75 per cent RDN + 25 per cent N substitution through vermicompost + PGPR-1), s_4b_0 (75 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) and s_1b_1 (75 per cent RDN + 25 per cent N substitution through poultry manure + PGPR-1) which were having the mean rank values of 161.65, 160.9, 150.5 and 137.05 respectively.

On the 6th day of storage, higher mean rank value for the taste parameter was obtained (163.13) for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1), which

Table 21. Effect of integrated nutrient management on the sensory parameters of baby corn cob at 3rd day of storage

Treatment	Appearance		Colour		Taste		Flavour		Texture		Overall acceptability	
	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV
s_1b_0	7.33	123.72	7.40	135.20	7.13	119.35	7.10	125.73	7.60	146.00	7.37	138.28
s_1b_1	7.37	132.77	7.53	149.68	7.40	137.05	7.40	153.23	7.47	137.67	7.40	140.58
s_2b_0	7.63	150.87	7.40	133.73	6.90	97.85	7.07	114.70	7.40	125.57	7.13	111.53
s_2b_1	7.47	140.10	7.30	126.38	7.57	160.90	7.10	125.18	7.53	138.10	7.50	142.73
s_3b_0	7.27	119.63	7.13	104.67	6.97	105.65	7.10	126.80	7.53	141.83	7.37	117.85
s_3b_1	7.37	124.52	7.53	147.78	7.63	161.65	7.37	142.68	7.27	112.73	7.60	155.10
s_4b_0	7.83	171.37	7.27	118.71	7.53	150.50	7.27	137.28	7.40	125.20	7.43	142.33
s_4b_1	7.60	145.82	7.77	169.60	7.67	165.50	7.63	173.15	7.57	141.87	7.67	160.62
C	7.27	110.72	7.37	128.95	7.20	121.05	7.10	120.73	7.63	150.53	7.03	110.47
K value	15.83*		16.85*		29.82*		15.68*		7.18		15.65*	
CD (0.05)	34.82											

(MS – Mean score, MRV - mean rank value) *significant at 5%

Table 22. Effect of integrated nutrient management on the sensory parameters of baby corn cob at 6th day of storage

Treatment	Appearance		Colour		Taste		Flavour		Texture		Overall acceptability	
	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV
s_1b_0	6.93	133.07	6.73	132.25	6.70	122.00	6.67	111.81	6.67	115.30	6.63	124.29
s_1b_1	6.87	128.50	6.80	137.17	6.80	128.95	6.67	112.50	6.67	113.80	6.57	111.93
s_2b_0	7.00	139.70	6.87	143.58	7.00	146.00	7.06	146.50	6.93	137.50	6.97	148.00
s_2b_1	6.93	135.23	6.73	132.25	7.00	149.10	7.13	155.33	7.17	159.80	7.17	168.17
s_3b_0	6.87	128.53	6.63	121.50	6.67	117.93	6.83	127.53	6.86	133.20	6.63	123.33
s_3b_1	7.07	146.53	6.50	111.75	6.57	108.13	6.80	124.75	6.73	121.90	6.63	117.77
s_4b_0	7.17	158.75	6.87	143.92	7.10	155.55	6.83	126.08	6.77	123.10	6.80	136.02
s_4b_1	6.87	130.70	6.90	156.75	7.17	163.13	7.30	163.95	7.20	163.10	7.03	153.68
C	6.77	118.48	6.83	140.33	6.80	128.70	7.03	145.78	7.07	151.80	6.73	130.65
K value	6.46		7.98		15.59*		15.93*		16.05*		15.53*	
CD (0.05)	34.82											

(MS – Mean score, MRV - mean rank value) *significant at 5%

was significantly higher than s_1b_0 (MRV 122), s_3b_0 (MRV 117.93) and s_3b_1 (MRV 108.13). The superior treatment s_4b_1 was however on par with s_4b_0 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost), s_2b_1 (75 per cent RDN + 25 per cent N substitution through vermicompost + PGPR-1), s_2b_0 (75 per cent RDN + 25 per cent N substitution through vermicompost), s_1b_1 (75 per cent RDN + 25 per cent N substitution through poultry manure + PGPR-1) and the control (135:65:45 kg NPK ha^{-1} through chemical fertilizers) which produced a mean rank value of 155.55, 149.1, 146, 128.95 and 128.7 respectively.

4.6.3.4 Flavour

The data on the effect of INM practices on the flavor of baby corn cob at 3rd and 6th day of storage are presented in Table 21 and 22 respectively.

On the 3rd day of storage, maximum mean rank value (173.15) and mean score value (7.63) were obtained for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) which was significantly higher than the MRV recorded with the treatments, s_4b_0 (137.28), s_3b_0 (126.8), s_1b_0 (125.73), s_2b_1 (125.18) and control (120.73.) and was on par with s_1b_1 (153.23), s_3b_1 (142.68) and s_2b_0 (114.7).

On the 6th day of storage, higher mean rank score (163.95) was obtained for s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) which was found to be superior to s_3b_0 (MRV 127.53), s_4b_0 (MRV 126.08), s_3b_1 (MRV 124.75), s_1b_1 (MRV 112.5) and s_1b_0 (MRV 111.81). The superior treatment (s_4b_1) was on par with s_2b_1 (75 per cent RDN + 25 per cent N substitution through vermicompost + PGPR-1), s_2b_0 (75 per cent RDN + 25 per cent N substitution through vermicompost) and the control (135:65:45 kg NPK ha^{-1} through chemical fertilizers) which produced a mean rank value of 155.33, 146.5 and 145.78 respectively.

4.6.3.5 Texture

The effect of INM practices on the textural parameter of baby corn cob at 3rd and 6th day of storage is presented in Table 21 and 22 respectively.

The textural parameter of baby corn cob was not affected by the treatments on the 3rd day of storage.

On the 6th day of storage, the s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) had significantly higher mean rank value(163.1) and mean score (7.2) compared to s_4b_0 (MRV 123.1), s_3b_1 (MRV 121.9), s_1b_0 (MRV 115.3) and s_1b_1 (MRV 113.8) and was on par with s_2b_1 (75 per cent RDN + 25 per cent N substitution through vermicompost+ PGPR-1), control (135: 65: 45 kg NPK ha^{-1} through chemical fertilizers), s_2b_0 (75 per cent RDN + 25 per cent N substitution through vermicompost) and s_3b_0 (75 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost).

4.6.3.6. Overall acceptability

The results on the effect of INM practices on overall acceptability of baby corn cob on 3rd and 6th day of storage are presented in Table 21 and 22 respectively.

The s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) had the highest mean rank value (160.62) and was significantly superior to s_3b_0 (MRV 117.85) and s_2b_0 (MRV 111.53) and was on par with s_3b_1 (MRV 155.1), s_2b_1 (142.73), s_4b_0 (142.33), s_1b_1 (140.58) and s_1b_0 (138.28). The lowest MRV was recorded (110.47) with the control (135: 65: 45 kg NPK ha^{-1} through chemical fertilizers) on the 3rd day of storage.

On the 6th day of storage, the highest mean rank value of 168.17 and mean score of 7.17 was registered with s_2b_1 (75 per cent RDN + 25 per cent N substitution through vermicompost + PGPR-1) which was significantly higher than the control (MRV

130.65), s_3b_0 (MRV 123.33), s_1b_0 (MRV 124.29), s_2b_0 (MRV 148.) and s_3b_1 (MRV 117.77). The result also showed that the s_2b_1 was on par with s_4b_1 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1), s_2b_0 (75 per cent RDN + 25 per cent N substitution through vermicompost) and s_4b_0 (50 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost) which were having a mean rank value of 153.68, 148 and 136.02 respectively.

4.7 SOIL ANALYSIS

4.7.1 Soil pH

Effect of INM practices on soil pH after the field experimentation is indicated in Table 23.

The soil pH after the experimentation was not significantly influenced by the main effects or interaction effect of INM practices. There was no significant difference between the treatments and the control in their effect on soil pH after the experimentation. However, there was a general increase in the pH irrespective of the treatments after the field experiment compared to the initial pH status of the soil.

4.7.2 Electrical conductivity

The influence of INM practices on electrical conductivity of soil after the field experimentation is given in Table 23.

None of the treatments or their interaction could significantly influence the electrical conductivity of the soil after the experiment. The treatments did not significantly vary from the control in their effect on electrical conductivity after the field experiment. However, the electrical conductivity of the soil after the experiment was found to decline in general compared to the initial value.

Table 23. Effect of N substitution with organic sources, biofertilizer and their interaction on pH, EC and organic carbon content of soil after the experimentation.

Treatments	pH	EC ($dS\ m^{-1}$)	Organic carbon (%)
N substitution with organic sources (S)			
s_1 (25 % N through PM)	5.57	0.15	1.14
s_2 (25 % N through VC)	5.43	0.13	0.97
s_3 (12.5% N through PM + 12.5 % N through VC)	5.30	0.14	1.21
s_4 (25% N through PM + 25 % N through VC)	5.32	0.14	0.97
SEm (±)	0.10	0.02	0.08
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	5.45	0.15	1.06
b_1 (PGPR-1 seed treatment + soil application)	5.36	0.13	1.08
SEm (±)	0.07	0.01	0.06
CD (0.05)	NS	NS	NS
S x B interaction			
s_1b_0	5.60	0.16	1.19
s_1b_1	5.53	0.14	1.08
s_2b_0	5.41	0.12	0.87
s_2b_1	5.45	0.14	1.07
s_3b_0	5.37	0.15	1.15
s_3b_1	5.24	0.13	1.29
s_4b_0	5.40	0.16	1.05
s_4b_1	5.23	0.11	0.89
SEm (±)	0.14	0.02	0.12
CD (0.05)	NS	NS	NS
Treatment mean	5.40	0.14	1.07
Control mean	5.41	0.13	1.06
Treatment *vs*. Control	NS	NS	NS
Initial status	5.07	0.26	1.35

PM- Poultry manure, VC- Vermicompost, EC- Electrical conductivity, NS- Not significant

4.7.3 Organic carbon

The data on the effect of INM practices on organic carbon status of the soil after the experiment was presented in Table 23.

The main effects of INM practices or their interaction could not affect the organic carbon content of soil after the experiment. The treatments and control did not differ significantly with respect to their influence on organic carbon content of soil after the experiment. However, the organic carbon status of soil after the experimentation was found to decrease in general when compared to the initial status.

4.7.4 Available nutrient status of soil after the experiment

4.7.4.1 Available nitrogen

Table 24 depicts the results on effect of INM practices on available soil N status after the experiment.

The INM practices did not have any significant influence on the available N status after the experimentation. The treatments and the control also did not show any variation in terms of post experiment available N status of the soil. However, compared to the initial status there was a general decline in the available N status of soil irrespective of treatments after the experimentation.

4.7.4.2 Available phosphorus

The effect of INM practices on available P status of soil after the field experiment is given in Table 24.

Main effects of their interaction did not have any influence on the available P status of soil after the field experimentation. The treatments did not show any significant variation from the control in the case of available P content of soil after the experimentation. There was drastic reduction in the available P content of soil after the experiment compared to the initial value in all the treatments.

Table 24. Effect of N substitution with organic sources, biofertilizer and their interaction on available N, P and K status of soil after the experimentation, kg ha^{-1}.

Treatments	Available N	Available P	Available K
N substitution with organic sources (S)			
s_1 (25 % N through PM)	248.79	50.60	304.55
s_2 (25 % N through VC)	267.60	50.33	313.34
s_3 (12.5% N through PM + 12.5 % N through VC)	252.97	46.94	299.11
s_4 (25% N through PM + 25 % N through VC)	271.79	49.64	329.80
SEm (±)	19.45	1.94	31.22
CD (0.05)	NS	NS	NS
Biofertilizer (B)			
b_0 (Without biofertilizer)	257.15	49.45	288.95
b_1 (PGPR-1 seed treatment + soil application)	263.42	49.30	334.45
SEm (±)	13.75	1.37	22.07
CD (0.05)	NS	NS	NS
S x B interaction			
s_1b_0	246.70	53.19	247.71
s_1b_1	250.88	48.02	361.38
s_2b_0	271.79	51.74	280.41
s_2b_1	263.42	48.92	346.27
s_3b_0	255.06	43.32	294.52
s_3b_1	250.88	50.56	303.71
s_4b_0	255.06	49.57	333.16
s_4b_1	288.51	49.70	326.44
SEm (±)	27.50	2.74	44.15
CD (0.05)	NS	NS	NS
Treatment mean	260.29	49.38	311.70
Control mean	255.06	50.44	278.92
Treatment *vs*. Control	NS	NS	NS
Initial status	301.06	96.21	225.30

PM- Poultry manure, VC- Vermicompost, NS- Not significant

4.7.4.3 Available potassium

The available K status of soil after the experiment as influenced by the INM practices is expressed in Table 24.

None of the treatments or their interaction did influence the available K status of the soil after the experiment. There was no significant variation between the treatments and control with respect to the available K content of soil after the experiment.

4.7.4.4 Available micronutrients

The data on the availability of micronutrients (Fe, Mn, Zn and Cu) after the experiment as influenced by N substitution with organic sources and biofertilizer application are given in Table 25.

Substitution of nutrient N with organic sources, application of biofertilizer and their interaction could not influence the available status of micronutrients viz., Fe, Mn, Zn and Cu in the soil after the experiment.

4.8 ECONOMIC ANALYSIS

4.8.1 Net income

The effect of INM practices on the net income of baby corn cultivation is indicated in Table 26.

Among the treatments, the control (135:65:45 kg NPK ha^{-1} through chemical fertilizers) recorded the highest net income of ₹ 843182 ha^{-1} compared to the other treatments and was followed by the treatments s_3b_1 (₹ 8,36,465 ha^{-1}), s_1b_1 (₹ 7,95,510 ha^{-1}), s_2b_0 (₹ 7,49,253 ha^{-1}), s_2b_1 (₹ 7,48,390 ha^{-1}), s_4b_0 (₹ 7,46,181 ha^{-1}), s_3b_0 (₹ 7,33,442 ha^{-1}) and s_1b_0 (₹ 7,27,022 ha^{-1}). The lowest net income of ₹ 5,21,982 ha^{-1} was recorded with s_4b_1.

Table 25. Effect of N substitution with organic sources, biofertilizer and their interaction on micronutrient status of soil after the experimentation, mg kg^{-1}

Treatments	Available Fe	Available Mn	Available Zn	Available Cu
N substitution with organic sources (S)				
s_1 (25 % N through PM)	15.12	5.79	10.03	17.15
s_2 (25 % N through VC)	12.80	5.57	10.00	14.56
s_3 (12.5% N through PM + 12.5 % N through VC)	9.19	5.42	9.62	15.95
s_4 (25% N through PM + 25 % N through VC)	25.26	5.40	9.17	15.02
SEm (±)	4.46	0.35	0.78	2.59
CD (0.05)	NS	NS	NS	NS
Biofertilizer (B)				
b_0 (Without biofertilizer)	11.72	5.55	10.08	1.6.20
b_1 (PGPR-1 seed treatment + soil application)	19.50	5.54	9.34	15.14
SEm (±)	3.15	0.25	0.55	1.83
CD (0.05)	NS	NS	NS	NS
S x B interaction				
s_1b_0	11.76	5.97	11.52	20.97
s_1b_1	18.61	5.60	8.53	13.32
s_2b_0	8.62	4.92	9.81	12.92
s_2b_1	16.98	6.21	10.19	16.70
s_3b_0	7.55	5.19	8.93	14.92
s_3b_1	10.82	5.65	10.31	16.97
s_4b_0	18.95	6.12	10.01	15.98
s_4b_1	31.58	4.70	8.34	14.06
SEm (±)	6.31	0.50	11.09	3.66
CD (0.05)	NS	NS	NS	NS
Treatment mean	15.61	5.55	9.71	15.73
Control mean	23.43	5.28	10.83	18.67
Treatment *vs.* Control	NS	NS	NS	NS
Initial status	20.70	6.00	8.60	14.80

PM- Poultry manure, VC- Vermicompost, NS- Not significant

4.8.2 Benefit- cost ratio

The results of the effect of INM practices on the BCR of baby corn cultivation are presented in Table 26.

The highest BCR of 4.5 was obtained from the control treatment wherein the entire recommended dose of nutrients was applied through chemical sources (@ 135:65:45 kg NPK ha^{-1}) which was followed by the treatments s_1b_0 (3.67), s_2b_0 (3.42), s_3b_0 (3.28), s_1b_1 (3.25), s_4b_0 (3.13), s_3b_1 (3.09) and s_2b_1 (2.92). The lowest BCR (2.24) was recorded with s_4b_1 treatment.

The results of the study indicated the influence of INM practices on growth attributes, yield, sensory characters, shelf life, nutrient content and uptake and economics of cultivation of baby corn.

Table 26. Effect of integrated nutrient management practices on economics of baby corn cultivation

Treatments	Net income (₹ ha^{-1})	Benefit – cost ratio*
s_1b_0	727022	3.67
s_1b_1	795510	3.25
s_2b_0	749253	3.42
s_2b_1	748390	2.92
s_3b_0	733442	3.28
s_3b_1	836465	3.09
s_4b_0	746181	3.19
s_4b_1	521982	2.24
Treatment mean	732281	3.13
Control mean	843182	4.50

*Benefit -cost ratio calculated based on variable cost

DISCUSSION

5. DISCUSSION

The project entitled "Integrated nutrient management in baby corn (*Zea mays* L.)" was conducted at College of Agriculture, Vellayani, Thiruvananthapuram during February to April 2018 to investigate the influence of INM practices on growth, yield, nutritive quality, storage life and economics of cultivation of baby corn. The results of the experiment are discussed in this chapter.

5.1 GROWTH ATTRIBUTES

Nitrogen substitution with organic sources had no significant effect on the growth attributes of baby corn.

Application of biofertilizer PGPR-I had significant influence on the growth and growth attributes of baby corn. The biofertilizer application resulted in taller plants at 15 and 45 DAE, higher number of leaves per plant at 45 DAE and higher LAI at 30 DAE compared to no biofertilizer application. Gopi *et al.* (2019) reported that the PGPR-1 contains component cultures- *Azospirillum lipoferum, Azotobacter chroococcum, Bacillus megaterium* and *Bacillus sporothermodurans* as a consortium for supplementing all the major nutrients. As reported by Vacheron *et al.* (2013), PGPR can improve root development and growth through the production of phytohormones or by initiating enzymatic activities, as well as by favouring the establishment of rhizobial or mycorrhizal symbioses. The PGPR may reduce the growth rate of the primary root, increase the number and/or length of lateral roots and stimulate root hair elongation and consequently, the uptake of minerals and water and growth of the whole plant is increased. Maize plants inoculated by PGPR were found to grow faster than the non inoculated plants (Vikram, 2007). The colonization of microbes in the rhizosphere that facilitate better mineral nutrition for the plant and progressive water relation leading to an increase in the vegetative growth was reported previously by Kavya (2017).

Application of biofertilizer could also influence the DMP of the plants. The highest DMP was recorded with application of PGPR-1 as seed treatment followed by soil application. Application of PGPR-1 had a direct favourable influence on vegetative characters such as plant height, number of leaves and LAI which would have reflected in the total DMP at harvest. As reported by Vikram (2017), the rhizobacteria have the ability to secrete auxins to the root zone of the crop. The presence of auxins in the rhizosphere might have positively influenced the development of the root system and then contributed to the absorption of essential nutrient elements that would have reflected in the higher dry matter accumulation. Application of biofertilizer increasing the growth attributes and dry matter yield of baby corn was previously reported by Rao *et al.* (2009).

The S x B interaction significantly influenced the plant height only at 45 DAE and the s_3b_1 (12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1 along with 75 per cent RDN) resulted in significantly higher plant height (Fig. 3). The same interaction (s_3b_1) also resulted in higher DMP (Fig. 5) and was on par with s_4b_0, s_1b_1 and s_2b_0. Vermicompost has the excreta of earth worms that contains bacteria and large amount of growth promoters like auxin, gibberellin and cytokinin that might have promoted the plant growth and dry matter accumulation. Canellas *et al.* (2002) have reported the beneficial effect of vermicompost on growth of maize. Adeniyan and Ojeniyi (2003) have previously reported that the application of poultry manure in combination with chemical fertilizer resulted in increased growth of maize plants. Poultry manure enriched with inorganic sources have initial, fast release of nutrients than without inorganic source that might have helped to overcome the slow release of nutrients from organic source (Gopinath *et al.*, 2009). Dadarwal (2008) reported that biofertilizer had a positive influence on plant growth by the colonization in the rhizosphere of baby corn plants. According to Thavaprakaash *et al.* (2005), the addition of biofertilizers helped in N fixation, secretion of growth promoting substances such as Indole Acetic Acid (IAA), GA

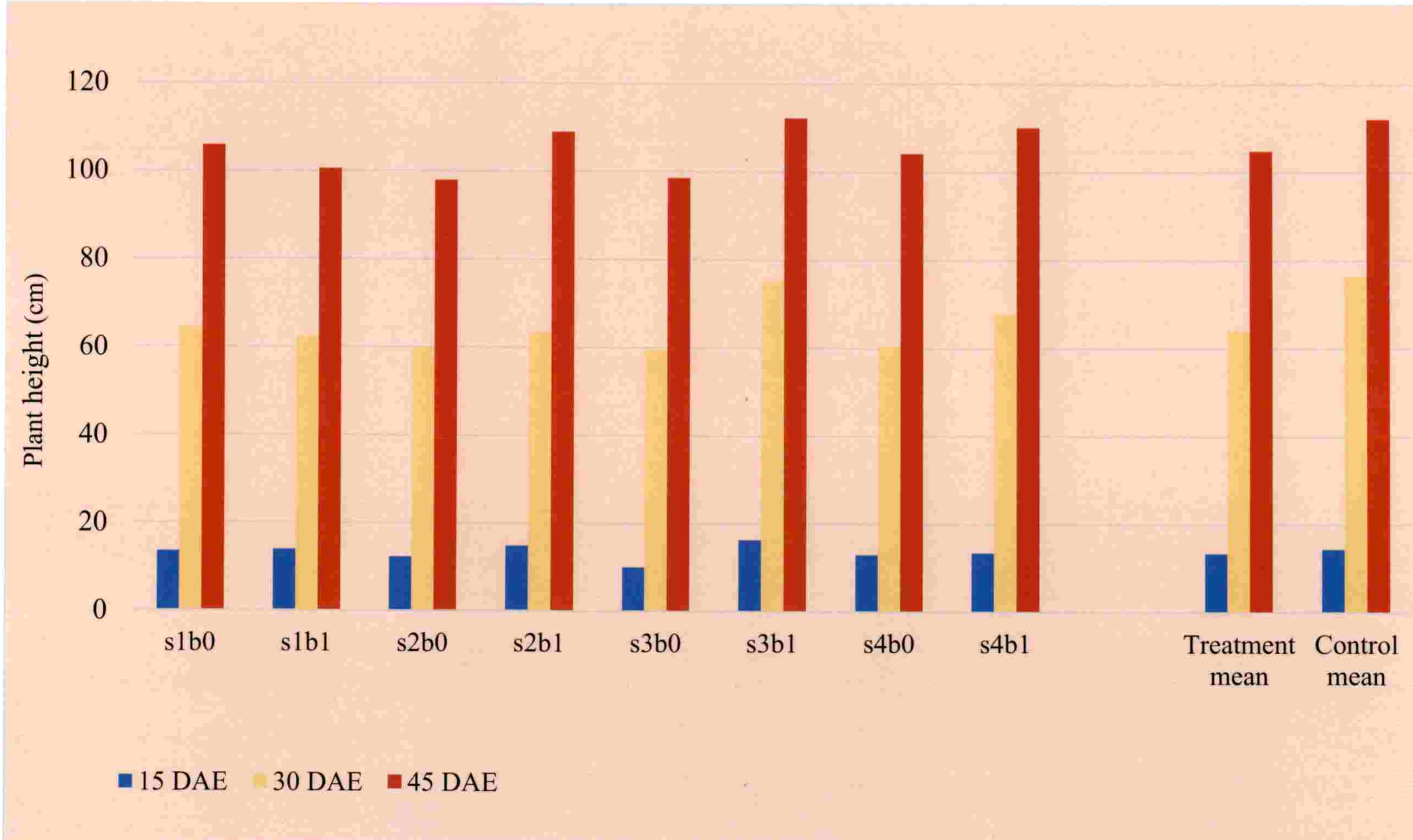


Fig 3. Interaction effect of N substitution with organic sources and biofertilizer on plant height of baby corn, cm

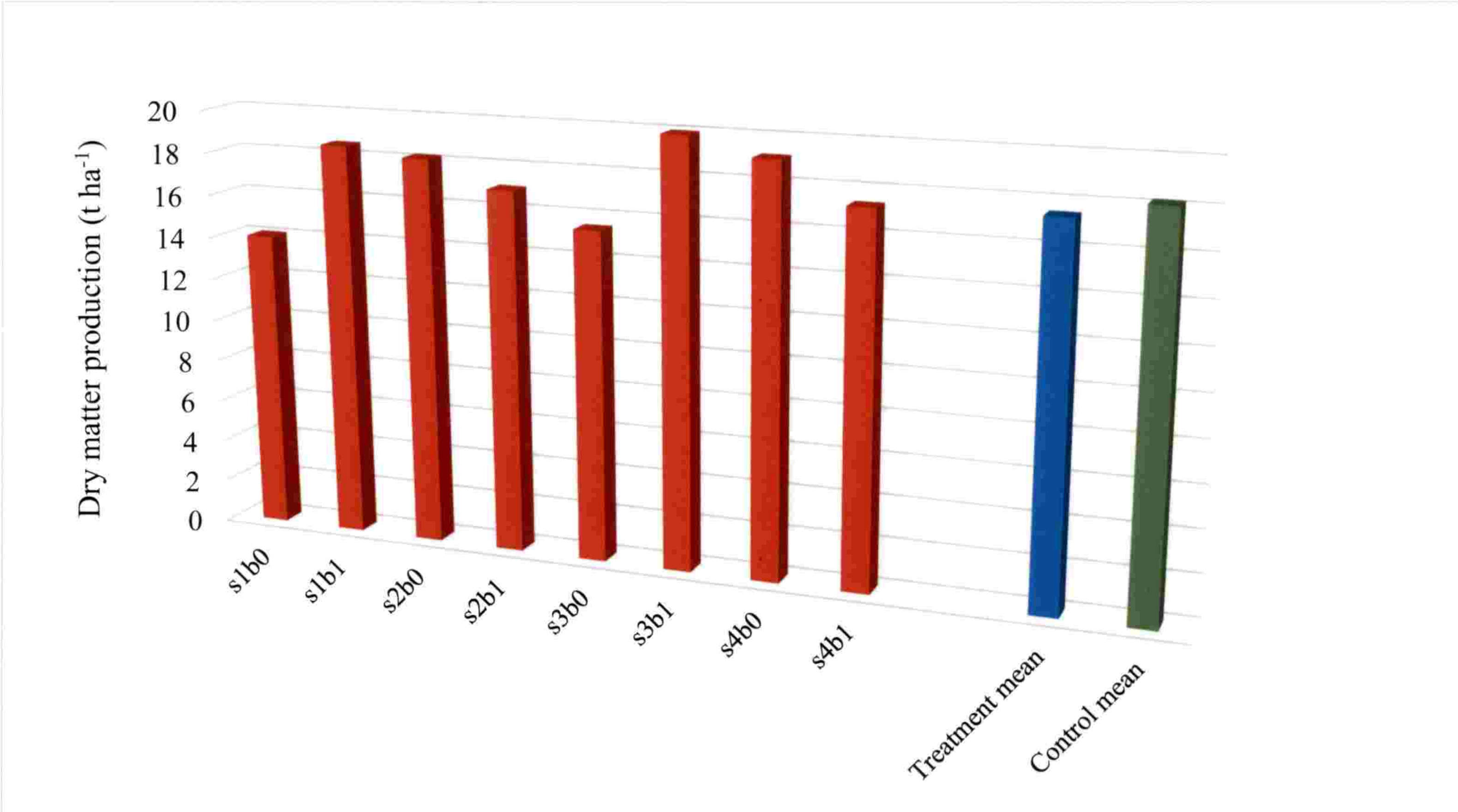


Fig 5.Interaction effect of N substitution with organic sources and biofertilizer on dry matter production of baby corn, t ha^{-1}

(gibberellic acid) and cytokinin which promoted the growth of baby corn plants. The beneficial effect of vermicompost and poultry manure might have manifested in the response of these organic sources in moderate quantity along with biofertilizer and chemical source of N, which would have improved the growth characteristics and the DMP in turn. Synergistic effect of vermicompost along with biofertlizer in increasing the growth attributes in baby corn was previously reported by Ranjan *et al.* (2013).

Eventhough days to 50 per cent tasseling was not affected by either N substitution with organic sources or biofertilizer application, their interaction produced significant variation in the days taken for 50 per cent tasseling (Fig. 4). The s_2b_0 (75 per cent RDN + 25 per cent N substitution through vermicompost without biofertilizer) took more number of days to tassel (47.67) while s_3b_1 (75 per cent RDN + 12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) required shorter period for the tassel emergence. Even though the tassel emerged earlier in the later treatment, none of them was fertile. Application of biofertilizer alone or in combinations with chemical sources shortening the days to 50 per cent tasseling was previously reported by Biraris and Lal (2018) in sweet corn. This might be due to the forced meristem transition from vegetative to floral stage under the influence of biofertilizer rhizobacteria through modification in hormonal action and flowering characteristics.

There was no significant difference between the treatment mean and control (135:65:45 kg NPK ha^{-1} through chemical fertilizer only) with respect to growth attributes of baby corn. However, control mean in general recorded higher value for vegetative characters such as plant height, number of leaves and LAI than the treatment mean. This might be due to the presence of readily available nutrients in chemical source than that in organic manures which would have coincided with the physiological needs of the crop (Ashalatha, 2009) which also could have resulted in greater absorption of nutrient N. Nitrogen being a constituent of protoplasm, plays a positive role through increased cell division and multiplication, resulting in taller plants and higher leaf area index leading to increased dry matter production.

5.2 YIELD ATTRIBUTES AND YIELD

Nitrogen substitution with organic sources did not significantly influence the yield attributes and yield of baby corn as in case of growth attributes of the crop.

The results of the study showed that the yield attributes and yield of the crop were influenced by the biofertilizer application. The cob weight with husk (both g per plant and g per cob), cob yield with husk and marketable cob yield in baby corn were increased by the application of biofertilizer. Application of PGPR-1 as seed treatment and soil application was found to produce the highest cob weight, cob yield with husk and marketable cob yield. As suggested by Vacheron *et al.* (2013), the PGPR interferes with pathways coordinating plant development and plant nutrition to elicit both increased nutrient acquisition rate and plant growth promotion. This specific effect has reflected favourably on the total DMP of the plants (Table 9) which would have contributed to higher cob weight and cob yield with husk. Similar results were reported by Jarak *et al.* (2012) in maize and Biraris and Lal (2018) in sweet corn.

The interaction effect of sources of N substitution and biofertilizer application was found to have an influence on yield attributes and yield of baby corn crop. Among the interactions, the s_3b_1 (75 per cent RDN + 12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) or s_2b_1 (25 per cent N through vermicompost + PGPR-I) .produced the highest cob weight with husk (Fig. 6) which did not vary from the s_2b_1 treatment. The interaction s_3b_1 also resulted in higher cob yield with husk (Fig. 7) which did not vary from s_1b_1, s_2b_1 or s_4b_0. Integrated use of chemical fertilizer and organic sources along with PGPR-I would have improved the overall growth of the crop by providing required nutrients from the initial stage and by increasing the supply of nutrients in a synchronized way which was finally expressed in terms of growth attributes by virtue of increased

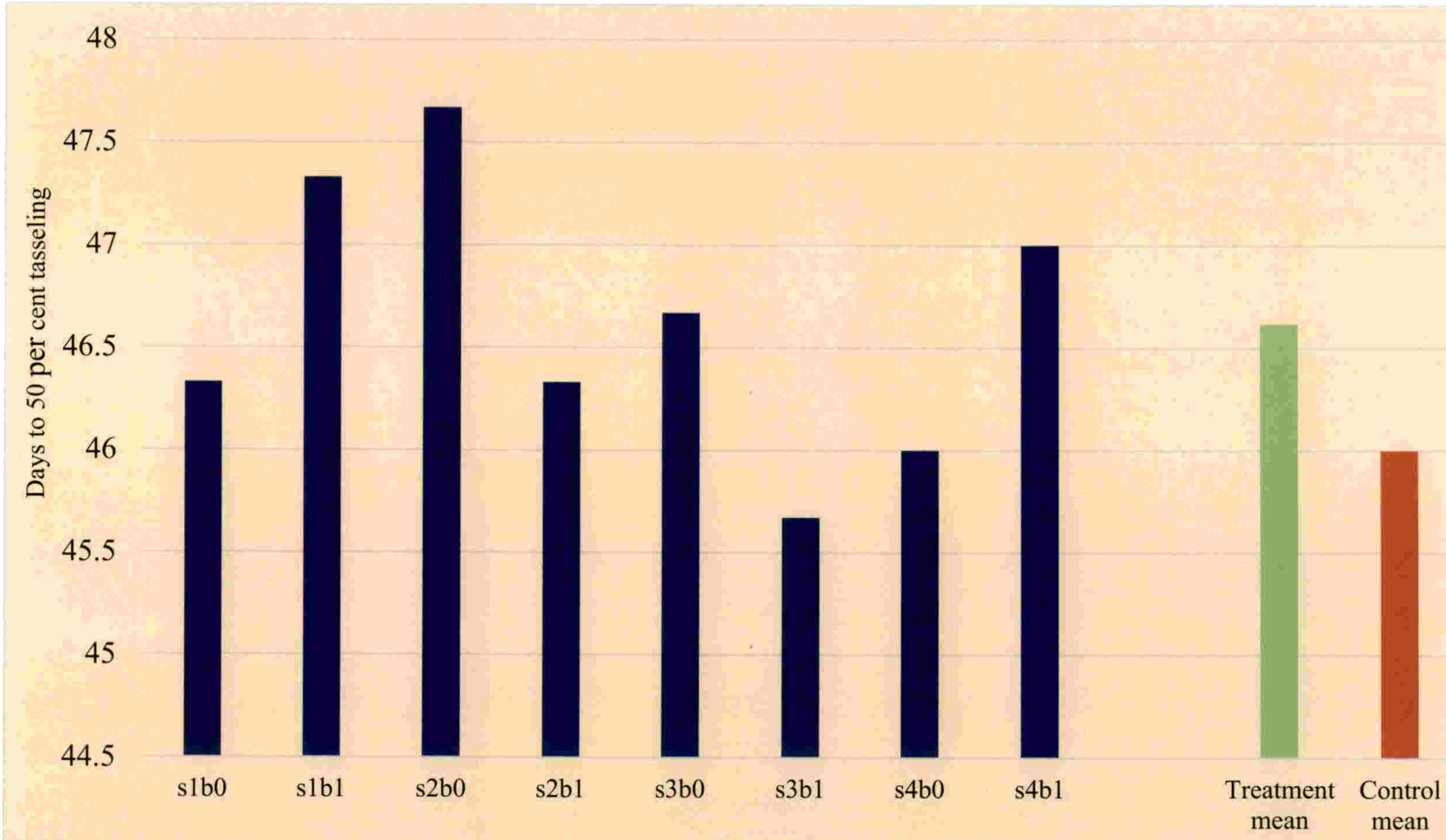


Fig 4. Interaction effect of N substitution with organic sources and biofertilizer on days to 50 per cent tasseling of baby corn.

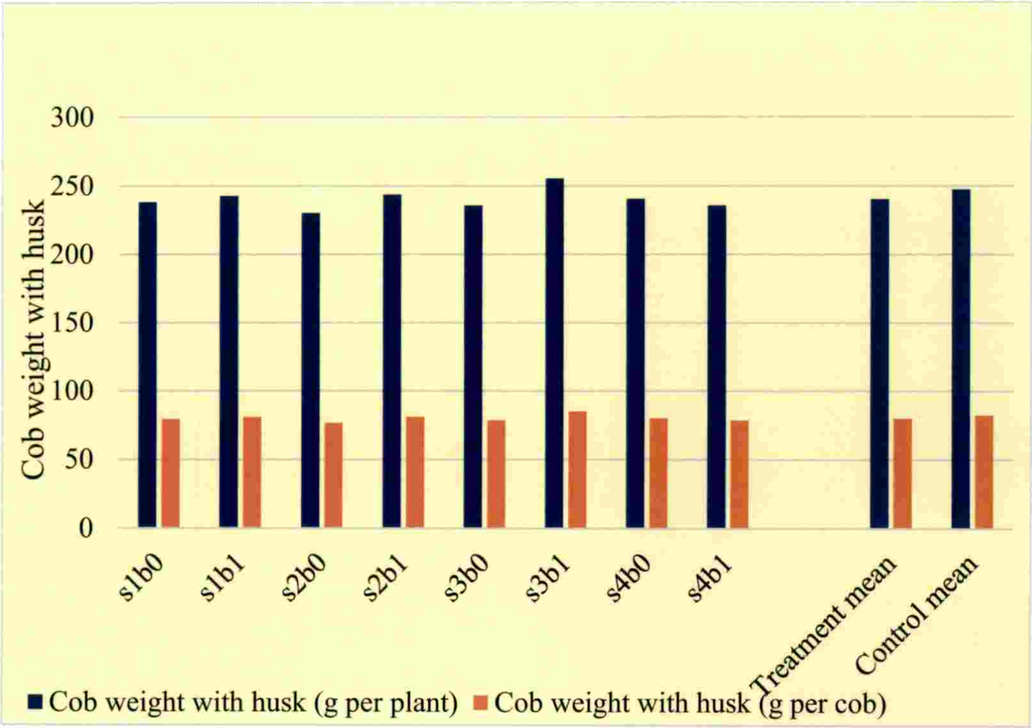


Fig 6. Interaction effect of N substitution with organic sources and biofertilizer on cob weight with husk of baby corn.

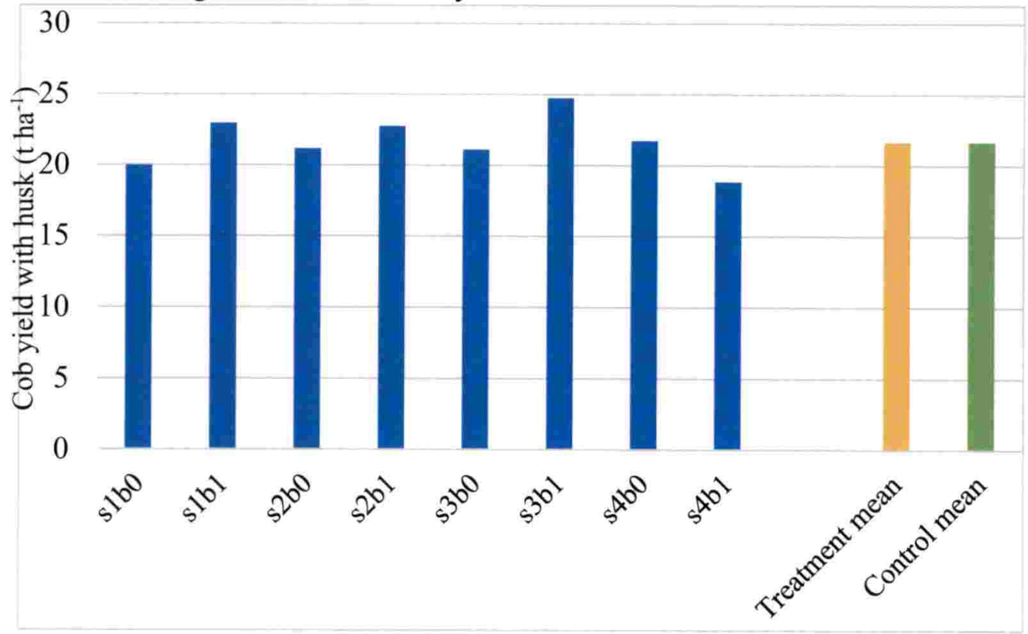


Fig7. Interaction effect of N substitution with organic sources and biofertilizer on cob yield with husk of baby corn, t ha^{-1}.

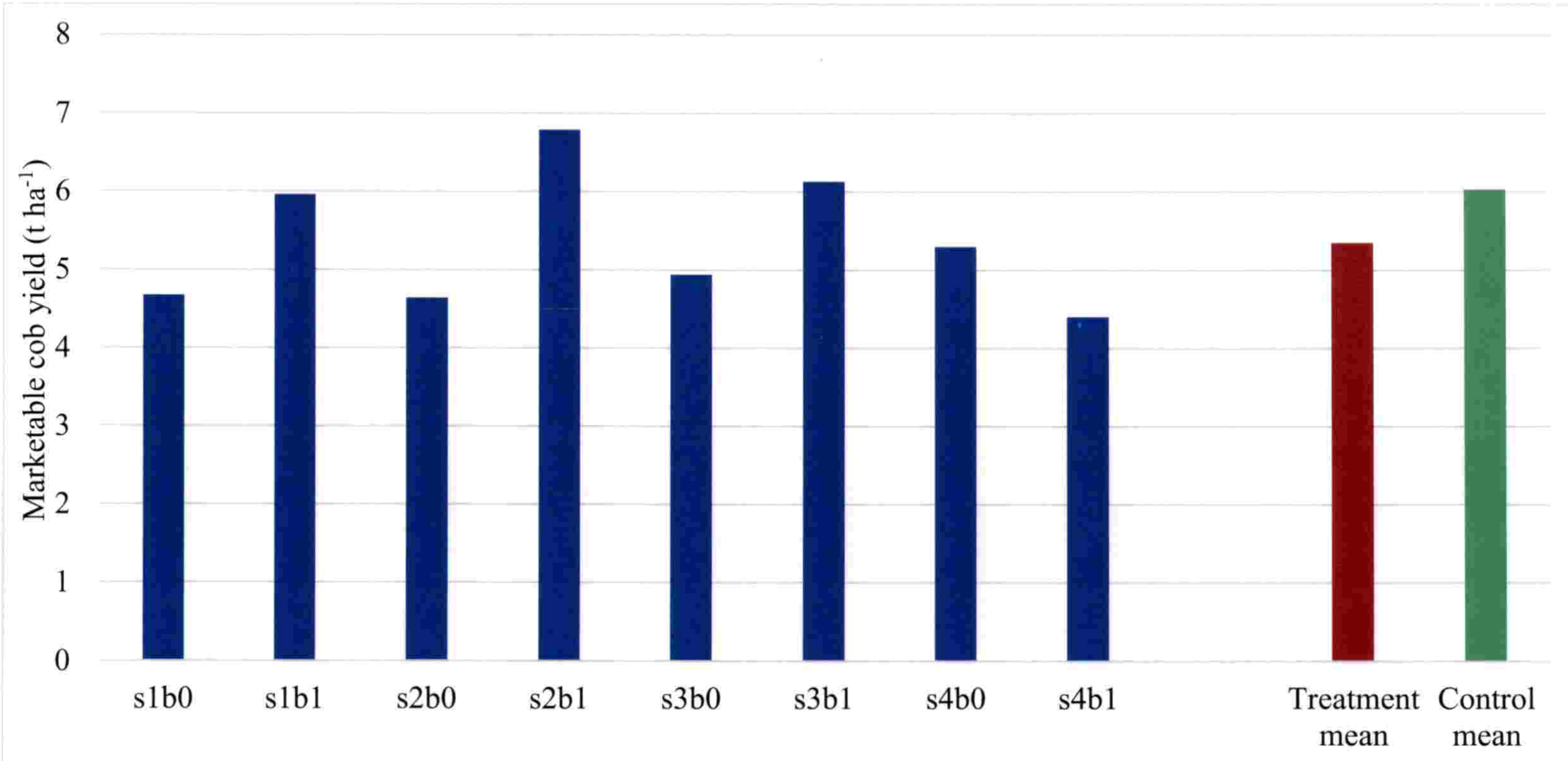


Fig 8. Interaction effect of N substitution with organic sources and biofertilizer on marketable cob yield of baby corn, t ha^{-1}

Plate 9: Baby corn produced with biofertilizer (b_1)

Plate 10: Baby corn produced without biofertilizer (b_0)

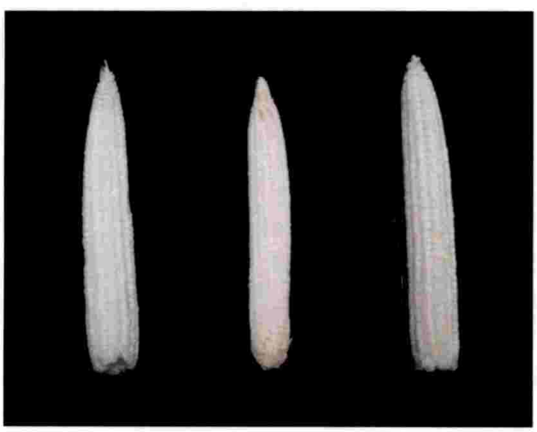


Plate 11: Marketable cob with biofertilizer (b_1)

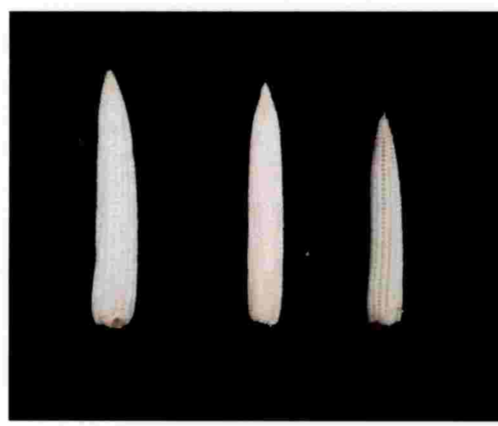


Plate 12: Marketable cob without biofertilizer (b_0)

photosynthetic efficiency. Thus, the greater availability of photosynthates, metabolites and nutrients to develop reproductive structure would have resulted in increased production as pointed out by Thavaprakaash *et al.* (2005) and Jinjala *et al.* (2016) in baby corn. The marketable baby cob yield (Fig. 8) was however the highest with the combined application of chemical fertilizer N and vermicompost along with biofertilizer in s_2b_1 (75 per cent RDN + 25 per cent N substitution through vermicompost + PGPR-1) which was also on par with s_3b_1 and s_1b_1. The marketable yield of the crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. Sahni *et al.* (2008) confirmed that vermicompost contains considerable amounts of humic substances and had improved effects on the plant nutrition. Further more, the biofertilizer PGPR-I is reported to produce biologically active substances like vitamins, nicotinic acid, IAA and gibberellin (Ranjan *et al.*, 2013) and the combined application of vermicompost and PGPR-I would have caused more dry matter partitioning to the cob resulting in higher marketable cob yield. Similar result was reported by Sharma and Banik (2014) in baby corn.

No significant difference was observed between the mean value of treatments and control (135:65:45 kg NPK ha^{-1} through chemical fertilizer only) in case of yield attributes and yield of baby corn. However, mean values of control treatment with respect to yield attributes and yield were found to be higher than that of treatments. The taller plants and higher LAI would have led to the increased dry matter production in control, that might have resulted in better partitioning of produce and better yield of the crop. Similar findings were reported by Muthuswamy *et al.* (1990) in maize and Kumar (2006) in baby corn.

5.3 NUTRIENT CONTENT AND UPTAKE

Appreciable variation in the ascorbic acid content of baby corn was noticed with different organic sources for N substitution. The highest ascorbic acid content

Plate 13: Baby corn in the treatment s_3b_1 (Highest cob yield with husk)

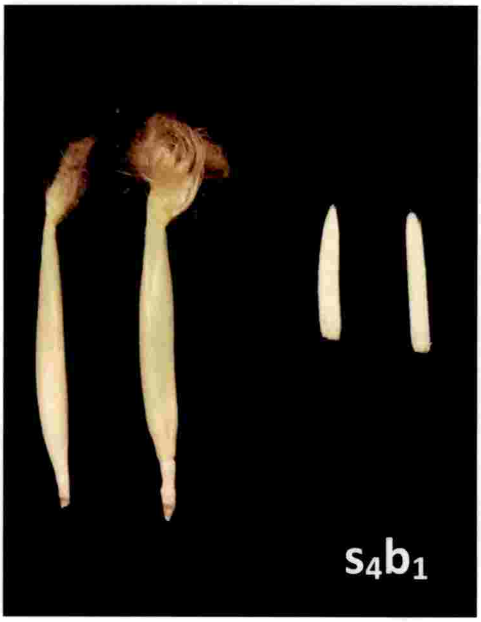


Plate 14: Baby corn in the treatment s_4b_1 (Lowest cob yield with husk)

Plate 15: Baby corn in the control

in baby corn cob (Fig. 9) was recorded when 25 per cent of N was substituted through vermicompost (s_2). The content of ascorbic acid is a function of the content of ascorbic acid oxidase enzyme and zinc and manganese concentrations have key roles in enabling the ascorbic acid oxidase enzyme (Bybordi and Malkouti, 2007). Since vermicompost has sufficient amount of these elements, its application to the soil (especially high amount vermicompost) might have resulted in improvement in the uptake and utilization of Zn and Mn, increasing the activity of the ascorbic acid oxidase enzyme resulting in more concentration of vitamin C. Similar findings have been reported by Aminifard and Bayat (2016) in bell pepper.

Application of biofertilizer PGPR-1 both as seed treatment and soil application produced significantly higher total soluble sugar, reducing sugar and ascorbic acid content in cob (Fig. 9) compared to no biofertilizer application. This might be due to the increased growth attributes of the plant that resulted in the better uptake of NPK and increased photosynthetic activity with subsequent accumulation of carbohydrate in plant (Kavya, 2017). Carbohydrate acts as the precursor for the synthesis of ascorbic acid (Brar *et al.*, 2015) and hence it would have enhanced the ascorbic acid content. As reported by EL-Hamid *et al.* (2006), improved sugar content in the cob would have been due to the synergistic effect of *Azotobacter* and *Azospirillum* present in the PGPR consortium. These results are in agreement with the findings of Golda *et al.* (2013) in baby corn.

The main effects could not significantly influence the nutrient uptake by the crop. However the interaction effect, s_3b_1 (75 per cent N substitution through RDF + 12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) recorded significantly higher K uptake than other treatments. The high affinity of maize roots to K absorption may be due to the co transport of H^+ and K^+ ions into the roots since the soil is strongly acidic and high in K content (Kochian *et al.*, 1989). Furthermore, the organic sources (poultry manure and vermicompost) were rich in K than N and P and that again might have contributed for

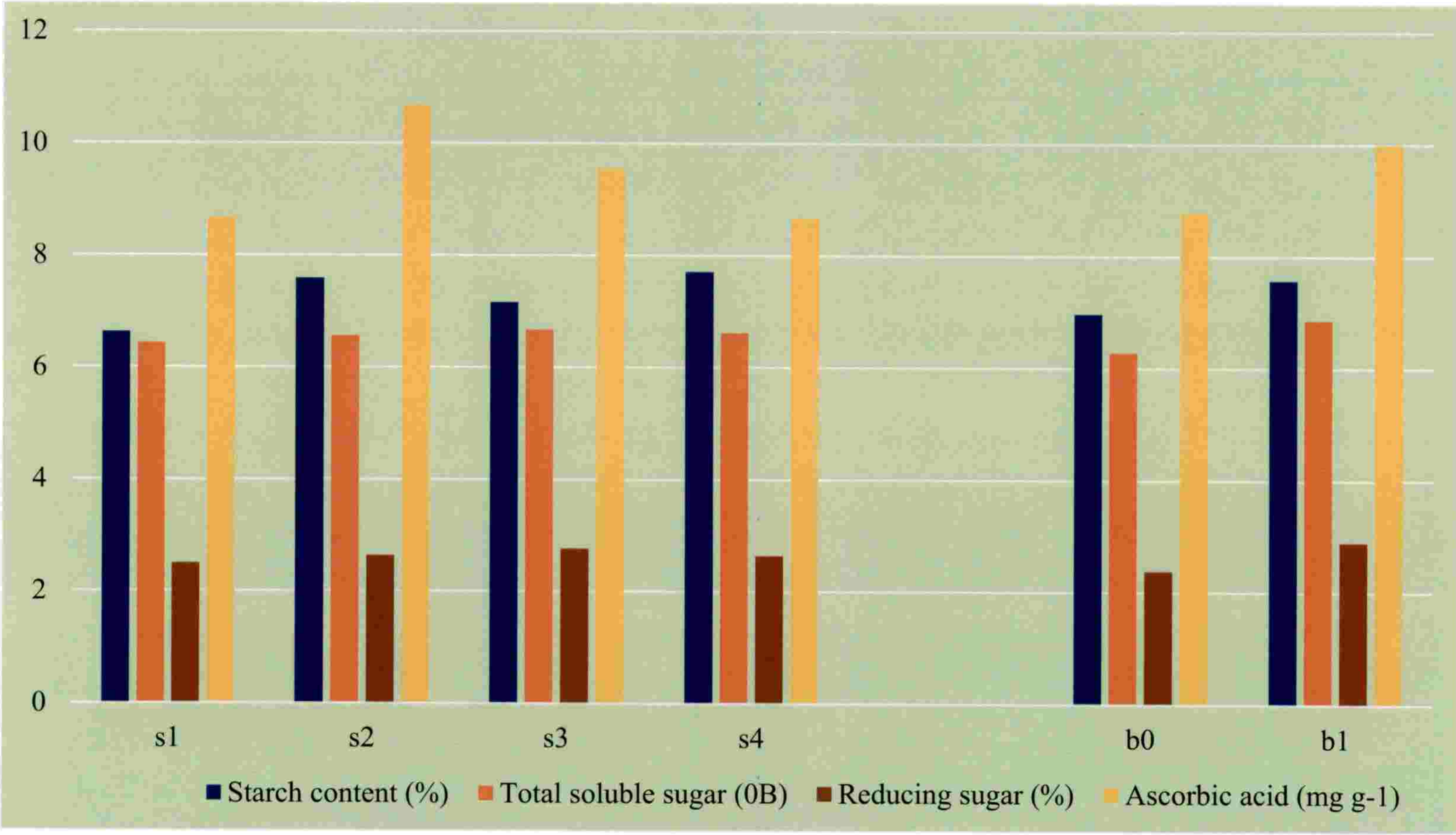


Fig 9. Effect of N substitution with organic sources and biofertilizer on starch, total soluble sugar, reducing sugar and ascorbic acid content of baby corn cob.

the enhanced uptake of K by the roots. Similar results were reported by Thavaprakaash *et al.* (2005) and Dadarwal (2008) in baby corn.

5.4 ORGANOLEPTIC STUDY AND SHELF LIFE

According to Stonel and Sidel (2002), organoleptic evaluation is the scientific method to evoke, analyse and interpret the responses as perceived through smell, touch, sight and taste.

5.4.1 Sensory quality of fresh baby corn

Sensory evaluation was conducted so as to rate the quality product having wide consumer acceptance. Fresh baby corn cob was evaluated for six sensory parameters like appearance, colour, flavor, taste, texture and overall acceptability. Among the different INM practices, s_3b_1 (75 percent N substitution through RDN + 12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1) recorded the highest mean rank value for all the sensory parameters (Fig. 10) except the appearance of fresh baby corn cob compared to the application of N only through chemical fertilizer (control). The results of sensory quality in general revealed that, the organic sources (poultry manure and vermicompost) and biofertilizer along with chemical fertilizers played a significant role in the taste and liking by the respondents. The preference by the consumers is often based on the taste, flavor, sweetness and juiciness of the fresh steamed baby corn. Significantly higher total soluble sugar, reducing sugar and ascorbic acid content were produced with the application of biofertilizer that might have contributed for the sweetness and taste. As reported by Worthington (2001), crops raised by organic practices contain more vitamin C, Fe, Mg, P and less nitrates than conventional crops and the reduced nitrate level leads to higher quality and better consumer acceptance. Kavya (2017) reported higher sensory values of baby corn with combined application of biofertilizer and chemical sources.

5.4.2 Shelf life of baby corn

Baby corn is a perishable produce due to its high respiration rate and shelf life plays an important role in determining its keeping quality. The sensory parameters like colour, taste, flavour, overall acceptability (Fig. 11) and OVQ (Fig. 12) were significantly higher under the application of 50 per cent of N through chemical source combined with 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost along with biofertilizer (s_4b_1) on the 3rd day of storage. The possible reason for this trend may be attributed to the availability of all macro and micro nutrients, that might have resulted in the firmness of the cob as reported by Brar *et al.* (2015) in tomato. In addition to that, the organic source of N has got beneficial effect on the shelf life of fruits, due to the delayed activity of organic N compounds in the source (poultry manure and vermicompost) as suggested by Asano *et al.* (1981). However, on the 6th day of storage, the mean rank value and mean score obtained were low due to the higher moisture loss which resulted in reduced acceptance by the respondents.

5.5 SOIL PROPERTIES

The pH, EC, organic carbon content and available NPK content in soil and micro nutrient status in field after the experiment were not affected significantly by N substitution with organic source, biofertilizer and their interaction.

However, the result showed that there was an increase in pH and a decrease in the EC and organic carbon content of the soil after the experiment compared to the initial status. The increase in pH may be due to the presence of basic cations produced from the mineralization of organic matter (poultry manure and vermicompost) that are rich in Ca, Mg and K. Since the soil was strongly acidic, the soil might have been rich in hydroxides of Fe and aluminium (Al). The ion exchange reaction with the terminal OH^- ion of Fe and Al with that of the organic anions from the decaying organic sources

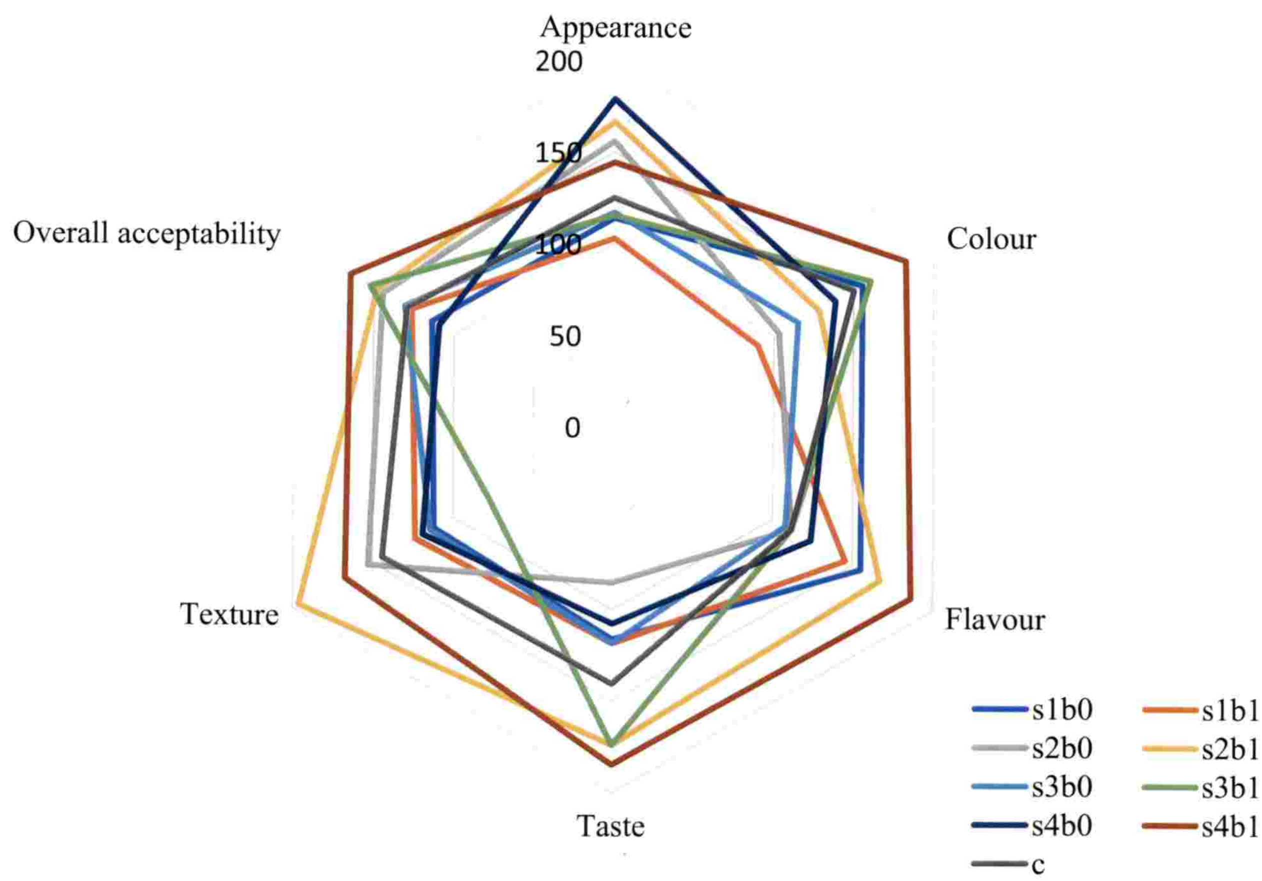


Fig 10. Effect of integrated nutrient management on sensory parameters of fresh baby corn cob.

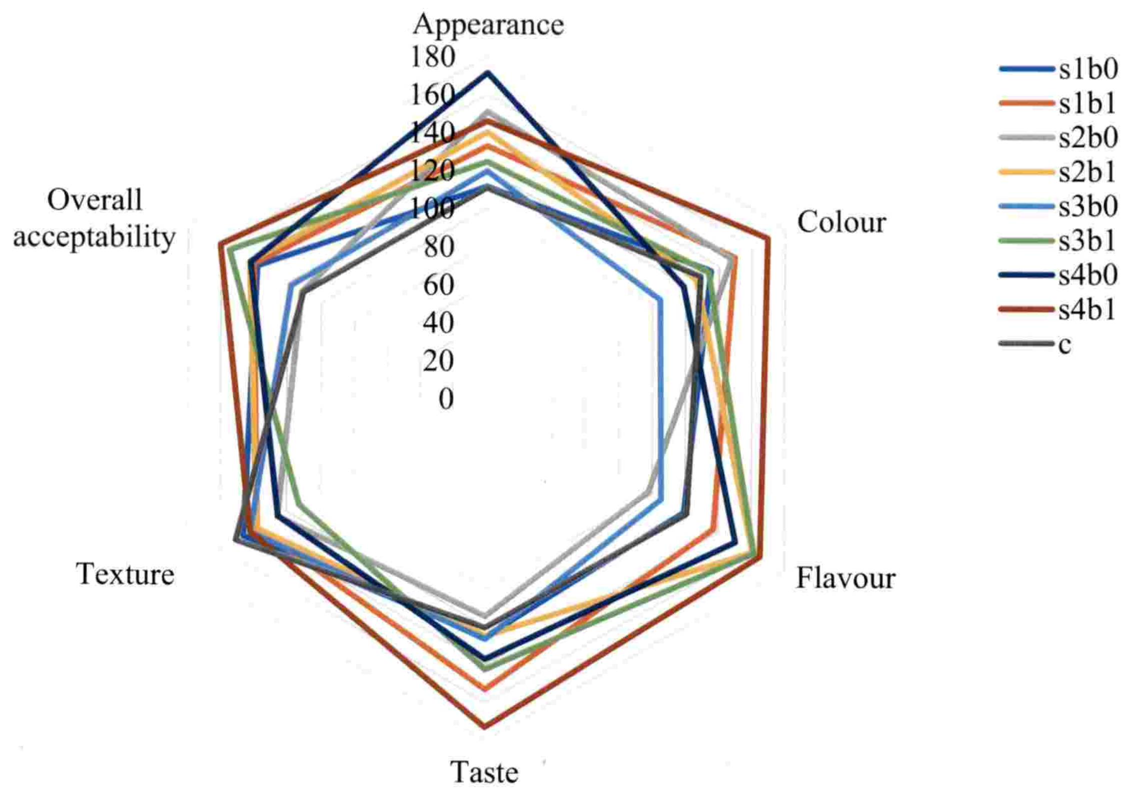


Fig 11. Effect of integrated nutrient management on sensory parameters of baby corn cob on 3rd day of storage.

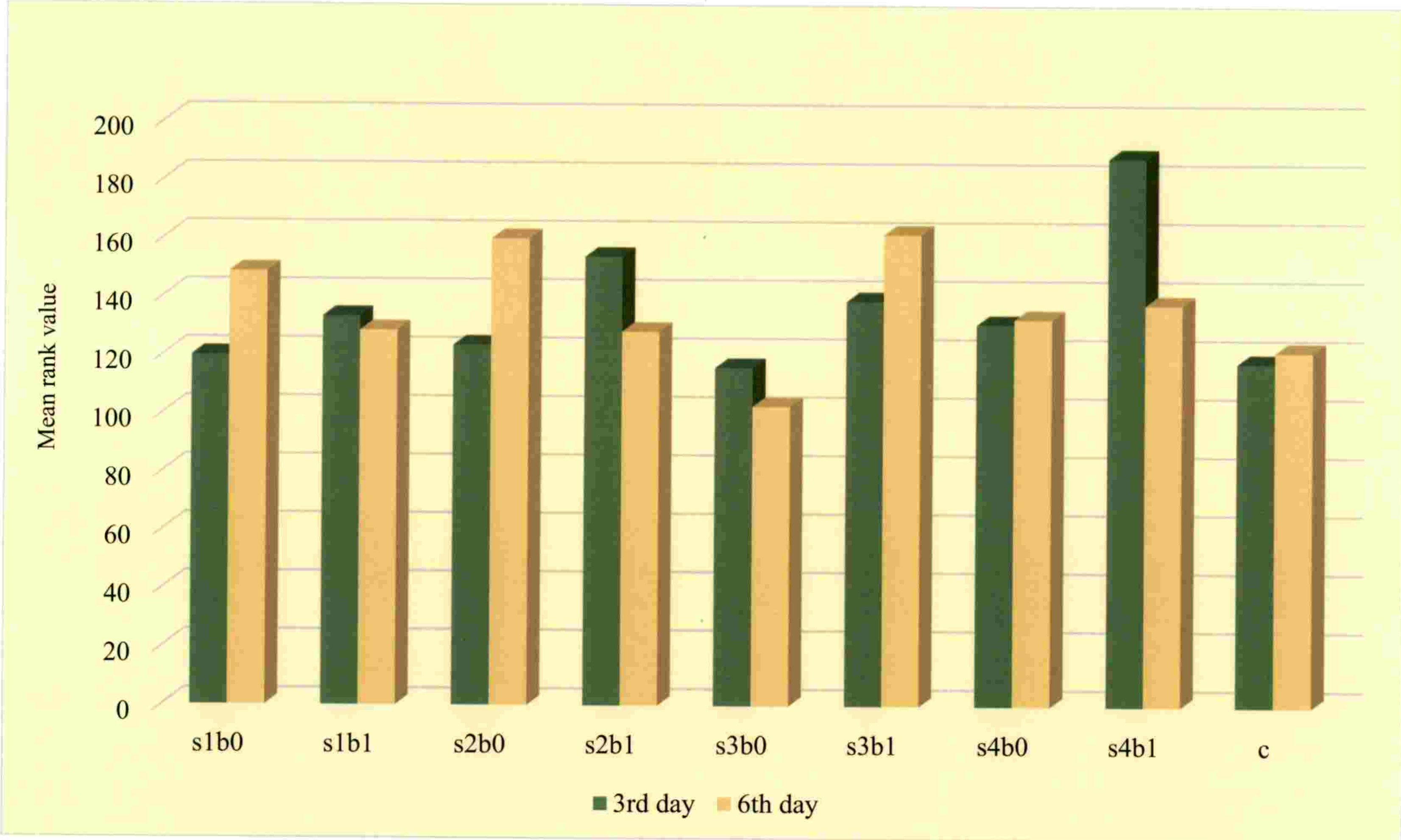


Fig 12. Effect of integrated nutrient management on overall visual quality of baby corn cob on 3rd and 6th day of storag

can occur in such a situation. This might have enhanced the hydroxyl content in the rhizosphere which caused a reduction in the acidity of soil (Jacob, 2018).

The organic carbon content of the soil sample showed a slight decrease after the experiment. The addition of organic sources might have enhanced the activity of microorganisms by generating energy for their growth and maintenance. This would have led to a loss of soil organic carbon as carbon dioxide. In addition to that, higher amount of energy required for N fixation by native micro organisms in the soil and also for those present in applied PGPR would have been derived from the organic sources, which might have caused a further reduction in the soil organic carbon content (Wu *et al.*, 2005).

The available macro and micro nutrient status (after the experiment) did not show any significant variation in response to the different integrated nutrient management practices. Since the soil itself was sufficient in these nutrients before the experiment, further addition of nutrients might not have contributed for a significant difference.

5.6 ECONOMICS OF CULTIVATION

The highest net income (Fig. 13) was obtained from s_3b_1 (75 per cent RDN + 12.5 percent poultry manure + 12.5 per cent vermicompost +PGPR-1) and highest BCR (Fig. 14) was registered with s_1b_0 (75 per cent RDN + 25 per cent poultry manure) treatment. However, the application of nutrients through chemical source only (control) recorded the highest net income and BCR compared to the other treatments. Higher economic yield from the chemical sources coupled with low cost of cultivation obviously resulted in higher economic returns. On the other hand, the cost involved in the purchase of organic manures was higher than that of chemical fertilizer, which resulted in reduced net return and BCR. Vermicompost and poultry manure were the organic sources used in the experiment and the vermicompost can easily be prepared by the farmer at farm level which can reduce the cost of cultivation. Though the application of chemical fertilizers may produce more yields in short duration crops like baby corn due to early availability of nutrients, it may result in accumulation of toxic compounds in the soil and the produce. Since baby corn is mainly consumed in the raw form, the consumers especially the urban people who are more conscious of the ill effects on health would prefer a high quality produce without compromising the price. The INM in baby corn seems to be highly relevant in this back drop.

A detailed analysis of the results obtained in this investigation indicated that 25 per cent N substitution through poultry and vermicompost (12.5 per cent N from each source) combined with 75 per cent RDN and recommended dose of P and K (@ 65 kg P_2O_5 and 45 kg K_2O) through chemical sources along with PGPR-1 or substituting 25 per cent N through vermicompost alone with PGPR-1 with recommended dose of P and K application was found to be best INM practices for getting higher cob yield with husk and marketable cob yield with added advantage of higher net returns. The net returns and the BCR produced by the control treatment (application of RDF only through chemical fertilizers) was however found to be higher than the other treatments due to low cost of chemical fertilizers compared to organic sources. With respect to the sensory characters and shelf life, application 50 per cent N through chemical source and remaining 50 per cent N through the poultry manure and vermicompost (25 per cent N from each source) along with biofertilizer PGPR-1 was found to be the best INM practice.

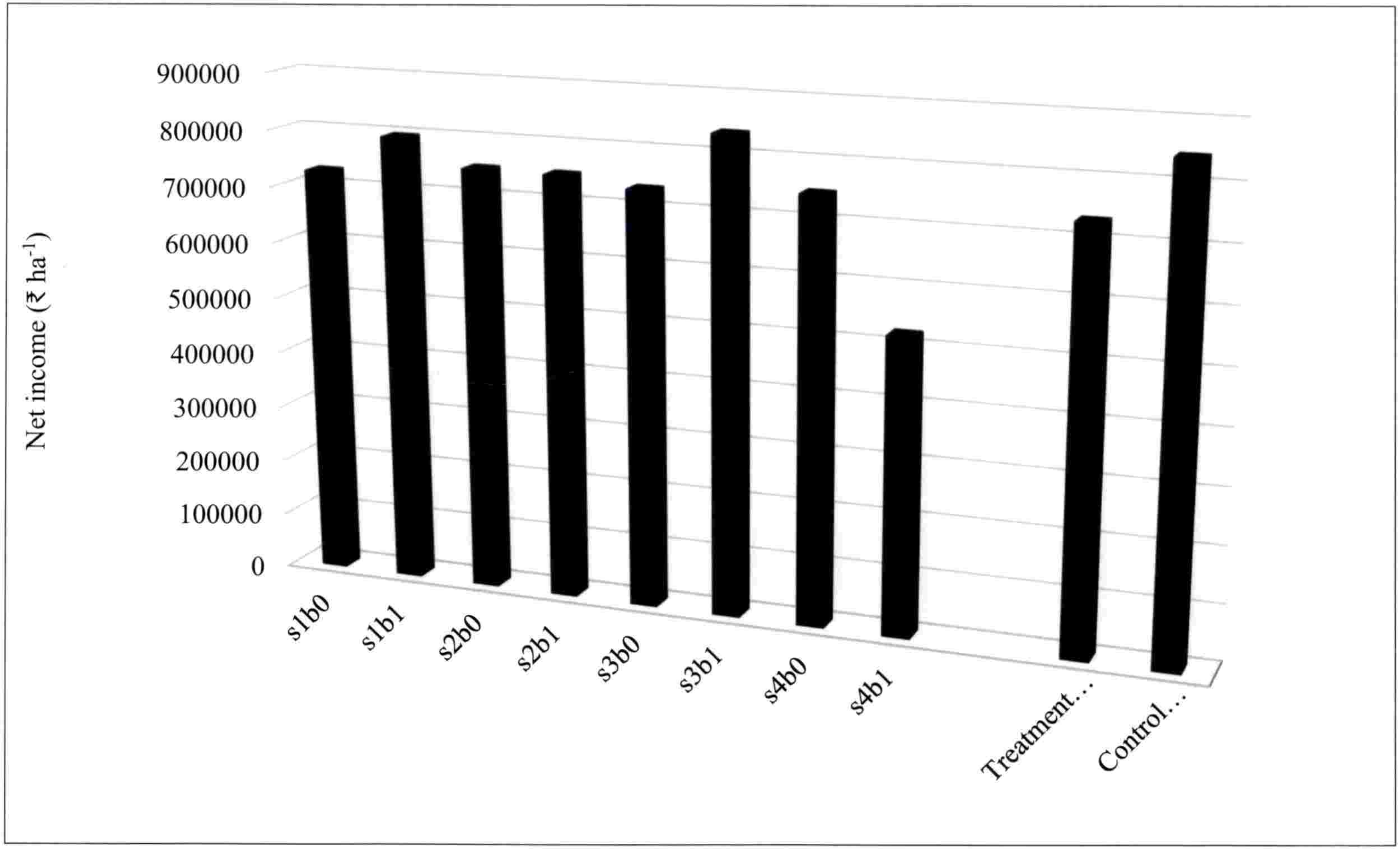


Fig 13. Effect of integrated nutrient management practices on net income of baby corn cultivation, ₹ ha^{-1}.

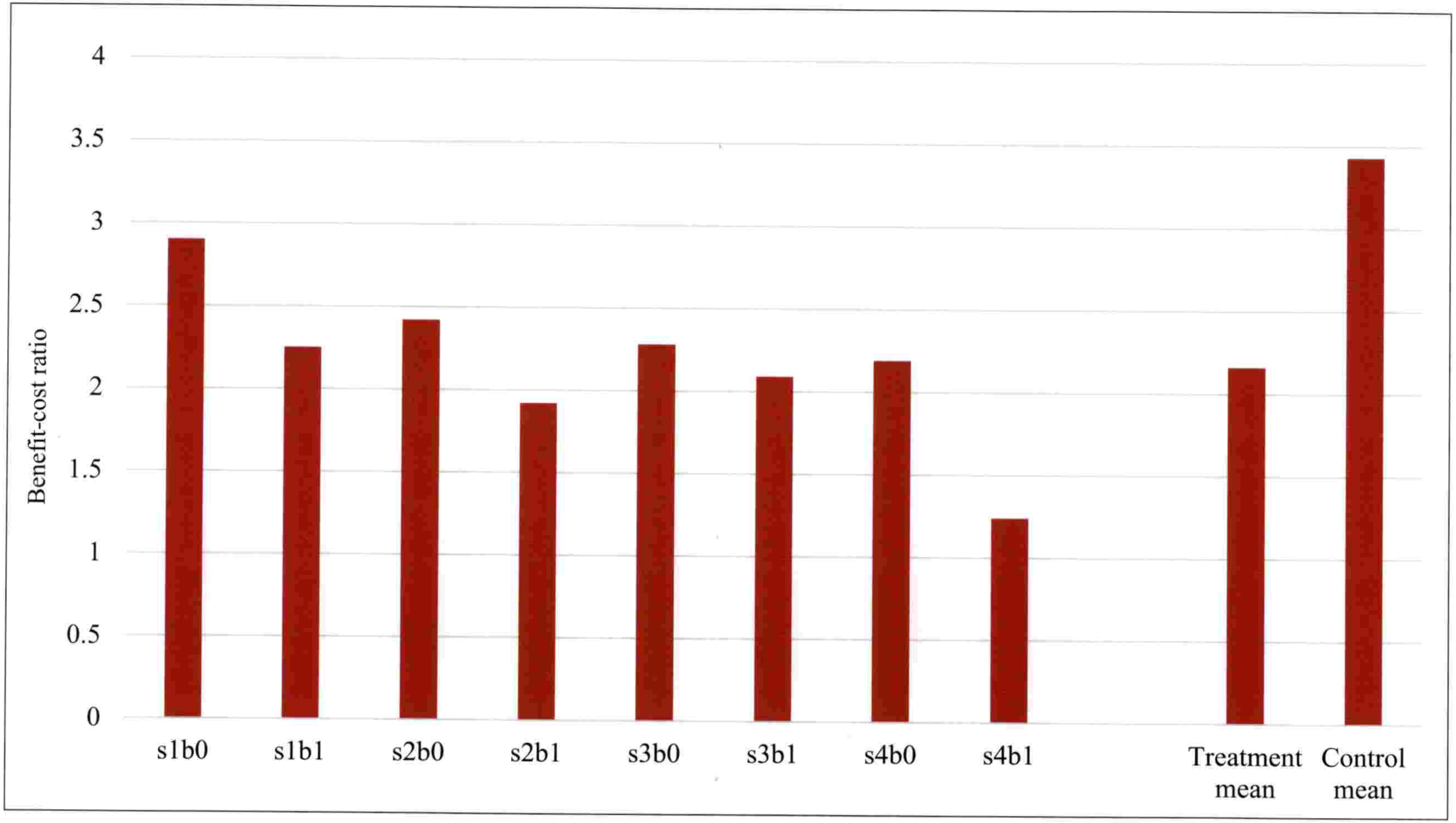


Fig 14. Effect of integrated management practices on benefit- cost ratio of baby corn cultivation.

SUMMARY

6. SUMMARY

The study entitled "Integrated nutrient management in baby corn (*Zea mays* L.)" was conducted during February to April 2018 at College of Agriculture, Vellayani, Thiruvananthapuram. The main objective of the study was to investigate the influence of INM practices on growth, yield, nutritive quality, storage life and economics of cultivation of baby corn (*Zea mays* L.).

The field experiment was laid out at block D of Instructional Farm, Vellayani in randomized block design with eight treatment combinations and a control, with three replications. The baby corn hybrid, G-5414 was the variety selected for the experiment. The treatments comprised four types of N substitution with organic sources (s_1 - 25 per cent N substitution through poultry manure; s_2 - 25 per cent N substitution through vermicompost; s_3 -12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost and s_4- 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost) and biofertilizer treatments (b_0- without biofertilizer and b_1- PGPR-1 seed treatment and soil application). The organic manures were substituted on N equivalent basis @ 135 kg N ha^{-1} as per the treatments and the remaining N was supplied through chemical fertilizers. The P @ 65 kg P_2O_5 ha^{-1} and K @ 45 kg K_2O ha^{-1} were supplied through chemical fertilizers in all the treatments. In the control, RDF were given @ 135:65:45 kg NPK ha^{-1} as per the nutrient dose standardized for baby corn in southern Kerala (Mavarkar, 2016). The PGPR-1 supplied from the Department of Agricultural Microbiology, College of Agriculture, Vellayani was used as the biofertilizer. Seed treatment with PGPR-1 was done by moistening the seeds and treating the seeds with PGPR-1 @ 30 g kg^{-1} of seeds followed by soil application @ 110 g m^{-2} area (mixture of dry cowdung and PGPR-1) in the respective treatment.

The results revealed that, no significant variation in the growth attributes of baby corn was obtained, due to N substitution with organic manures or between treatment and control. However, the growth attributes viz., plant height, leaves per plant, LAI and DMP were significantly higher with the application of biofertilizer (PGPR-1) compared to no biofertilizer application. Taller plants were produced with the application of biofertilizer (b_1) at 15 and 45 DAE with a plant height of 14.64 cm and 107.93 cm respectively. Higher number of leaves per plant at 45 DAE (11.70), LAI at 30 DAE (2.61) and total DMP at harvest (18.20 t ha^{-1}) were also produced by b_1 (PGPR-1 seed treatment and soil application). The biofertilizer application (b_1) also had a significant influence on the yield attributes and yield of baby corn compared to no biofertilizer application (b_0). The cob weight with husk per plant (244.33 g), cob weight with husk per cob (81.44 g), cob yield with husk (22.33 t ha^{-1}) and marketable cob yield (5.82 t ha^{-1}) were found to be significantly higher for b_1.

Among different INM practices, combined application of chemical fertilizer and organic manures (vermicompost and poultry manure) with 12.5 per cent N substitution through each source (s_3b_1) along with biofertilizer application (PGPR-1) recorded significantly higher plant height at 45 DAE (112.18cm) and was found to be on par with with s_4b_1 (110.05 cm), s_2b_1 (108.93 cm), s_1b_0 (105.77 cm) and s_4b_0 (104.13 cm). The total DMP at harvest was significantly higher (19.94 t ha^{-1}) for s_3b_1 (75 per cent RDN +12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost + PGPR-1). However, s_3b_1 was on par with s_4b_0 (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost), s_1b_1 (75 per cent RDN + 25 per cent N substitution through poultry manure + PGPR-1) and s_2b_0 (75 per cent RDN + 25 per cent N substitution through vermicompost). The s_3b_1 treatment also resulted in the highest cob weight with husk (85.11g per cob) and cob yield with husk (24.74 t ha^{-1}). In case of cob weight with husk s_3b_1 was on par with s_2b_1 however it did not vary from s_1b_1, s_2b_1 or s_4b_0 in case of cob yield with husk. In the case of marketable cob yield, the s_2b_1 (6.79 t ha^{-1}) recorded the highest value and was on par with s_3b_1 (6.13 t ha^{-1}) and s_1b_1 (5.96 t ha^{-1}). While comparing the treatments with the control, it was observed that there was no significant difference between treatments and control with respect to the yield attributes and yield of baby corn, but the control recorded higher mean value than the treatment.

The main effects and interaction effect had no significant influence on the chlorophyll content, crude protein (cob and stover), crude fibre (cob and stover) and starch content in baby corn. The N substitution with organic sources had a significant effect on the ascorbic acid content of baby corn cob. The highest ascorbic acid content (10.67 mg g^{-1}) was recorded when 25 per cent of N was substituted through vermicompost (s_2) which was superior to other main effects of N substitution. Application of biofertilizer (b_1- PGPR-1 as seed treatment and soil application) produced significantly higher total soluble sugar (6.86 °Brix), reducing sugar (2.89 per cent) and ascorbic acid content (10 mg g^{-1}) in cob compared to no biofertilizer application. The treatments and control did not show any significant variation in case of nutrient content.

The interaction effect could significantly influence only the K uptake by the crop and all the treatment combinations produced the same effect except s_3b_0 which recorded a lower uptake. There was no significant variation between control and the treatment in case of nutrient uptake.

Organoleptic and shelf life studies indicated that the interaction between N substitution with organic sources and biofertilizer significantly influenced the sensory characters and shelf life of baby corn cob on 3rd and 6th day of storage. Application of 50 per cent of N through chemical source combined with 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost along with biofertilizer (s_4b_1) recorded the highest organoleptic score in fresh samples and during storage upto three days. The highest mean rank value (MRV) and mean score for appearance of fresh baby corn cob (MRV 179 and mean score 8.56) were recorded with s_4b_0 (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost) and was on par with s_2b_1 (MRV 166.4), s_2b_0 (MRV 155.9) and s_4b_1 (MRV 144.2). The highest mean rank value and mean score for other sensory parameters viz., colour, flavour, taste, texture and overall acceptability were recorded with s_4b_1 treatment (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost +PGPR-1).

Assessment of overall visual quality (OVQ) on 3rd day of storage indicated that that the OVQ was significantly superior in s_4b_1 (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost +PGPR-1) with a mean rank value of 187.7, whereas on the 6th day the s_3b_1 (75 per cent RDN + 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) had the highest mean rank value of 161.42 for OVQ. Sensory evaluation on the 3rd day indicated significantly higher mean rank value (171.37) and mean score (7.83) for appearance of fresh baby corn cob with the treatment s_4b_0 (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost) compared to other treatments. The s_4b_1 (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost +PGPR-1) recorded superior mean rank value and mean score with respect to remaining sensory parameters viz. colour, taste, flavour and overall acceptability except the texture. On the 6th day of storage, the INM practices could not significantly influence the appearance and colour of the baby corn cob. However, the remaining parameters viz. taste, flavour and texture were the highest (MRV 163.13, 163.95 and 163.1 respectively) for s_4b_1 (50 per cent RDN +25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost + PGPR-1) and the overall acceptability was maximum with s_2b_1 (MRV 168.17).

The post experiment status of soil pH, electrical conductivity, organic carbon content, available N, available P, available K and available micronutrients (Fe, Mn, Zn and Cu) were unaffected by the treatments.

Application of nutrients through chemical sources only (control) recorded the highest net income (₹ 8,43,182 ha^{-1}) compared to treatments involving N substitution with organic source and biofertilizer application and was followed by s_3b_1 (₹ 8,36,465 ha^{-1}), s_1b_1 (₹ 7,95,510 ha^{-1}), s_2b_0 (₹ 7,49,253 ha^{-1}), s_2b_1 (₹ 7,48,390 ha^{-1}), s_4b_0 (₹ 746181 ha^{-1}), s_3b_0 (₹ 7,33,442 ha^{-1}) and s_1b_0 (₹ 7,27,022 ha^{-1}). The net returns obtained was the lowest with s_4b_1 (₹ 5,21, 982 ha^{-1}). The control treatment also recorded the highest BCR (4.50) which was followed by s_1b_0 (3.67), s_2b_0 (3.42), s_3b_0 (3.28), s_1b_1 (3.25), s_4b_0 (3.19), s_3b_1 (3.09), s_2b_1 (2.92) and s_4b_1(2.42).

The results of the study indicated that INM practice with 25 per cent N substitution through poultry and vermicompost (12.5 per cent N from each source), combined with 75 per cent RDN @ 135 kg $ha^{-1}$and recommended dose of P and K (@ 65 kg P_2O_5 and 45 kg K_2O) through chemical sources along with PGPR-1 or substituting 25 per cent N through vermicompost alone with PGPR-1 and recommended dose of P and K could be recommended for realising higher cob yield with husk, marketable cob yield and net returns in baby corn. The net returns and the BCR produced by the control treatment (application of RDF only through chemical fertilizers) was however found to be higher than the other treatments due to low cost of cultivation. With respect to the sensory characters and shelf life, application 50 per cent N through chemical source and remaining 50 per cent N through the poultry manure and vermicompost (25 per cent N from each source) along with biofertilizer PGPR-1 was found to be the best INM practice.

The results pointed out the possibility of substituting N through organic sources such as poultry manure and or vermicompost for obtaining higher yields and economics with appreciable nutritive value, quality and storage life.

FUTURE LINE OF WORK

- Exploring the possibility of baby corn cultivation with organic management practices under intercropped situation in coconut gardens.
- The feasibility of raising baby corn intercropped with other suitable crops such as vegetables may be studied aiming at standardising the INM practices for the intercropping system.
- Low cost production of organic sources at the farm level may be explored to make the INM in baby corn more profitable.

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Integrated nutrient management in baby corn (*Zea mays* L.)

by

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ABSTRACT

The investigation entitled "Integrated nutrient management in baby corn (*Zea mays* L.)" was conducted at College of Agriculture, Vellayani to investigate the influence of integrated nutrient management practices on growth, yield, quality, storage life and economics of cultivation of baby corn (*Zea mays* L.).

The field experiment was conducted from February to April 2018 at the Instructional Farm, College of Agriculture, Vellayani. The experiment was laid out in randomized block design with eight treatment combinations and one control, with three replications. The variety planted was baby corn hybrid, G-5414. The treatments comprised four organic sources for nitrogen substitution (s_1 - 25 per cent N substitution through poultry manure; s_2 - 25 per cent N substitution through vermicompost; s_3 -12.5 per cent N substitution through poultry manure + 12.5 per cent N substitution through vermicompost and s_4- 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost) and two biofertilizer treatments (b_0- without biofertilizer and b_1- seed treatment and soil application of PGPR-1). The organic manures were substituted on N equivalent basis @ 135 kg N ha^{-1} as per the treatments and the balance was supplied through fertilizer source. Phosphorus @ 65 kg P_2O_5 ha^{-1} and potassium @ 45 kg K_2O ha^{-1} were supplied through chemical fertilizers in all the treatments. In the control treatment, nutrients were given @ 135:65:45 kg NPK ha^{-1} through chemical fertilizers.

The results indicated that baby corn responded well to biofertilizer application (PGPR-1) which significantly increased the plant height at 15 and 45 DAE, leaves per plant at 45 DAE (11.70) and LAI at 30 DAE (2.61) compared with no biofertilizer application. This treatment also produced significantly higher total DMP at harvest (18.20 t ha^{-1}), cob weight with husk per plant (244.33 g), cob weight with husk per cob (81.44 g), and marketable cob yield (5.82 t ha^{-1}). Among different INM practices, combined application of chemical fertilizer and organic manures (vermicompost and

poultry manure) with 12.5 per cent N substitution through each source (s_3b_1) along with biofertilizer application (PGPR-1) recorded significantly higher plant height (112.18 cm) at 45 DAE and was on par with s_4b_1, s_2b_1, s_1b_0 and s_4b_0. The same treatment recorded the highest DMP at harvest (19.94 t ha^{-1}) but was on par with s_4b_0, s_1b_1 and s_2b_0 compared to other treatment combinations. The s_3b_1 also resulted in the highest cob weight with husk (85.11g per cob) and cob yield with husk (24.74 t ha^{-1}) but it did not vary from s_1b_1, s_2b_1 and s_4b_0 with respect to cob weight with husk and was on par with s_2b_1 in case of cob yield with husk. However, adopting INM with 25 per cent substitution of N through vermicompost along with biofertilizer application (s_2b_1) produced the highest marketable cob yield (6.79 t ha^{-1}), where it was on par with s_3b_1 and s_1b_1.

The highest ascorbic acid content in baby corn cob (10.67 mg g^{-1}) was recorded when 25 per cent of N was substituted through vermicompost (s_2). Application of biofertilizer PGPR-1 produced significantly higher total soluble sugar (6.86 ^{0} Brix), reducing sugar (2.89 per cent) and ascorbic acid content (10 mg g^{-1}) in cob compared to no biofertilizer application. Organoleptic and shelf life studies indicated that the application of 50 per cent of N through chemical source combined with 25 per cent N substitution through poultry manure + 25 per cent N substitution through vermicompost along with biofertilizer (s_4b_1) recorded the highest organoleptic score in fresh samples and during storage upto three days.

Application of nutrients through chemical sources (control) recorded the highest net income (₹ 8,43,182 ha^{-1}) compared to other treatments and was followed by the application of 75 per cent N through chemical fertilizer in combination with 25 per cent N substitution through poultry manure and vermicompost (12.5 per cent N from each source) along with biofertilizer PGPR-1 (₹ 8,36,465 ha^{-1}). The control treatment also resulted in the highest BCR (4.50) which was followed by the treatment with substitution of 25 per cent N through poultry manure and applying remaining quantity of N through chemical source without biofertilizer (3.67).

The results of the study indicated that INM practice with 25 per cent N substitution through poultry manure and vermicompost (12.5 per cent N from each source) combined with 75 per cent RDN @ 135 kg $ha^{-1}$and recommended dose of P and K (@ 65 kg P_2O_5 and 45 kg K_2O) through chemical sources along with PGPR-1 or substituting 25 per cent N through vermicompost alone with PGPR-1 and recommended dose of P and K could be recommended for realising higher cob yield with husk, marketable cob yield and net returns. The net returns and the BCR produced by the control treatment (application of RDF only through chemical fertilizers) was however found to be higher than the other treatments due to low cost of cultivation. Application 50 per cent N through the poultry manure and vermicompost (25 per cent N from each source) along with biofertilizer PGPR-1 was found to be the best INM practice with respect to organoleptic characters and shelf life of baby corn.

സംഗ്രഹം

പിഞ്ചുചോളത്തിലെ സംയോജിത വളപ്രയോഗം എന്ന വിഷയത്തെ സംബന്ധിച്ച ഒരു പഠനം 2018 ഫെബ്രുവരി മുതൽ മെയ് വരെ വെള്ളായണി കാർഷിക കോളേജിൽ വച്ച് നടത്തുകയുണ്ടായി. സംയോജിത വളപ്രയോഗത്തിലൂടെ പിഞ്ചുചോളത്തിൻറ്റെ വളർച്ച, ഉത്പാദനക്ഷമത, ഗുണമേന്മ, സംഭരണ കാലാവധി എന്നിവയെക്കുറിച്ച് പഠിക്കുക, പിഞ്ചുചോളക്കൃഷിയുടെ സാമ്പത്തിക വശത്തെക്കുറിച്ച് മനസിലാക്കുക എന്നിവയായിരുന്നു പ്രസ്തുത പഠനത്തിൻറ്റെ ലക്ഷ്യങ്ങൾ.

പ്രസ്തുത പരീക്ഷണത്തിന് റാൻഡമൈസ്ഡ് ബ്ലോക്ക് ഡിസൈൻ എന്ന സ്റ്റാറ്റിസ്റ്റിക്കൽ പഠനരീതിയാണ് അവലംബിച്ചത്. ജി 5414 എന്ന സങ്കരഇനത്തിൽപെട്ട പിഞ്ചുചോളമാണ്പഠനവിധേയമാക്കിയത്. പരീക്ഷണത്തിനായി, ശുപാർശ ചെയ്ത അളവിലെ പാക്യജനകം (135 കി ഗ്രാം ഹെക്ടറിന്) രാസവളമായി നൽകുന്നതിന് പകരമായി തുല്യ അളവിൽ നാല് ജൈവ സ്രോതസുകളും (s_1- ശുപാർശ ചെയ്ത പാക്യജനത്തിൻറ്റെ 25 ശതമാനം കോഴിവളമായി, s_2- ശുപാർശ ചെയ്ത പാക്യജനത്തിൻറ്റെ 25 ശതമാനം മണ്ണിരകമ്പോസ്റ്റായി, s_3- ശുപാർശ ചെയ്ത പാക്യജനത്തിൻറ്റെ 12.5 ശതമാനം കോഴിവളവും, 12.5 ശതമാനം മണ്ണിരകമ്പോസ്റ്റുമായി, s_4- ശുപാർശ ചെയ്ത പാക്യജനത്തിൻറ്റെ 25 ശതമാനം കോഴിവളവും, 25 ശതമാനം മണ്ണിരകമ്പോസ്റ്റുമായി) കൂടെ മിത്രസൂക്ഷ്മാണു ഉത്പന്നമായ പി ജി പി ആർ മിശ്രിതം 1 ചേർത്തും (b_1), ചേർക്കാതെയുമാണ് (b_0) പഠനം നടത്തിയത്.

മേൽപറഞ്ഞ പഠനമുറകളിലെല്ലാം ശുപാർശ ചെയ്ത അളവിൽ ഭാവഹവും (65 കി ഗ്രാം ഹെക്ടറിന്), ക്ഷാരവും (45 കി ഗ്രാം ഹെക്ടറിന്) രാസവളത്തിൽക്കൂടി നൽകി.

മിത്രസൂക്ഷ്മാണു ഉത്പന്നത്തിൻറ്റെ ഉപയോഗത്തിൽ ചെടിയുടെ ഉയരവും, ഇലയുടെ വിസ്തീർണവും, കോബിൻറ്റെ ഭാരവും, കൂടുതലായതിനാൽ നല്ല വിളവ് രേഖപ്പെടുത്തി. ജൈവ സ്രോതസിൻറ്റെയും, മിത്രസൂക്ഷ്മാണു ഉത്പന്നത്തിൻറ്റെയും സംയുക്തമായ ഉപയോഗത്തി അപഗ്രഥനം നടത്തിയപ്പോൾ നല്ല വിളവും ആദായവും നൽകിയത് കോഴിവളവും മണ്ണിരകമ്പോസ്റ്റും ശുപാർശചെയ്ത പാക്യജനകത്തിൻറ്റെ 25 ശതമാനം (ഓരോ സ്രോതസ്സിൽനിന്നും 12.5 ശതമാനം വീതം) ലഭിക്കത്തക്കവിധത്തിൽ നൽകുകയും, ശേഷിക്കുന്ന 75 ശതമാനം പാക്യജനകം, ഭാവഹത്തിനും ക്ഷാരത്തിനുമൊപ്പം രാസവളമായി ചേർത്ത് പി ജി പി ആർ മിശ്രിതം 1 നോടൊപ്പം നൽകിയോ, അല്ലെങ്കിൽ 25 ശതമാനം പാക്യജനകം മണ്ണിരകമ്പോസ്റ്റ് വഴി മാത്രമായി ചേർത്ത് കൂടെ പി ജി പി ആർ മിശ്രിതം 1 ഉപയോഗിക്കുകയും ചെയ്തപ്പോഴാണ്. മുഴുവൻ പാക്യജനകവും രാസവളമായി നല്കിയപ്പോഴും സമാനരീതിയിലുള്ള പ്രകടനമായിരുന്നു. കോഴിവളത്തിലൂടെയും, മണ്ണിരകമ്പോസ്റ്റിലൂടെയും 50 ശതമാനം പാക്യജനകം (ഓരോ സ്രോതസ്സിൽനിന്നും 25 ശതമാനം വീതം) നൽകുകയും കൂടെ പി ജി പി ആർ മിശ്രിതം 1 ചേർക്കുകയും ചെയ്തപ്പോൾ നല്ല ഗുണമേന്മയും, സംഭരണ കാലാവധിയമുള്ള ചോളങ്ങളിലാണ് ലഭിച്ചത്.

APPENDICES

APPENDIX I

Weather parameters during the cropping period (February to March 2018)

Standard week	Mean temperature (^0C)		Total rainfall (mm)	Mean RH (%)		Bright sunshine hours
	Max.	Min.		Max.	Min	
8 (19 Feb. – 25 Feb.)	32.5	23.1	0.0	92.1	77.9	9.1
9 (26 Feb. – 04 Mar.)	33.5	24.1	0.0	90.4	73.7	9.6
10 (05 Mar. – 11 Mar.)	32.9	24.1	0.0	93.9	74.0	8.9
11 (12 Mar. - 18 Mar)	33.3	24.5	3.0	92.3	76.4	7.9
12 (19 Mar.- 25 Mar)	33.7	25.1	5.3	90.1	74.9	9.0
13 (26 Mar. - 1 April)	33.9	25.6	0.0	88.4	74.0	9.3
14 (2 April - 8 April)	34.4	25.7	1.1	87.9	73.1	9.4
15 (9 April - 15 April)	33.6	25.7	13.2	89.4	73.6	8.2
16 (16 April- 22April)	33.3	25.9	1.5	90.0	76.7	7.3
17 (23 April- 29 April)	34.3	26.3	4.3	84.0	74.4	9.1
18 (30 April – 6 May)	34.7	26.1	2.0	82.0	73.7	8.8
19 (7 May –13 May)	33.2	25.7	6.8	89.6	75.0	6.1
20 (14 May – 20 May)	32.2	24.8	27.3	89.3	75.0	4.8

APPENDIX II

Sensory Evaluation

SCORE CARD

Particulars	Score	Appearance	Colour	Flavour	Taste	Texture	Overall Acceptability	Overall visual quality
Like Extremely	9							
Like Very Much	8							
Like Moderately	7							
Like Slightly	6							
Neither Like nor Dislike	5							
Dislike Slightly	4							
Dislike Moderately	3							
Dislike Very Much	2							
Dislike Extremely	1							

APPENDIX III

Cost of cultivation of baby corn

Particulars	Unit cost (₹)
Seed	800 kg^{-1}
Farmyard manure	5 kg^{-1}
Poultry manure	2 kg^{-1}
Vermicompost	20 kg^{-1}
Biofertilizer	70kg^{-1}
Urea	8 kg^{-1}
Rajphos	12 kg^{-1}
Muriate of potash	18 kg^{-1}
Labourers	800
Fuel charge	800 hr^{-1}
Transportation	1000
Plant protection	1000