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**LIST OF SYMBOLS AND ABBREVIATIONS**

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<thead>
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<tr>
<td>%</td>
<td>Per cent</td>
</tr>
<tr>
<td>@</td>
<td>At the rate of</td>
</tr>
<tr>
<td>&amp;</td>
<td>And</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
<tr>
<td>B</td>
<td>Boron</td>
</tr>
<tr>
<td>B.C.</td>
<td>Benefit cost ratio</td>
</tr>
<tr>
<td>CD</td>
<td>Critical difference</td>
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<tr>
<td>CV</td>
<td>Coefficient of variation</td>
</tr>
<tr>
<td>DAP</td>
<td>Di ammonium phosphate</td>
</tr>
<tr>
<td>DAS</td>
<td>Days after sowing</td>
</tr>
<tr>
<td>dS m&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>Deci Siemens per metre</td>
</tr>
<tr>
<td>EC</td>
<td>Electrical conductivity</td>
</tr>
<tr>
<td><em>et al.</em></td>
<td>And other</td>
</tr>
<tr>
<td>Fe</td>
<td>Iron</td>
</tr>
<tr>
<td>FeSO&lt;sub&gt;4&lt;/sub&gt;</td>
<td>Iron sulphate</td>
</tr>
<tr>
<td>Fig.</td>
<td>Figure</td>
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<tr>
<td>FYM</td>
<td>Farmyard manure</td>
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<tr>
<td>g</td>
<td>Gram</td>
</tr>
<tr>
<td>g ha&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>Gram per hectare</td>
</tr>
<tr>
<td>GKVK</td>
<td>Gandhi Krishi Vignan Kendra</td>
</tr>
<tr>
<td>H.I.</td>
<td>Harvest Index</td>
</tr>
<tr>
<td>IARI</td>
<td>Indian Agricultural Research Institute</td>
</tr>
<tr>
<td>ICAR</td>
<td>Indian Council of Agricultural Research</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
</tr>
<tr>
<td>K&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>Potassium Oxide</td>
</tr>
<tr>
<td>kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>kg ha&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>Kilogram per hectare</td>
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<tr>
<td>km</td>
<td>Kilometer</td>
</tr>
<tr>
<td>L&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>Per litre</td>
</tr>
<tr>
<td>Symbol</td>
<td>Unit</td>
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</tr>
<tr>
<td>m</td>
<td>Metre</td>
</tr>
<tr>
<td>m²</td>
<td>Metre square</td>
</tr>
<tr>
<td>MAU</td>
<td>Marthawada Agricultural University</td>
</tr>
<tr>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>mg kg⁻¹</td>
<td>Milligram per kilogram</td>
</tr>
<tr>
<td>mL</td>
<td>Milliliter</td>
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<tr>
<td>mm</td>
<td>Millimeter</td>
</tr>
<tr>
<td>MSL</td>
<td>Mean Sea Level</td>
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<tr>
<td>Mn</td>
<td>Manganese</td>
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<tr>
<td>Mo</td>
<td>Molybdenum</td>
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<tr>
<td>N</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>NS</td>
<td>Non significant</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>PSB</td>
<td>Phosphorus Solubilizing Bacteria</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>Phosphorus Pentoxide</td>
</tr>
<tr>
<td>pH</td>
<td>Potential of hydrogen ion concentration</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts per million</td>
</tr>
<tr>
<td>RH</td>
<td>Relative Humidity</td>
</tr>
<tr>
<td>RD</td>
<td>Recommended dose</td>
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<tr>
<td>RDF</td>
<td>Recommended dose of fertilizer</td>
</tr>
<tr>
<td>Rs.</td>
<td>Rupees</td>
</tr>
<tr>
<td>S</td>
<td>Sulphur</td>
</tr>
<tr>
<td>SEm ±</td>
<td>Standard error of mean</td>
</tr>
<tr>
<td>SP</td>
<td>Superphosphate</td>
</tr>
<tr>
<td>SSP</td>
<td>Single superphosphate</td>
</tr>
<tr>
<td>t ha⁻¹</td>
<td>Tonnes per hectare</td>
</tr>
<tr>
<td>UAS</td>
<td>University of Agricultural Sciences</td>
</tr>
<tr>
<td>Viz.,</td>
<td>Namely</td>
</tr>
<tr>
<td>Zn</td>
<td>Zinc</td>
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<td>ZnSO₄</td>
<td>Zinc sulphate</td>
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It is by grace of Almighty, omnipotent blessings of my teachers and parents that I could accomplish and bring to light this humble piece of work.

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Place: 

Date: (INDIRA PRIYADARSHINI.J)
A field experiment was conducted on clay loam soil of the Agricultural College Farm, Bapatla to assess the soybean [Glycine max (L.) Merrill] need for zinc and iron with and without vermicompost during rabi, 2007-08. The treatments consisted of three vermicompost levels (application of NPK alone, combined application of NPK and vermicompost and application of vermicompost alone) assigned to main plots and six micronutrient levels (no micronutrient application, soil application of ZnSO₄ @ 25 kg ha⁻¹, foliar application of ZnSO₄ @ 0.2%, foliar application of FeSO₄ @ 0.5%, soil application of ZnSO₄ & FeSO₄ @ 25 kg ha⁻¹ and 10 kg ha⁻¹ and foliar application of ZnSO₄ @ 0.2% and FeSO₄ @ 0.5%) assigned to sub-plots arranged in split-plot design and the treatments were replicated thrice.
In general, growth parameters like plant height and drymatter accumulation were found to be the highest with the combined application of NPK and vermicompost over NPK alone and vermicompost alone. No significant differences were observed among vermicompost levels for number and dryweight of nodules at 30 DAS; however, at 60 DAS the highest number and nodule dryweight was recorded with integrated application of NPK and vermicompost. Days to 50% flowering was not significantly influenced by different treatments. Yield attributes, seed and haulm yield of soybean were the highest with combined application of NPK and vermicompost over NPK alone and vermicompost alone. Quality parameters like protein, zinc and iron contents in seed were the highest with the integrated application of NPK and vermicompost. Oil content of soybean was not significantly influenced by the vermicompost levels. Uptake of nutrients and available nutrients in soil at harvest were superior with combined application of NPK and vermicompost.

The maximum plant height, highest drymatter accumulation, more number and dryweight of nodules were recorded with the soil application of ZnSO$_4$ and FeSO$_4$. But, it was comparable with foliar application of zinc and iron. No significant difference was observed for days to 50% flowering with micronutrient levels. The highest number of pods, more test weight and increased seed and haulm yield were recorded with soil application of ZnSO$_4$ and FeSO$_4$ over no micronutrient application and it was on a par with foliar application of zinc and iron. The maximum protein content was recorded with the soil application of ZnSO$_4$ and FeSO$_4$. Conversely, oil content was not significantly influenced by micronutrient levels. No significant difference in NPK uptake and available NPK content of soil at harvest were found with
micronutrient levels, whereas, zinc and iron uptake by plant and seed were significantly influenced by micronutrient levels. The highest zinc and iron uptake was recorded with foliar application of zinc and iron and it was on a par with soil application of zinc and iron.

Thus the present study indicated that application of NPK along with vermicompost was found significantly superior to NPK alone and vermicompost alone in increasing growth parameters, yield attributes, yield and quality parameters. Soil application of ZnSO₄ + FeSO₄ increased growth parameters, yield attributes, yield and quality parameters, and was comparable with foliar application of zinc and iron. Combined application of NPK and vermicompost along with zinc and iron either by soil application or by foliar application significantly increased the seed yield of soybean compared to no micronutrient application, whereas, integrated application of NPK and vermicompost without micronutrient application was found to be similar in increasing the growth, yield and quality parameters as that of combined application of NPK, vermicompost along with micronutrient application.
CHAPTER – I

INTRODUCTION

Soybean, although a non-traditional crop in India, is gaining popularity in recent times because of its diverse adaptability, better quality and multiple uses. Soybean is a miracle “Golden bean” of twentieth century. It is called as poor man’s meat as it contains about 40 to 44 per cent good quality protein, 20 per cent cholesterol-free oil and 20 per cent carbohydrates. In addition, it contains all the vitamins (A,B,C,D,E,K) and other essential amino acids.

Soybean is the third major oil-seed crop grown in India after groundnut, rapeseed and mustard. In India, it is grown on an area of 6.5 million hectares with a productivity of 1.2 tonnes per hectare. In Andhra Pradesh, it is cultivated in about 1 lakh hectares mainly in Adilabad, Nizamabad and Medak districts.

With growing awareness on food quality and nutritional status of food, agronomic interventions to improve the mineral content of grain is required; however, it may depend on the way the crop is manured. In intensive agriculture, use of high analysis fertilizers and sub-optimal application of micronutrients are the major reasons for micronutrient deficiencies leading to reduced crop productivity.

Among the micronutrients, zinc plays an important role in synthesis of protein and nucleic acids. Likewise iron plays an important role in nitrogen fixation and protein synthesis. Hence optimum supply of these micronutrients deserves special attention in protein-rich legume crops like soybean.
In recent years, awareness is increasing on using vermicompost as organic manure, which acts as an excellent base for establishment of soil microflora and fauna. As the foods that are produced organically are well preferred, the potential of vermicompost as organic manure to meet the need of both macro and micro nutrients is to be explored.

Keeping these in view, an experiment entitled “Assessment of the soybean need for zinc and iron with and without vermicompost” was conducted at the Agricultural College Farm, Bapatla with the following objectives.

i. To study the influence of zinc and iron on growth, yield and quality of soybean.

ii. To workout the beneficial effect of vermicompost with and without NPK application.

iii. To know whether or not the application of vermicompost eliminates the need for the application of zinc and iron along with NPK fertilizers.
CHAPTER – II
REVIEW OF LITERATURE

A brief review of work done on the effect of micronutrients with and without organic manures on growth, yield and quality of soybean under different situations of India and abroad are presented in this chapter.

2.1 EFFECT OF INTEGRATION OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH, YIELD AND QUALITY OF SOYBEAN

Integrated nutrient management approach minimizes the use of fertilizers but maximizes their use efficiency. Combined application of inorganic fertilizers with manures in proper proportion can counter balance the shortage of costly fertilizer and enhances the quality and restores the physical, chemical and biological health and provide sustainable fertile soil for plant growth. In recent years, vermicompost is being used as organic manure, which acts as an excellent base for establishment of soil microflora and fauna, and to support better nutrient availability. The work done on the effect of integration of inorganic fertilizers and vermicompost as organic manure on growth, yield and quality of soybean is reviewed under different subheads.

2.1.1 Growth

Thanunathan et al. (2002) found that application of enriched vermicompost @ 750 kg ha$^{-1}$ significantly increased the plant height of soybean than FYM application on clay loam soil during the kharif season at the Annamalai University Experimental Farm. Paradkar and Deshmukh (2004) stated that integrated incorporation of recommended NPK coupled with FYM
@ 10 t ha\(^{-1}\) increased the plant height of soybean over NPK alone. Dash et al. (2005) showed that plant height of soybean was found to be significantly higher under application of crop residue @ 5 t ha\(^{-1}\) + FYM @ 5 t ha\(^{-1}\) + ZnSO\(_4\) @ 5 kg ha\(^{-1}\) on clay soil during the \textit{kharif} season at the Instructional Farm, Indira Gandhi Agricultural University, Raipur. Plant height was significantly higher with the application of 75 per cent RDF and 25 per cent RDF through vermicompost than sole application of 100 per cent RDF during the \textit{kharif} season at the Agricultural College Farm, Nagpur (Kanase et al. 2006).

Rajat and Ahlawat (2009) revealed that plant height of groundnut and pigeonpea were significantly improved due to application of FYM @ 5 t ha\(^{-1}\) over no FYM application during two consecutive \textit{kharif} seasons at the Research Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi.

Thanunathan et al. (2002) observed significantly increased number of effective nodules with the application of enriched vermicompost @ 750 kg ha\(^{-1}\) than FYM application in soybean on clay loam soil during the \textit{kharif} season at the Annamalai University Experimental Farm.

Paradkar and Deshmukh (2004) reported that integrated application of NPK along with FYM @ 10 t ha\(^{-1}\) recorded significantly more number of nodules and the highest dry weight of nodules in soybean over application of NPK alone, whereas, Dash et al. (2005) revealed that number of nodules and drymatter of nodules in soybean were found to be higher with application of crop residue @ 5 t ha\(^{-1}\) + FYM @ 5 t ha\(^{-1}\) + ZnSO\(_4\) @ 5 kg ha\(^{-1}\) on clay soil during the \textit{kharif} season at Instructional Farm, Indira Gandhi Agricultural University, Raipur.
Application of 75 per cent RDF and remaining 25 per cent through vermicompost significantly increased the number of nodules of soybean during the *kharif* season on medium black clay soil at the Agricultural College Farm, Nagpur (Kanase *et al.* 2006).

Drymatter production increased with application of FYM @ 10 t ha$^{-1}$ on clay loam soil at Akola (Chawale *et al.* 1993). Studies conducted by Rajkhowa *et al.* (2000) indicated that the highest drymatter accumulation was obtained with the application of 75 per cent of N recommended as urea along with 5 t ha$^{-1}$ vermicompost at University Farm, Jorhat (Assam) in greengram crop. Accumulation of the highest drymatter was observed by Saxena *et al.* (2001) with the application of micronutrients Zn @ 5 kg ha$^{-1}$, B @ 0.5 kg ha$^{-1}$, Mo @ 0.5 kg ha$^{-1}$ along FYM @ 10 t ha$^{-1}$ in soybean on silty clay loam soil during the *kharif* season at Pantnagar.

Khutate *et al.* (2005) reported that application of 75 per cent NPK recommended through fertilizer + 25 per cent NPK recommended through vermicompost significantly increased the drymatter accumulation than application of 100 per cent NPK through fertilizers alone on medium black and clay soil at the Agricultural College Farm, Nagpur. Application of 100 per cent recommended dose of NPK along with 25 per cent of nitrogen recommended through vermicompost recorded the highest drymatter accumulation in french bean over no vermicompost application on sandy loam soil during winter season at the Pulse Block of Agricultural Research Farm, Banaras Hindu University, Varanasi (Rajput *et al.* 2009).


2.1.2 Yield Attributes

Aruna and Narasa Reddy (1999) reported significantly higher number of pods and 100-seed weight in soybean with the application of vermicompost @ 15 t ha\(^{-1}\) over FYM and biogas slurry on sandy loam soil during rabi season at the Agricultural College Farm, Bapatla. Kumaran et al. (2001) reported significant increase in number of pods per plant, kernels per pod and kernel weight of groundnut with the application of NPK along with FYM @ 12.5 t ha\(^{-1}\) during the rabi on red sandy loam soil at the Agricultural College and Research Institute, Killikulam, Tamil Nadu. Thanunathan et al. (2002) observed increased number of pods, number of seeds and 100-seed weight of soybean with the application of vermicompost @ 750 kg ha\(^{-1}\) over FYM application on clay loam soil during the kharif season at the Annamali University Experimental Farm.

Combined application of NPK and FYM @ 10 t ha\(^{-1}\) increased the number of pods per plant, number of seeds per pod and 100-seed weight of soybean (Paradkar and Deshmukh, 2004).

Billore et al. (2005) found that application of FYM @ 10 t ha\(^{-1}\) alone is sufficient to compensate the requirements of different micronutrients (Zn, Fe, B and Mo) and in turn recorded the significantly higher number of pods, number of seeds per pod and 100 seed weight in soybean. Application of optimum dose of NPK in combination with FYM @ 15 t ha\(^{-1}\) showed the highest number of yield attributes in groundnut over no FYM during rainy season on a typic hapludult at the Kolasib, Mizoram (Laxminarayana and Patiram, 2005).
Significantly higher numbers of pods, number of seeds per pod were recorded under the application of 75 per cent of NPK recommended through fertilizer and the remaining 25 per cent through vermicompost on medium black clay soil over application of 100 per cent NPK through fertilizer only, Agriculture College Farm, Nagpur (Khutate et al. 2005). Experiment conducted by Suryawanshi et al. (2006) indicated that application of wheat straw @ 5 t ha\(^{-1}\) + FYM @ 5 t ha\(^{-1}\) + ZnSO\(_4\) @ 5 kg ha\(^{-1}\) recorded significantly higher number of pods, 100-seed weight of soybean over application of NPK alone during the *kharif* season on clay soil at the Marathwada Agricultural University, Parbhani. Recommended dose of NPK + ZnSO\(_4\) @ 10 kg ha\(^{-1}\) + FYM @ 10 t ha\(^{-1}\) contributed higher number of pods, number of seeds, 100-seed weight of soybean during the *kharif* season on vertisols at the Agricultural Research Station, Nasik (Shirpukar et al., 2006).

Rajput et al. (2009) reported that application of 100 per cent recommended dose of NPK along with 25 per cent of nitrogen through vermicompost recorded significantly the highest number of yield attributes in french bean over no vermicompost application on sandy loam soil of during the winter season at the Pulse Block of Agricultural Research Farm, Banaras Hindu University, Varanasi.

### 2.1.3 Yield

Mohamad Ali *et al.* (1976) did not find any significant increase in seed yield of soybean with FYM application @ 12.6 t ha\(^{-1}\). Experiment conducted by Patil *et al.* (1986) revealed that application of FYM @ 5 t ha\(^{-1}\) recorded the highest pod yield of groundnut at Rahuri on a sandy loam soil.
Agasimani and Hosmani (1989) reported that application of FYM @ 7.5 t ha\(^{-1}\) recorded the highest pod yield in groundnut. Deverajan and Palaniappan (1995) revealed that soybean recorded significantly higher seed yield under the combined application of ZnSO\(_4\) @ 2.5 kg ha\(^{-1}\) along with FYM @ 10 t ha\(^{-1}\) on black calcareous and red non-calcareous soils during both kharif and rabi seasons over FYM alone at the Tamil Nadu Agricultural University Farm.

Saxena et al. (2001) observed that seed yield of soybean was significantly increased under the integrated application of micronutrients (Zn @ 5.0 kg ha\(^{-1}\), B @ 0.5 kg ha\(^{-1}\), Mo @ 0.5 kg ha\(^{-1}\)) and FYM @ 10 t ha\(^{-1}\) over the application of NPK alone on silty clay loam soil during the kharif season at Pantnagar. Application of FYM @ 5 t ha\(^{-1}\) along with recommended dose of NPK significantly increased the seed yield in blackgram over NPK alone during rainy season on sandy soil at the Krishi Vignan Kendra, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Tikamgarh (Tomar, 1998).

Aruna and Narasa Reddy (1999) reported significantly higher seed yield of soybean with application of vermicompost @ 15 t ha\(^{-1}\) compared to FYM and biogas slurry on clay loam soil during the rabi season at the Agriculture College Farm, Bapatla. Babhulkar et al. (2000) conducted an experiment during the kharif and rabi seasons at the Farm of College of Agriculture, Nagpur on a swell shrink soil revealed that application of NPK and FYM @ 7.5 t ha\(^{-1}\) recorded the highest seed yield of soybean.
Studies conducted by Rajkhowa et al. (2000) revealed the highest seed yield with the application of 75 per cent of recommended N as urea along with 5 t ha⁻¹ vermicompost at University Farm, Jorhat in greengram crop. Kumaran et al. (2001) reported significant increase in pod yield of groundnut with the application of NPK along with FYM @ 12.5 t ha⁻¹ compared to application of NPK alone during the rabi on red sandy loam soil at the Agricultural College and Research Institute, Killikulam, Tamil Nadu.

Shanwad and Agasimani (2001) reported that application of 50 per cent recommended dose of NPK through vermicompost significantly increased the sunflower seed yield over application of 100 per cent NPK through chemical fertilizers during the kharif at the Main Research Station, UAS Dharwad. Application of vermicompost @ 750 kg ha⁻¹ enhanced the grain yield of soybean (Thanunathan et al. 2002).

Experiment conducted during kharif at the ICAR Mizoram Center, Kolasib, on sandy loam soil indicated that the highest pod yield of groundnut with integrated application of 100 per cent NPK along with FYM @ 15 t ha⁻¹ (Laxminarayana, 2004). Similarly, Paradkar and Deshmukh (2004) recorded the highest seed yield of soybean with integrated application of NPK and FYM @ 10 t ha⁻¹.

Experiment conducted on clayey soil at Integrated Oilseed Research Station, Gujarat Agricultural University, Navsari during the rabi revealed that seed yield of mustard significantly influenced due to application of FYM @ 10 t ha⁻¹ (Thanki et al. 2004). Experiment conducted by Billore et al. (2005) indicated that the application of FYM @ 10 t ha⁻¹ along with NPK significantly
increased the seed yield of soybean over application of NPK alone. Application of optimum dose of NPK in combination with FYM @ 15 t ha\(^{-1}\) showed the highest pod yield in groundnut over no FYM application during rainy season on a typic hapludult at Kolasib, Mizoram (Laxminarayana and Patiram, 2005).

Rajshree et al. (2005) reported that application of FYM @ 7.5 t ha\(^{-1}\) with half of the dose of N and P on swell shrink soil gave significantly higher seed yield in soybean during the *kharif* and *rabi* seasons at the Agriculture College Farm, Nagpur. Dash et al. (2005) observed that seed yield of soybean was found to be the highest under the application of crop residue @ 5 t ha\(^{-1}\) + FYM @ 10 t ha\(^{-1}\) + Zn @ 5 kg ha\(^{-1}\) on clay soil during *kharif* season at the Instructional Farm, Indira Gandhi Agricultural University, Raipur.

Soybean recorded significantly the highest seed yield under the combined application of 75 per cent NPK through fertilizers and 25 per cent through vermicompost over 100 per cent NPK through fertilizers (Khutate et al., 2005 and Kanase et al. 2006).

The highest seed yield was recorded with the application of wheat straw @ 5 t ha\(^{-1}\) + FYM @ 5 t ha\(^{-1}\) + ZnSO\(_4\) @ 5 kg ha\(^{-1}\) than application of NPK alone during the *kharif* season on clay soil at the Marathwada Agricultural University, Parbhani (Suryawanshi et al. 2006).

Shirpukar et al. (2006) reported significantly higher seed yield of soybean under the application of recommended dose of NPK + Zn @10 kg ha\(^{-1}\) + FYM @ 10 t ha\(^{-1}\) on vertisols during the *kharif* season compared to NPK alone at the Agricultural Research Station, Nasik, whereas, Mali and Gokhale (2007) reported that application of 100 per cent recommended dose of
fertilizers through FYM recorded the highest seed yield of soybean in pigeonpea and soybean intercropping system during the *kharif* at the Agronomy Farm, College of Agriculture, Latur, Maharashtra.

Billore *et al.* (2009) revealed that application of FYM in combination with recommended dose of NPK recorded the highest seed yield in soybean over application of NPK alone on typic chromusterts at the Research Farm of Directorate of Soybean Research, Indore.

Rajat and Ahlawat (2009) reported that application of FYM @ 5 t ha$^{-1}$ increased the yield of groundnut by 25.0 per cent and 27.2 per cent over no FYM during two consecutive *kharif* seasons at the Research Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi. Application of 25 per cent nitrogen through vermicompost integrated with recommended dose of NPK increased the grain yield by 57.4 per cent and 61.6 per cent in french bean over no vermicompost application on sandy loam soil during two consecutive winter seasons at the Pulse Block of Agricultural Research Farm, Banaras Hindu University, Varanasi. (Rajput *et al.* 2009)

Tolanur (2009a) reported that application of sunhemp to meet 50 per cent N with 50 per cent recommended dose of N recorded the highest grain yield in chickpea during the *rabi* at the Regional Research Station, Bijapur, Karnataka.

Tolanur (2009b) reported that application of 50 per cent recommended dose of N through the sunhemp recorded the highest seed yield in sorghum during the *rabi* at the Regional Research Station, Bijapur, Karnataka.
2.1.4 Quality Parameters

Aruna and Narasa Reddy (1999) observed significantly the highest protein and oil content of soybean with application of vermicompost @ 15 t ha\(^{-1}\) over NPK and biogass slurry. Singh et al. (2003) reported combined application of 75 per cent NPK along with FYM @ 5 t ha\(^{-1}\) recorded the highest protein, oil and mineral content of soybean during the winter season at the Research Farm of Indian Institute of Soil Science, Bhopal.

Experiment conducted on clayey soil at the Integrated Oilseed Research Station, Gujarat Agricultural University, Navsari during the rabi revealed that oil content in mustard was significantly influenced by the application of FYM @ 10 t ha\(^{-1}\) (Thanki et al. 2004). In contrary, Rajshree et al. (2005) did not found any significant difference in oil and protein content with combined application of FYM and NPK on swell-shrink soil at the Agricultural College Farm, Nagpur.

Mali and Gokhale (2007) reported that application of 100 per cent recommended dose of fertilizers through FYM recorded the highest protein and oil content of soybean in pigeonpea + soybean intercropping system during kharif at the Agronomy Farm, College of Agriculture, Latur, Maharashtra.

2.1.5 Uptake

Devarajan and Palaniappan (1995) observed pronounced effect of combined application of Zn @ 2.5 kg ha\(^{-1}\) + FYM @ 10 t ha\(^{-1}\) in enhancing the uptake of Zn, Cu, Fe and Mn by soybean. Pannerselvam et al. (1999) reported
that application of FYM @ 15 t ha\(^{-1}\) with NPK enhanced the uptake of nutrients in soybean. Babhulkar et al. (2000) conducted an experiment during the *kharif* and *rabi* seasons at the College of Agriculture, Nagpur on swell shrink soil revealed that integrated application of NPK and FYM @ 7.5 t ha\(^{-1}\) recorded the highest organic carbon, total nitrogen, available phosphorus and potassium.

Shanwad and Agasimani (2001) reported that application of 50 per cent recommended dose of NPK through vermicompost significantly increased the NPK uptake and available nitrogen, phosphorus and potassium in sunflower + pigeonpea cropping system during the *kharif* at the Main Research Station, University of Agricultural Sciences, Dharwad.

Experiment conducted during the *kharif* at ICAR Mizoram Center, Kolasib, on sandy loam soil indicated that higher NPK uptake and available NPK at harvest were recorded with integrated application of 100 per cent NPK along with FYM @ 15 t ha\(^{-1}\) (Laxminarayana, 2004).

Meena et al. (2006) revealed that the total uptake of iron and zinc was significantly increased with application of FYM @ 10 t ha\(^{-1}\) by conducting an experiment on loamy sand soils during the *kharif* at the Agricultural Research Station, Mandor.

Rajat and Ahlawat (2009) observed highest N, P and S uptake with the application of FYM @ 5 t ha\(^{-1}\) over no FYM during two consecutive *kharif* seasons at the Research Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi.
NPK Zn and Fe uptake by plant and grain was significantly higher with the application of 25 per cent nitrogen through vermicompost integrated with recommended dose of NPK in french bean over no vermicompost application on sandy loam soil during two consecutive winter seasons at the Pulse Block of Agricultural Research Farm, Banaras Hindu University, Varanasi. (Rajput et al. 2009).

Application of vermicompost @ 10 t ha\(^{-1}\) on sandy loam soil at the fields of Microbiological Division, IARI, New Delhi significantly increased the available N and P content in the soil over the application enriched compost (Shukla and Tyagi, 2009).

Tolanur (2009a) reported that application of sunhemp to meet 50 per cent N and 50 per cent through recommended dose of N recorded the highest N uptake in chickpea during the rabi at the Regional Research Station, Bijapur, Karnataka.

2.2 EFFECT OF MICRONUTRIENTS ON GROWTH, YIELD AND QUALITY OF SOYBEAN

Soybean is relatively sensitive to the deficiencies of zinc and iron. Significant increase in yield has been reported due to application of micronutrients. Since the work done on effect of micronutrients on growth, yield and quality of soybean is meager, the research work conducted on this aspect is reviewed under different subheads.

2.2.1 Growth Characters

Srimath and Malarkodi (2000) reported that seed pelleting with ZnSO\(_4\) @ 200 mg kg\(^{-1}\) seed significantly increased the plant height of soybean over
seed pelleting with borax during the rabi season at the central farm of Tamil Nadu Agricultural University, Coimbatore. Similar experiment conducted by Hugar and Kurdikeri (2000) indicated that significant increase in plant height of soybean with application of zinc as both seed treatment and foliar spray at flowering stage (40 DAS) was observed over application of zinc either by seed treatment or by foliar application during the kharif season at the University of Agricultural Sciences, Dharwad.

Ramesh and Thirumurugan (2001) reported that seed pelleting of ammonium molybdate @ 250 mg kg$^{-1}$ seed and ferrous sulphate @ 500 mg kg$^{-1}$ seed significantly produced the tallest plants of soybean at 60 and 90 DAS over seed pelleting with ammonium molybdate alone during the rabi season at the Agricultural College and Research Institute, Madurai.

Experiment conducted by Singaravel et al. (2001) at Annamalai University indicated that application of zinc either by soil (ZnSO$_4$ @ 25 kg ha$^{-1}$) or by foliar spray (ZnSO$_4$ @ 0.5 %) along with NPK recorded significantly the highest plant height compared to no micronutrient application. Application of ZnSO$_4$ @ 25 kg ha$^{-1}$ on sandy clay loam soil recorded the highest plant height of soybean over no micronutrient application during the kharif season at the Experimental Farm of Chhindwara (Paradkar and Deshmukh, 2004). In contrast studies conducted by Mohan Kumar et al. (2005) did not find any significant increase in plant height of soybean with application of ZnSO$_4$ @ 10 kg ha$^{-1}$ on sandy clay loam soil at the University of Agricultural Sciences, Bangalore.
Tejeswara Rao and Subbaiah (2006) observed significant increase in plant height of mustard with combined application of ZnSO$_4$, borax and ammonium molybdate along with NPK over either application of NPK alone or application of micronutrients alone during the rabi season at the Agricultural College Farm, Bapatla.

Kapur et al. (1975) observed application of 5 ppm of zinc as ZnSO$_4$ significantly increased the number of nodules and dry weight of nodules in soybean over no zinc application during the kharif season at Pantnagar. whereas, increase in nodule number in groundnut was observed by both soil application of ZnSO$_4$ @ 20 kg ha$^{-1}$ and foliar spray of ZnSO$_4$ @ 0.5% at 30, 40 and 50 DAS over no micronutrient application on sandy soil of Coimbatore (Sudarshan and Ramaswami,1993).

Saxena et al. (2001) reported that accumulation of plant biomass was the highest in soybean with application of ZnSO$_4$ @ 10 kg ha$^{-1}$ on silty loam soil during the kharif season at Pantnagar. Paradkar and Deshmukh (2004) reported that soil application of ZnSO$_4$ @ 25 kg ha$^{-1}$ on sandy clay loam soil during kharif season increased the number of nodules and dry weight of nodules in soybean over no micronutrient application at the Experimental Farm of Chinndwara.

Mohan Kumar et al. (2005) revealed that application of NPKS + Zn+ B + Mo + PSB rhizobium on red sandy clay loam soil during kharif season recorded the highest number and dry weight of nodules in soybean over application of NPKS alone at GKVK, Bangalore. Whereas, Mondal and Poi (2006) reported that application of Zn, Fe, Mo, B @ 1 kg ha$^{-1}$ significantly
increased the nodule number and nodule fresh weight of soybean over the application of NPK alone on laterite acid soils of Raghunathpur Farm, West Bengal.

Hugar and Kurdikeri (2000) revealed that drymatter accumulation in soybean was significantly higher with application of ZnSO₄ by both seed treatment and foliar spray compared to application of ZnSO₄ either by seed treatment or by foliar application during the kharif season at the UAS, Dharwad.

Drymatter production of soybean was significantly higher under seed pelleting with ammonium molybdate @ 250 mg kg⁻¹ seed and ferrous sulphate @ 500 mg kg⁻¹ seed over seed pelleting with ammonium molybdate alone on red sandy clay loam soil during rabi season at the Agricultural College and Research Institute, Madurai. Experiment conducted by Singaravel et al. (2001) at Annamalai University indicated that application of zinc either by soil application (ZnSO₄ @ 25 kg ha⁻¹) or by foliar spray (ZnSO₄ @ 0.5 %) along with NPK recorded the highest drymatter production in sesamum crop compared to no micronutrient application.

Mondal and Poi (2006) found that application of Zn, Fe, Mo and B @ 1 kg ha⁻¹ over application of NPK alone significantly increased the drymatter accumulation of the soybean during the kharif season on lateritic acid soils of Raghunathpur Farm, West Bengal.
2.2.2 Yield Attributing Characters

Kapur et al. (1975) reported that application of 5 ppm of zinc as ZnSO₄ significantly increased the number of pods, number of seeds per pod and 100-seed weight of soybean over no zinc application on silt loam soil during kharif season at Pantnagar. Lallu and Shankar (1995) reported that application of ZnSO₄ @ 25 kg ha⁻¹ along with NPK recorded the maximum number of siliqua per plant and seeds per siliqua in mustard crop in comparison to NPK alone.

Seed pelleting of soybean with ZnSO₄ @ 200 mg kg⁻¹ of seed significantly increased the number of pods, number of seeds per pod and 100-seed weight over no zinc application during the kharif season at the Central Farm of Tamil Nadu Agricultural University, Coimbatore (Srimath and Malarkodi, 2000), whereas, Hugar and Kurdikeri (2000) observed significant increase in number of pods, number of seeds and 100-seed weight of soybean with the application of ZnSO₄ both by seed treatment and by foliar spray compared to application of ZnSO₄ either by seed treatment or by foliar application during kharif at the University of Agricultural Sciences, Dharwad. Experiment conducted by Singaravel et al. (2001) at Annamalai University indicated that application of zinc either by soil (ZnSO₄ @ 25 kg ha⁻¹) or by foliar spray (ZnSO₄ @ 0.5 %) along with NPK recorded the highest yield components in sesamum crop compared to no micronutrient application.

Paradkar and Deshmukh (2004) reported that application of ZnSO₄ @ 25 kg ha⁻¹ on sandy clay loam soil significantly increased the number of pods, number of seeds per pod and 100-seed weight of soybean over no micronutrient application at the Experimental Farm of Chirndwara, whereas,
Rathore et al. (2006) reported that application FeSO\(_4\) @ 10 kg ha\(^{-1}\) recorded significantly the maximum number of yield attributes over no iron application in groundnut crop on loamy sand soils during *kharif* and *rabi* at the Agricultural Research Station, Mandor.

### 2.2.3 Yield

Arora et al. (1985) observed increase in pod yield of groundnut to the tune of 22 to 53 per cent due to application of zinc conducted at different locations in Punjab. Increase in pod yield of groundnut with 2 ppm zinc application on sandy loam soil in greenhouse experiment was observed by Singh (1986).

Deshpande et al. (1986) reported that application of ZnSO\(_4\) @ 10 kg ha\(^{-1}\) by soil application and ZnSO\(_4\) @ 0.2\% by foliar spray significantly increased the seed yield of soybean crop, whereas, soil application of ZnSO\(_4\) @ 20 kg ha\(^{-1}\) significantly increased the groundnut pod yield to 1.5 t ha\(^{-1}\) compared to 1.1 t ha\(^{-1}\) without zinc application (Kulkarni et al., 1989). Experiment conducted by Yadav et al. (1991) reported significant increase in pod and kernel yield in groundnut with application of ZnSO\(_4\) @ 5 ppm on calcareous soil. Beneficial effect of zinc nutrition was also reported in other crops like sunflower where soil application of ZnSO\(_4\) @ 25 kg ha\(^{-1}\) significantly increased the seed and stalk yield on clayey typic chromustert (Gangadhar et al., 1992). Sudarshan and Ramaswami (1993) found that application of ZnSO\(_4\) @ 20 kg ha\(^{-1}\) and 0.5 % ZnSO\(_4\) spray at 30, 40 and 50 DAS on sandy soil at Coimbatore increased the pod yield of groundnut crop over NPK alone. Vinay Singh et al. (1993) observed increase in pod yield due to application FeSO\(_4\) @ 10 ppm in chickpea.
Gupta and Vyas (1994) observed significant increase in seed yield of soybean with application of ZnSO$_4$ @ 15 kg ha$^{-1}$ over no micronutrient application during the *kharif* season at the Agricultural Research Station, Barkhera, Kota, whereas, Deverajan and Palaniappan (1995) reported that application of zinc @ 50 kg ha$^{-1}$ increased significantly the seed yield of soybean over NPK treated control on black calcareous and red non-calcareous soils during *kharif* season at the Tamil Nadu Agricultural University Farm.

Experiment conducted at the Regional Research Station, Madhurikund during the *rabi* by Lallu and Shankar (1995) reported that application of ZnSO$_4$ @ 25 kg ha$^{-1}$ along with NPK recorded the maximum biological and seed yield per plant in mustard crop in comparison to NPK alone. In chickpea seed yield was increased from 22.2 q ha$^{-1}$ to 25.1 q ha$^{-1}$ with application of ZnSO$_4$ @ 5.0 kg ha$^{-1}$ (Tripathi *et al.*, 1997).

Seed Pelleting of soybean with ZnSO$_4$ @ 200 mg kg$^{-1}$ of seed recorded significantly higher yield over no zinc application during both the *kharif* and *rabi* seasons at the Tamil Nadu Agricultural University, Coimbatore (Srimath and Malorkodi, 2000), whereas, Hugar and Kurdikeri (2000) revealed significantly higher seed yield in soybean under both seed treatment and foliar spray of zinc over either by seed treatment alone or foliar spray alone during the *kharif* season at the University of Agricultural Sciences, Dharwad. Studies conducted by Saxena *et al.* (2001) indicated that application of ZnSO$_4$ @ 10 kg ha$^{-1}$ on silty clay loam recorded significantly higher seed yield of soybean over the application of NPK alone during the *kharif* season at Pantnagar. Experiment
conducted by Singaravel et al. (2001) at Annamalai University indicated that application of zinc either by soil (ZnSO$_4$ @ 25 kg ha$^{-1}$) or foliar spray (ZnSO$_4$ @ 0.5 %) along with NPK recorded the highest seed yield in sesamum crop compared to no micronutrient application.

Paradkar and Deshmukh (2004) revealed that application of ZnSO$_4$ @ 25 kg ha$^{-1}$ on sandy clay loam soil significantly increased the seed yield of soybean than application of NPK alone during the kharif season at the Experimental Farm of Chhindwara. Subash and Rani (2005) reported that application of ZnSO$_4$ @ 10 kg ha$^{-1}$ significantly increased the seed yield of soybean. Experiment conducted by Mohan Kumar et al. (2005) revealed that application of NPKS + Zn + B + Mo + PSB + Rhizobium recorded significantly higher seed yield of soybean over NPK alone on sandy clay loam soil during the kharif season at the Regional Research Station, Bangalore. Application of Zn, Fe, Mo, and B @ 1 kg ha$^{-1}$ along with NPK significantly increased the seed yield of soybean on acid soil during the kharif season at Raghunathpur Farm, West Bengal (Mondal and Poi, 2006), whereas, Rathore et al. (2006) reported that application FeSO$_4$ @ 10 kg ha$^{-1}$ recorded significantly the maximum pod yield in groundnut crop over no iron application on loamy sand soils during the kharif and rabi at the Agricultural Research Station, Mandor.

Shelge et al. (2006) reported that application of ZnSO$_4$ @ 5 kg ha$^{-1}$ along with NPK significantly increased the seed yield of soybean over application of NPK alone on clay loam black soil during the kharif season at the Marathwada Agricultural University, Parbhani.
2.2.4 Quality

Kapur et al. (1975) recorded the maximum protein content in soybean with application of ZnSO$_4$ @ 5 ppm on silty loam soil during the kharif season at Pantnagar. Studies conducted by Gupta and Vyas (1994) indicated that protein and oil content of soybean was significantly higher with the application of ZnSO$_4$ @ 15 kg ha$^{-1}$ during the kharif season at the Agricultural Research Station, Borkhera Kota. Sonune et al. (2001) reported that application of zinc @ 3 kg ha$^{-1}$ on clay loam soil during the kharif season recorded significantly higher protein and oil content of soybean over NPK alone at Akola. Mohan Kumar et al. (2005) observed significantly higher protein content with application of NPK + Zn + B + PSB + Rhizobium during the kharif season at the University of Agricultural Sciences, Bangalore.

2.2.5 Uptake of Nutrients

Arora et al. (1985) reported that application ZnSO$_4$ @ 5 kg ha$^{-1}$ significantly increased the uptake of zinc in groundnut crop. Singh (1986) reported that there was 143, 157, 220 per cent increase in uptake of zinc in leaves, stem and kernels of groundnut, respectively, when ZnSO$_4$ @ 10 ppm was applied by foliar application over no zinc application. Experiment conducted by Yadav et al. (1991) indicated that zinc uptake increased with application of ZnSO$_4$ @ 5 ppm on calcareous soils of Saurashtra. Gangadhar et al. (1992) reported that soil application of zinc with both levels of ZnSO$_4$ @ 25 and 50 kg ha$^{-1}$ significantly increased the uptake of zinc in seeds and stalks of sunflower crop. Devarajan and Palaniappan (1995) reported
that higher zinc uptake by soybean seed was evident with application of ZnSO₄ @ 5.0 kg ha⁻¹ on black calcareous and red non calcareous soil during the kharif season at the Tamil Nadu Agricultural University Farm.

Tripathi et al. (1997) reported that application of ZnSO₄ @ 7.5 kg ha⁻¹ significantly increased the zinc content in seed. Mondal and Poi (2006) found that application of Zn, Fe, Mn and B @ 1 kg ha⁻¹ significantly increased total N and P contents in plant.
CHAPTER – III

MATERIALS AND METHODS

A field experiment entitled “Assessment of the soybean need for zinc and iron with and without vermicompost” during the rabi season was conducted at the Agricultural College Farm, Bapatla during the year 2007-08. The materials used and methods adopted during the experimentation are presented in this chapter.

3.1 LOCATION

The experiment was carried out in the Northern block (field No.28) of the Agricultural College Farm, Bapatla which is situated at $80^030'\text{E}$ longitude, $15^054'\text{N}$ latitude and at an altitude of 5.49 m above MSL about 7 km away from Bay of Bengal.

3.2 WEATHER CONDITIONS

Weather data were recorded during the crop growth period at Meteorological Observatory of the Indian Meteorological Observatory, Bapatla are presented in the Table 3.1 and depicted in Fig. 3.1. During the crop growth period the mean minimum and maximum temperatures ranged from 16.30$^0\text{C}$ to 22.57$^0\text{C}$ and 27.84$^0\text{C}$ to 32.02$^0\text{C}$, respectively. The weekly average relative humidity ranged from 77.29 to 88.43 per cent and the average relative humidity during the crop growth period was 81.55 per cent. A total rainfall of 88.3 mm was received during the experimentation in 3 rainy days, of which 96 per cent was received during first fortnight of February.
Table 3.1: Weekly meteorological data during crop growth period (08-12-07 to 04-03-08)

<table>
<thead>
<tr>
<th>Standard week</th>
<th>Date and month</th>
<th>Mean temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Max</td>
<td>Min.</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>3 Dec -9 Dec. 2007</td>
<td>30.48</td>
<td>19.34</td>
<td>83.84</td>
</tr>
<tr>
<td>50</td>
<td>10 Dec -16 Dec. 2007</td>
<td>29.90</td>
<td>20.31</td>
<td>81.36</td>
</tr>
<tr>
<td>51</td>
<td>17 Dec -23 Dec. 2007</td>
<td>30.55</td>
<td>18.20</td>
<td>77.29</td>
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<td>52</td>
<td>24- Dec 31 Dec. 2007</td>
<td>31.34</td>
<td>17.92</td>
<td>79.00</td>
</tr>
<tr>
<td>1</td>
<td>01 Jan -7 Jan. 2008</td>
<td>30.28</td>
<td>16.78</td>
<td>76.48</td>
</tr>
<tr>
<td>2</td>
<td>08 Jan -14 Jan. 2008</td>
<td>30.34</td>
<td>16.30</td>
<td>80.46</td>
</tr>
<tr>
<td>3</td>
<td>15 Jan -21 Jan. 2008</td>
<td>30.15</td>
<td>17.00</td>
<td>80.03</td>
</tr>
<tr>
<td>4</td>
<td>22 Jan -28 Jan. 2008</td>
<td>29.51</td>
<td>18.72</td>
<td>86.97</td>
</tr>
<tr>
<td>5</td>
<td>29 Jan -04 Feb. 2008</td>
<td>29.97</td>
<td>20.12</td>
<td>82.19</td>
</tr>
<tr>
<td>6</td>
<td>5 Feb -11 Feb. 2008</td>
<td>30.21</td>
<td>21.57</td>
<td>83.00</td>
</tr>
<tr>
<td>7</td>
<td>12 Feb -18 Feb. 2008</td>
<td>27.84</td>
<td>21.55</td>
<td>88.43</td>
</tr>
<tr>
<td>8</td>
<td>19 Feb -25 Feb. 2008</td>
<td>28.48</td>
<td>20.58</td>
<td>80.71</td>
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<tr>
<td>9</td>
<td>26 Feb -04 Mar. 2008</td>
<td>32.02</td>
<td>19.76</td>
<td>80.43</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>30.08</td>
<td>19.09</td>
<td>81.55</td>
</tr>
</tbody>
</table>

3.3 EXPERIMENTAL SOIL

To evaluate the initial fertility status of the experimental site, soil samples were collected from 0 to 30 cm depth at random from the different parts of the field. The composite samples were analyzed for physico-chemical properties by following standard methods and the results are presented in Table 3.2.
Table 3.2: Physical and physico-chemical properties of the experimental soil

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Particulars</th>
<th>Value</th>
<th>Method of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>I. Mechanical analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sand (%)</td>
<td>24</td>
<td>Bouyoucos hydrometer Method (Piper, 1966)</td>
</tr>
<tr>
<td></td>
<td>Silt (%)</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clay (%)</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Textural class</strong></td>
<td></td>
<td><strong>Clay loam</strong></td>
</tr>
<tr>
<td></td>
<td><strong>II. Chemical analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH (1:2 soil water suspension)</td>
<td>8.16</td>
<td>Glass electrode method (Jackson, 1973)</td>
</tr>
<tr>
<td></td>
<td>EC (dS m$^{-1}$ at 25°C)</td>
<td>0.36</td>
<td>Conductivity bridge (Jackson, 1973)</td>
</tr>
<tr>
<td></td>
<td>Organic Carbon (%)</td>
<td>0.41</td>
<td>Walkley and Black’s modified method (Walkley and Black, 1934)</td>
</tr>
<tr>
<td></td>
<td>Available Nitrogen (kg ha$^{-1}$)</td>
<td>244</td>
<td>Alkaline permanganate method (Subbiah and Asija, 1956)</td>
</tr>
<tr>
<td></td>
<td>Available P$_2$O$_5$ (kg ha$^{-1}$)</td>
<td>85</td>
<td>Olsen’s method (Olsen et al., 1954)</td>
</tr>
<tr>
<td></td>
<td>Available K$_2$O (kg ha$^{-1}$)</td>
<td>1198</td>
<td>Neutral Normal Ammonium Acetate Method (Jackson, 1973)</td>
</tr>
<tr>
<td></td>
<td>Available Zn (ppm)</td>
<td>0.57</td>
<td>DTPA Extractable Method (Lindsay and Norvell, 1978)</td>
</tr>
<tr>
<td></td>
<td>Available Fe (ppm)</td>
<td>0.60</td>
<td>DTPA Extractable Method (Lindsay and Norvell, 1978)</td>
</tr>
</tbody>
</table>

3.4 NUTRIENT ANALYSIS OF VERMICOMPOST

Vermicompost was analyzed for nutrient status by following the standard methods and the results are presented in Table 3.3.
Table 3.3: Physical and physico-chemical properties of the vermicompost

<table>
<thead>
<tr>
<th>Chemical analysis</th>
<th>Value</th>
<th>Method of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (1:2 soil water suspension)</td>
<td>7.2</td>
<td>Glass electrode method (Jackson, 1973)</td>
</tr>
<tr>
<td>EC (dS m(^{-1}) at 25(^{0})C)</td>
<td>0.37</td>
<td>Conductivity bridge (Jackson, 1973)</td>
</tr>
<tr>
<td>Organic Carbon (%)</td>
<td>4.25</td>
<td>Walkley and Black’s modified method (Walkley and Black, 1934)</td>
</tr>
</tbody>
</table>

**Major nutrients**

| Available Nitrogen (g kg\(^{-1}\)) | 215 | Alkaline permanganate method (Subbiah and Asija, 1956) |
| Available P\(_2\)O\(_5\) (g kg\(^{-1}\)) | 105 | Olsen’s method (Olsen et al., 1954) |
| Available K\(_2\)O (g kg\(^{-1}\)) | 35  | Neutral Normal Ammonium Acetate Method (Jackson, 1973) |

**Micronutrients**

| Fe (ppm) | 22.4 | DTPA Extractable Method (Lindsay and Norvell, 1978) |
| Zn (ppm) | 16.8 | DTPA Extractable Method (Lindsay and Norvell, 1978) |

### 3.5 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The experimental field has been under cultivation for many years. The information about the crops that were grown in the experimental field during the preceding three years is given below.
<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-05</td>
<td>kharif</td>
<td>Fallow</td>
</tr>
<tr>
<td></td>
<td>rabi</td>
<td>Fallow</td>
</tr>
<tr>
<td>2005-06</td>
<td>kharif</td>
<td>Ragi</td>
</tr>
<tr>
<td></td>
<td>rabi</td>
<td>Fallow</td>
</tr>
<tr>
<td>2006-07</td>
<td>kharif</td>
<td>Cotton</td>
</tr>
<tr>
<td></td>
<td>rabi</td>
<td>Cotton</td>
</tr>
<tr>
<td>2007-08</td>
<td>kharif</td>
<td>Fallow</td>
</tr>
<tr>
<td></td>
<td>rabi</td>
<td>Present experiment</td>
</tr>
</tbody>
</table>

### 3.6 EXPERIMENTAL DETAILS AND LAYOUT

The experiment was laid out in a split-plot design (Fig. 3.2) by allocating levels of vermicompost to main-plots and levels of micronutrients to sub-plots. The treatments were replicated thrice.

#### 3.5.1 Treatments

**Main Plot Treatments**

- $M_1$ - NPK alone @ $30 + 60 + 40$ kg ha$^{-1}$
- $M_2$ - Vermicompost alone @ 5 t ha$^{-1}$
- $M_3$ - NPK ($30 + 60 + 40$ kg ha$^{-1}$) + Vermicompost @ 2.5 t ha$^{-1}$

**Sub Plot Treatments**

- $S_0$ - Control (No micronutrients)
- $S_1$ - Soil application of ZnSO$_4$ @ 25 kg ha$^{-1}$
- $S_2$ - Foliar application of ZnSO$_4$ @ 0.2% at 30 DAS
S₃ - Foliar application of FeSO₄ @ 0.5% at 30 DAS

S₄ - Soil application of ZnSO₄ @ 25 kg ha⁻¹ and FeSO₄ @ 10 kg ha⁻¹

S₅ - Foliar application of ZnSO₄ @ 0.2% and FeSO₄ @ 0.5% at 30 DAS

### 3.7 CULTIVAR DESCRIPTION

The Soybean cultivar JS-335 is a stable and popular variety. It is determinate in growth habit with erect and compact plant stature. It matures in 80-85 days and grows to a height of 40-45 cm. It shows dark green foliage, purple flowers and grey pubescence with light yellow seed color and light brown hilum. The seeds are bold attractive with good germination and has an yield potential of 1500-2500 kg ha⁻¹.

### 3.8 CULTIVATION DETAILS

#### 3.8.1 Field Preparation

The experimental field was ploughed thrice with tractor drawn cultivator to get the required tilth. Clods are broken by disc harrow. The field was laid out into plots as per the layout plan in Fig 3.2.

#### 3.8.2 Fertilizer Application

All the required nutrients were applied as basal dose according to the treatments. Nitrogen, phosphorus and potassium were applied as per the recommendation N @ 30 kg ha⁻¹, P₂O₅ @ 60 kg ha⁻¹ and K₂O @ 40 kg ha⁻¹ through urea, diammonium phosphate (DAP) and murate of potash (MOP), respectively. Vermicompost was applied @ 5 t ha⁻¹ to the respective plot.
Micronutrients viz; ZnSO$_4$ @ 25 kg ha$^{-1}$ and FeSO$_4$ @ 10 kg ha$^{-1}$ were applied basally to the respective treatment plot. At 30 DAS, ZnSO$_4$ @ 0.2% and FeSO$_4$ @ 0.5% was applied as foliar spray to respective treatment plots.

3.8.3 Seed Treatment

Seeds were treated with *Rhizobium* culture @ 200 g/8 kg seed prior to sowing.

3.8.4 Seeds and Sowing

Healthy and bold seeds were selected and hand dibbled to a depth of 3-4 cm by adopting spacing of 45 cm × 5 cm.

3.8.5 Gap Filling

Gap filling was done at 10 days after sowing to obtain uniform population.

3.8.6 Weeding

Two manual weedings, one each at 30 DAS and 45 DAS, were done to keep the field relatively weed free.

3.8.7 Irrigation

Irrigations were given as and when required for raising a good crop. Overall, two irrigations were given to supplement the total rainfall of 88.3 mm during the crop growth period.

3.8.8 Plant Protection

No serious attack of pests and diseases was observed. However, minor incidence of tobacco caterpillar [*Spodoptera litura* (Fab.)] was observed at flowering. Monocrotophos @ 1.5 mL$^{-1}$ and Acephate @ 2 mL$^{-1}$ were used for effective control of pest.
3.8.9 Harvesting

The crop was harvested at dead-ripening stage. The borders were harvested first and collected as bulk separately and sun dried thoroughly. The weight of total biomass was recorded before threshing. The seeds were separated by threshing and cleaning. Seed yield was recorded after thorough drying and expressed in kg ha$^{-1}$. Yield obtained from sample plants were also added to the respective treatment yield. Haulm yield was recorded by deducting the seed yield from the total biomass.

3.9 PRE-HARVEST OBSERVATIONS

Ten plants were selected from net plot and were labeled with tags for continuous record of biometrical observations viz., plant height at different stages of growth and yield attributing characters. For estimation of drymatter production, plants from 0.5 m length in the second row were pulled out at different stages during crop growth period.

3.9.1 Plant Height

Ten plants were randomly selected in the net plot area and tagged. Plant height of these plants was recorded at 30, 60 DAS and at maturity from the base of the plant to the tip of the growing point. The mean value of ten plants was computed and expressed as plant height in cm.

3.9.2 Drymatter Production

Plants from 0.5 m row length were collected from destructive sampling area of the plot at 30, 60 DAS and at maturity. They were dried at 60°C till a constant weight is obtained. The dry weight per m$^2$ was calculated and expressed as kg ha$^{-1}$. 
3.9.3 Number of Nodules Plant\(^{-1}\)

The nodules removed from the roots of sampled plants after thorough washing with water in mesh basin were counted, averaged and expressed as mean number of nodules plant\(^{-1}\). Nodule weight was taken at 30 DAS and 60 DAS.

3.9.4 Dry Weight of Nodules Plant\(^{-1}\)

The collected nodules from the roots of sampled plants were oven dried to a constant weight before computing their dry weight and dry weight was expressed in mg plant\(^{-1}\).

3.9.5 Days to 50% Flowering

The number of days taken from date of sowing to the stage, when 50 per cent of plants in the plots showed anthesis, number of days taken to 50 per cent flowering was recorded.

3.10 POST-HARVEST OBSERVATIONS

3.10.1 Number of Pods Plant\(^{-1}\)

The number of pods from ten tagged plants were counted, averaged and expressed as number of pods plant\(^{-1}\).

3.10.2 Number of Seeds Pod\(^{-1}\)

The total number of seeds present in twenty pods, selected at random from the net plot area, were counted and averaged as number of seeds per pod. After counting, these seeds were added to the net plot yield.
3.10.3 Test Weight

One hundred seeds were counted from a sample drawn at random from the net plot seed yield and its weight was recorded in grams.

3.10.4 Seed and Haulm Yields

At maturity all the above ground soybean phytomass from each net plot area was harvested and transported to the threshing floor. After drying under the sun for seven days, the phytomass from each plot was weighed before subjecting it for threshing. After threshing weight of the grains was recorded plot-wise and expressed in kg ha\(^{-1}\). The haulm yield from each plot was arrived at by subtracting the grain weight from biomass and expressed in kg ha\(^{-1}\).

3.10.5 Harvest Index

The harvest index was computed by using formula given below (Donald and Humblin, 1976).

\[
\text{Harvest Index} = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100
\]

\[
\text{(seed + haulm)}
\]

3.11 CHEMICAL ANALYSIS OF PLANT MATERIAL

Plant samples collected for chemical analysis were shade dried initially and then in an oven at 60\(^0\)C for about 24 hours. These samples were ground in a hammer mill subsequently after cooling for estimating N, P, K, micronutrients zinc and iron content. Nitrogen was estimated by modified micro kjeldhal method, phosphorus by Vanado molybdo phosphoric acid method (Jackson, 1973) and potassium by flame photometric method.
Micronutrient (zinc and iron) analysis in soil and plant was done by using Atomic Absorption Spectrophotometer. (Lindsay and Norvell, 1978)

Nutrient uptake was calculated by using the formula as given below:

\[
\frac{\text{Nutrient concentration (\%) \times weight of drymatter (kg ha}^{-1})}{100}
\]

Nutrient uptake (kg ha\(^{-1}\))

3.11.1 Chemical Analysis of Soil

After harvest of the crop, soil samples were collected in respective plots and analyzed for N, P, K, Zn and Fe content in the soil. Nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956), phosphorus was by modified Olsen’s method (Olsen et al., 1954) and potassium by neutral normal ammonium acetate method (Jackson, 1973). Micronutrients (zinc and iron) analysis was conducted by using Atomic Absorption Spectrophotometer.

3.11.2 Uptake of Nutrients

Uptake of N, P, K, Zn and Fe in each treatment was worked out by multiplying their concentrations with corresponding drymatter yields at harvest in haulm and seeds.

3.11.3 Chemical Analysis in Seed

Seed samples collected for chemical analysis were dried and ground for estimating zinc and iron content. Zinc and iron estimation was done by using Atomic Absorption Spectrophotometer.
3.12 ECONOMICS

For each treatment, net benefit-cost ratio was calculated by considering prevailing input costs and output prices. The existing rate of labour, seeds and fertilizers were considered for calculation. The cost of cultivation was calculated according to respective fertility input levels. The cost of cultivation for all the treatments was same for cultivation practices except for nutrient application.

\[
\begin{align*}
\text{Gross returns} & = \text{Value of the product (Grain + Haulm)} \\
\text{Net returns} & = \text{Gross returns} - \text{Total cost of cultivation} \\
\text{Benefit cost ratio} & = \frac{\text{Net returns}}{\text{Total cost of cultivation}}
\end{align*}
\]

3.13 STATISTICAL ANALYSIS

All the data recorded during the course of experimentation were subjected to statistical analysis using Fisher’s method of analysis of variance as outlined for split plot design by Panse and Sukhatme (1978). Critical differences were worked out at 5 per cent level of probability to test the treatment effects wherever ‘F’ test was found significant.
Fig. 3.1: Weekly weather prevailed during the crop growth period
IRRIGATION CHANNEL

<table>
<thead>
<tr>
<th>R1</th>
<th></th>
<th>R2</th>
<th></th>
<th>R3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M1S1</td>
<td>M2S5</td>
<td>M3S1</td>
<td></td>
<td>M3S0</td>
<td>M1S5</td>
</tr>
<tr>
<td>M1S0</td>
<td>M2S4</td>
<td>M3S2</td>
<td>M2S4</td>
<td>M3S0</td>
<td>M1S3</td>
</tr>
<tr>
<td>M1S3</td>
<td>M2S0</td>
<td>M3S5</td>
<td>M2S0</td>
<td>M3S1</td>
<td>M1S2</td>
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<tr>
<td>M1S2</td>
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<td>M2S2</td>
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</tr>
<tr>
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<td>M3S4</td>
<td>M2S3</td>
<td>M3S5</td>
<td>M2S0</td>
</tr>
</tbody>
</table>

TREATMENTS

Vermicompost levels (M)

M₁ : NPK alone @ 30+60+40 kg ha⁻¹
M₂ : Vermicompost alone @ 5 t ha⁻¹
M₃ : NPK + Vermicompost @ 2.5 t ha⁻¹

Micronutrient levels (S)

S₀ : No micronutrient application (control)
S₁ : Soil application of ZnSO₄ @ 25 kg ha⁻¹
S₂ : Foliar application of ZnSO₄ @ 0.2% at 30 DAS
S₃ : Foliar application of FeSO₄ @ 0.5% at 30 DAS
S₄ : Soil application of ZnSO₄ @ 25 kg ha⁻¹ and FeSO₄ @ 10 kg ha⁻¹
S₅ : Foliar application of ZnSO₄ @ 0.2% and FeSO₄ @ 0.5%

Fig. 3.2 Layout plan of the experiment

Design : Split plot design
Replications : Three
Gross plot size : 4.5 m x 3.0 m
Net plot size : 2.7 m x 2.6 m
Spacing : 45 cm x 5 cm
Season : Rabi, 2007-2008
CHAPTER – IV

RESULTS

Results of the field experiment entitled “Assessment of the soybean [Glycine max (L) Merrill] need for zinc and iron with and without vermicompost” during the rabi season conducted at the Agricultural College Farm, Bapatla are presented in this chapter.

4.1 GROWTH PARAMETERS

4.1.1 Plant Height

The data on plant height (cm) of soybean recorded at various growth stages as influenced by different levels of vermicompost and micronutrients are presented in the Tables 4.1 to 4.3. Plant height was affected by different levels of vermicompost and micronutrients, but not by their interaction.

Vermicompost levels significantly influenced the plant height of soybean at all the stages of crop growth. Integrated application of NPK and vermicompost recorded significantly the higher plant height (32.5 cm) over the application of NPK alone (30.0 cm) and vermicompost alone (28.4 cm) at 30 DAS. Lowest plant height was recorded with the application of vermicompost alone, which was significantly inferior to other levels of vermicompost through out the crop growth period.

Plant height was significantly influenced by different micronutrient levels at 30 DAS. The maximum plant height of 31.80 cm was recorded with the soil application of ZnSO₄ and FeSO₄, which was significantly superior to
all the other micronutrient levels, however, it was on a par with the soil application of ZnSO₄ alone (31.40 cm). Whereas, the lowest plant height (29.30 cm) was recorded with no micronutrient application.

Plant height was significantly influenced by micronutrient levels at 60 DAS. The maximum plant height of 44.5 cm was recorded with the foliar application of zinc and iron (S₅). However, it was on a par with that of all other levels of micronutrient applications except with soil application of ZnSO₄ and no micronutrient application. Lowest Plant height was recorded with no micronutrient application and it was comparable with that of soil application of ZnSO₄ alone (S₁).

At maturity significantly higher plant height was recorded with soil and foliar application of ZnSO₄ and FeSO₄ (S₄ and S₅). However, the differences among the treatments, except S₀, are not significant in increasing the plant height. Whereas, the lowest plant height was recorded with no micronutrient application, however, it was comparable with the application of ZnSO₄ alone (S₂).

4.1.2 Drymatter Production

Data pertaining to drymatter production at various growth stages of soybean are presented in Table 4.4, 4.5 and 4.6 which differed significantly due to vermicompost and micronutrient levels but not by their interaction.

Drymatter production was significantly influenced by vermicompost levels at all the stages of observations. Wherein it was significantly higher with the integrated application of NPK and vermicompost at 30 DAS (950 kg ha⁻¹),
60 DAS (2733 kg ha\(^{-1}\)) and at maturity (4465 kg ha\(^{-1}\)) than that of vermicompost alone and NPK alone. Application of NPK alone was also found significantly superior to vermicompost alone in accumulation of drymatter at all the growth stages.

Drymatter production was significantly influenced by the application of different micronutrients levels at 30 DAS, 60 DAS and at maturity. At 30 DAS, soil application of ZnSO\(_4\) and FeSO\(_4\) recorded significantly higher drymatter production (892 kg ha\(^{-1}\)) and it was on a par with application of ZnSO\(_4\) alone (879 kg ha\(^{-1}\)). Whereas, the differences in drymatter production among the rest of the treatments were not significant at 30 DAS.

At 60 DAS soil application of ZnSO\(_4\) and FeSO\(_4\) recorded higher drymatter accumulation (2426 kg ha\(^{-1}\)) than all other treatments. However, it was on a par with the foliar application of zinc and iron. Whereas, the treatments S\(_5\) and S\(_2\) were comparable with each other. The lowest drymatter production was recorded with no micronutrient application, which was significantly inferior to the rest of the treatments.

At maturity the highest drymatter accumulation was recorded with the soil application of ZnSO\(_4\) and FeSO\(_4\) (3900 kg ha\(^{-1}\)) over no micronutrient application. Whereas, differences in drymatter production among all micronutrient levels except with no micronutrient application were not significant. The lowest drymatter was accumulated with no micronutrient application (3407 kg ha\(^{-1}\)). However, it was on a par with the soil application of ZnSO\(_4\) alone and foliar application of iron.
4.1.3 Number of Nodules per Plant

The data pertaining to number of nodules per plant presented in the Table 4.7 and 4.8 revealed that significant differences were observed in number of nodules per plant due to micronutrient levels only.

Number of nodules are significantly affected by micronutrient levels at all growth stages i.e. at 30 DAS, soil application of ZnSO₄ and FeSO₄ recorded significantly higher number of nodules per plant (7.9) over the rest of micronutrient levels. It was followed by the soil application of ZnSO₄ alone, in increasing nodule number per plant and found superior to other micronutrient levels.

At 60 DAS, soil application of ZnSO₄ and FeSO₄ recorded the highest number of nodules per plant (23.6). However, it was comparable with all other micronutrient levels except S₀. There was no significant difference between the micronutrient levels in number of nodules. Whereas, no micronutrient application recorded significantly the lowest number of nodules per plant (20.2).

4.1.4 Dry Weight of Nodules per Plant

The data on nodule dry weight per plant at 30 DAS and 60 DAS were presented in table 4.9 and 4.10. It is evident that significant response of treatments on nodule weight was observed with micronutrient levels only at 30 DAS. Whereas, at 60 DAS, Vermicompost levels and micronutrient levels significantly influenced the nodule dry weight and their interaction did not show any significant affect in nodule dry weight.
The highest nodule dry weight per plant was recorded with the soil application of ZnSO₄ and FeSO₄ (22.2 mg per plant) and it was on a par with soil application of ZnSO₄ alone (21.5). The lowest nodule dry weight recorded with S₂ was found on a par with S₅, S₃ and S₀ levels of micronutrients.

Highest nodule dry weight was recorded with combined application of NPK and vermicompost (75 mg per plant) at 60 DAS which was significantly superior to that of vermicompost alone whereas, nodule dry weight recorded with the application of vermicompost alone and application of NPK alone did not differ significantly.

At 60 DAS, the highest nodule dry weight was recorded with soil application of ZnSO₄ and FeSO₄ (83.2 mg) which was on a par with foliar application of zinc and iron. These treatments were significantly superior to rest of the micronutrient levels in increasing nodule dryweight. The lowest nodule dry weight was recorded with S₀ (57.18) and it was significantly inferior to rest of the treatments.

4.1.5 Days to 50% Flowering

Data pertaining to days to 50% flowering was presented in the Table 4.11 and it was not significantly influenced by micronutrient and vermicompost levels.

4.2 YIELD COMPONENTS AND YIELD

4.2.1 Number of Pods per Plant

The data presented in Table 4.12 revealed that the number of pods per plant significantly differed by vermicompost and micronutrient levels and by their interaction.
Combined application of NPK and vermicompost recorded the highest number of pods per plant (49.6) which was significantly superior to application of NPK alone (43.5) and vermicompost alone (31.2). Vermicompost alone recorded the lowest number of pods per plant.

Micronutrient levels significantly influenced the number of pods per plant. The highest number of pods was recorded with application of ZnSO$_4$ and FeSO$_4$ (43.8) which were significantly higher over no micronutrient application. However, it was comparable with $S_5$ (42.6), $S_3$ (41.8), $S_2$ (41.5) and $S_1$ (40.7).

Application of NPK and vermicompost at each level of micronutrient recorded the highest number of pods per plant than all the other vermicompost levels. Similarly, application of NPK and vermicompost along with application of ZnSO$_4$ and FeSO$_4$ recorded the highest number of pods per plant (53.3) which was significantly superior to the other vermicompost levels at the same level of micronutrient.

Soil application of ZnSO$_4$ and FeSO$_4$ at M$_3$ level of vermicompost recorded highest number of pods per plant. Application of NPK and vermicompost without micronutrient application ($S_0$) recorded more number of pods per plant (43.5) than application of NPK alone and vermicompost alone at the same level of micronutrient ($S_0$). However it was on a par with other levels of micronutrient application except $S_0$ at the same level of vermicompost.
4.2.2 Number of Seeds per Pod

Perusal of data pertaining to number of seeds per pod are presented in the Table 4.13 indicated that number of seeds per pod are not significantly influenced by vermicompost and micronutrient levels.

4.2.3 Test Weight of Soybean

Data related to test weight furnished in Table 4.14 showed significant differences due to vermicompost and micronutrient levels. Their interaction was not found significant in test weight.

Integrated application NPK and vermicompost (16.0 g) recorded the highest test weight; however it was on a par with application of NPK alone (15.6 g). The lowest test weight was recorded with vermicompost alone (15.1 g), which was on a par with application of NPK alone.

Application of ZnSO$_4$ and FeSO$_4$ recorded significantly the higher test weight (15.90 g) over no micronutrient application. However, it was comparable with the remaining micronutrient levels S$_5$ (15.69 g), S$_3$ (15.57 g), S$_2$ (15.51 g) and S$_1$ (15.50 g).

4.2.4 Seed Yield

The data presented in Table 4.15 showed that the seed yield of soybean was significantly influenced by the micronutrient and vermicompost levels and by their interaction.
Integrated application of NPK and vermicompost recorded significantly more seed yield of 1663 kg ha\(^{-1}\) over application of NPK alone and vermicompost alone. Whereas, application of vermicompost alone (662 kg ha\(^{-1}\)) recorded the lowest seed yield which was significantly inferior to that of other treatments.

The per cent increase in seed yield with integrated application of NPK and vermicompost and application of NPK alone over application of vermicompost alone was 31.39 per cent and 20.47 per cent, respectively.

The maximum seed yield of 1329 kg ha\(^{-1}\) was recorded with the application of ZnSO\(_4\) and FeSO\(_4\) which was significantly superior to no micronutrient application. However it was comparable with foliar application of zinc and iron (1281 kg ha\(^{-1}\)) with rest of the treatments. The percentage increase of seed yield of soybean with application of ZnSO\(_4\) and FeSO\(_4\) over no micronutrient application was 25.14%.

Interaction between micronutrient levels and vermicompost levels significantly influenced the seed yield of soybean. Application of NPK and vermicompost at each level of micronutrient recorded the highest seed yield than all the other vermicompost levels. Whereas M\(_3\) level of vermicompost at S\(_4\) level of micronutrient application was significantly superior to other levels of vermicompost. However, application of NPK and vermicompost along with soil application of ZnSO\(_4\) and FeSO\(_4\) recorded the highest seed yield of 1863 kg ha\(^{-1}\) which was on a par with all other levels of micronutrient application except no micronutrient application (S\(_0\)) at the same level of M\(_3\).
Application of NPK and vermicompost without micronutrient application recorded significantly higher seed yield (1322 kg ha\(^{-1}\)) over application of vermicompost alone (M\(_2\)). However it was comparable with application of NPK alone (1152 kg ha\(^{-1}\)). Interestingly seed yield of soybean with combined application of NPK and vermicompost without micronutrient application was found on a par with NPK alone at different levels of micronutrient applications.

### 4.2.5 Haulm Yield

The data pertaining to haulm yield (Table 4.16) indicated significant differences due to vermicompost and micronutrient levels. However, their interaction effect on increasing haulm yield was not significant.

Combined application of NPK and vermicompost recorded the highest haulm yield (2831 kg ha\(^{-1}\)) which was significantly superior to M\(_1\) (2303 kg ha\(^{-1}\)) and M\(_2\) (1641 kg ha\(^{-1}\)). Vermicompost alone recorded the lowest haulm yield, which was significantly inferior to other treatments.

Micronutrient levels significantly influenced the haulm yield. Application of ZnSO\(_4\) and FeSO\(_4\) (2623 kg ha\(^{-1}\)) recorded the highest haulm yield over all the other micronutrient levels. Foliar application of zinc and iron (2295 kg ha\(^{-1}\)) was on a par with S\(_1\) (2232 kg ha\(^{-1}\)), S\(_2\) (2180) and S\(_3\) (2176 kg ha\(^{-1}\)). Significantly the lowest haulm yield was recorded with no micronutrient application (1866 kg ha\(^{-1}\)).

### 4.2.6 Harvest Index

Data on harvest index were furnished in Table 4.17 which revealed that harvest index of soybean was not influenced by varied levels of vermicompost and micronutrients and by their interaction
4.3 QUALITY

4.3.1 Protein Content

The data pertaining to protein content of soybean presented in Table 4.18 revealed that significant differences were observed due to vermicompost and micronutrient levels but not by their interaction.

Protein content of soybean seed was significantly influenced by vermicompost levels. Maximum protein content of 40 per cent was recorded with application of NPK and vermicompost which was significantly superior to application of NPK alone (37.8%) and application of vermicompost alone (36.6%). The lowest protein content was recorded with the application of vermicompost alone; however, it was on a par with the application of NPK alone.

Soil application of ZnSO$_4$ and FeSO$_4$ increased the protein content (39.7 %) over no micronutrient application (35.8 %), foliar application of zinc alone (37.7 %) and soil application of zinc alone (37.6%) and it was on a par with foliar application of zinc and iron (39.2 %) and foliar application of iron alone (38.8 %).

4.3.2 Oil Content

Data pertaining to oil content analyzed statistically and presented in Table 4.19 revealed that vermicompost levels and micronutrient levels did not have any significant influence.
4.4 CHEMICAL ANALYSIS

4.4.1 Nitrogen Uptake

Data presented in the Table 4.20 revealed that variation in nitrogen uptake was not significant due to micronutrient levels. Whereas, the N uptake was significantly affected by different vermicompost levels. However, interaction between vermicompost and micronutrient levels was not significant with respect to nitrogen uptake.

Application of NPK and vermicompost recorded highest nitrogen uptake of 81.2 kg ha\(^{-1}\) which was significantly superior to application of NPK alone (68.6 kg ha\(^{-1}\)) and application of vermicompost alone (56.1 kg ha\(^{-1}\)). The lowest nitrogen uptake recorded by vermicompost alone was significantly inferior to other treatments.

4.4.2 Phosphorus Uptake

Data pertaining to the phosphorus uptake by soybean as influenced by the different micronutrient and vermicompost levels are presented in the table 4.21. Vermicompost levels significantly influenced the phosphorus uptake by soybean. Micronutrient levels and their interaction did not have any significant effect on the phosphorus uptake.

Phosphorus uptake of 16.0 kg ha\(^{-1}\) obtained with application of NPK and vermicompost was significantly superior to application of NPK alone (13.2 kg ha\(^{-1}\)) and application of vermicompost alone (11.9 kg ha\(^{-1}\)). The lowest phosphorus uptake was observed with application of vermicompost alone; however, it was on a par with application of NPK alone.
4.4.3 Potassium Uptake

Data on potassium uptake by crop at maturity presented in Table 4.22 revealed that uptake was significantly influenced by vermicompost levels only.

Highest potassium uptake of 47.3 kg ha\(^{-1}\) recorded with integrated application of NPK and vermicompost was significantly superior to application of vermicompost alone (37.8 kg ha\(^{-1}\)). However it was on a par with the application of NPK alone (45.4 kg ha\(^{-1}\)). The lowest potassium uptake was recorded with application of vermicompost alone.

4.4.4 Zinc Uptake

Data regarding zinc uptake by soybean as influenced by different levels of vermicompost and micronutrients are presented in Table 4.23. Vermicompost and micronutrient levels significantly influenced the zinc uptake by soybean. Whereas, interaction effect was not significant on zinc uptake in plant.

Combined application of NPK and vermicompost recorded the highest zinc uptake of 521 g ha\(^{-1}\) which was significantly superior to that of remaining vermicompost levels (M\(_1\) and M\(_2\)). The lowest zinc uptake was observed with the application NPK alone (487 g ha\(^{-1}\)). However, it was on a par with the application of vermicompost alone.
Among the micronutrient levels, foliar application of zinc and iron showed more zinc uptake of 549 g ha\(^{-1}\) than all the other micronutrient levels however, it was on a par with the foliar application of zinc (539 g ha\(^{-1}\)). The zinc uptake recorded with no micronutrient application (425 g ha\(^{-1}\)) and with foliar application of iron alone was statically on a par with each other.

### 4.4.5 Iron Uptake

Data in Table 4.24 showed significant differences in iron uptake due to vermicompost and micronutrient levels. Whereas, their interaction did not show any significant effect.

Micronutrient levels and vermicompost levels significantly influenced the iron uptake by soybean but not by their interaction.

Application of NPK and vermicompost significantly recorded the more iron uptake (850 g ha\(^{-1}\)) over all the other vermicompost levels. Iron uptake recorded with the application of vermicompost alone was the lowest and it was on a par with the application of NPK alone.

The iron uptake recorded with foliar application of zinc and iron was the highest and it was significantly superior to all other treatments. The differences in iron uptake between foliar application of iron alone and soil application of ZnSO\(_4\) and FeSO\(_4\) was not significant. Iron uptake with by no micronutrient application was significantly inferior to all other treatments.
4.4.6 Zinc Content in Seed

The data pertaining to zinc content of soybean seed in Table 4.25 indicated significant differences due to vermicompost and micronutrient levels. However, their interaction effect was not significant.

Vermicompost levels significantly influenced the zinc content of soybean seed. Integrated application of NPK and vermicompost recorded the highest zinc content of 116 mg kg\(^{-1}\) which was significantly superior to all other vermicompost levels. Zinc content recorded with application of NPK alone was the lowest. However, it was comparable with no micronutrient application.

Foliar spray of zinc and iron recorded the highest zinc content of 122 mg kg\(^{-1}\), which was significantly superior to all the other micronutrient levels. However, it was statistically comparable with the application of ZnSO\(_4\) and FeSO\(_4\). The lowest zinc content in seed was recorded with no micronutrient application. However, it was on a par with foliar application of iron.

4.4.7 Iron content in seed

Data presented in Table 4.26 revealed that iron content in seed differed due to vermicompost and micronutrient levels and their interaction was found to be non significant.

Integrated application of NPK and vermicompost recorded the highest iron content of 209.6 mg kg\(^{-1}\) seed which significantly superior to application of vermicompost alone (174.7 mg kg\(^{-1}\)) and application of NPK alone (137.3 mg kg\(^{-1}\)). The lowest iron content was recorded with application of NPK alone.
Highest iron content of 255 mg kg$^{-1}$ seed was observed with foliar application of zinc and iron which was significantly superior to other micronutrient levels. However, it was on a par with the soil application of ZnSO$_4$ and FeSO$_4$ and foliar application of iron alone. The lowest iron content was recorded with the no micronutrient application however; it was comparable with the soil application of ZnSO$_4$.

**4.4.8. Available Nitrogen in Soil**

Data pertaining to available nitrogen at harvest presented in Table 4.27 revealed that significant differences were observed due to only vermicompost levels.

Available nitrogen content of 282 kg ha$^{-1}$ observed with the combined application of NPK and vermicompost was significantly higher than application of NPK alone (257 kg ha$^{-1}$) and application of vermicompost alone (231 kg ha$^{-1}$). Available nitrogen content recorded with application of vermicompost alone was found to be lowest among the treatments.

**4.4.9 Available Phosphorus in Soil**

Data pertaining to available phosphorus content in soil as influenced by the different vermicompost and micronutrient levels were presented in Table 4.28. Available phosphorus content in soil was significantly influenced by vermicompost levels whereas micronutrient levels and their interaction did not show any significant effect.
Highest available phosphorus content of 75 kg ha\(^{-1}\) was recorded with integrated application of NPK and vermicompost. This was significantly superior to application of vermicompost alone (67.0 kg ha\(^{-1}\)). However, it was on a par with application of NPK alone (72 kg ha\(^{-1}\)). Whereas, the difference in phosphorus content obtained with the application of vermicompost alone and with application of NPK alone was not significant.

### 4.4.10 Available Potassium in Soil

Data of to the available potassium content in soil as influenced by the micronutrient and vermicompost levels are presented in Table 4.29. Vermicompost levels and micronutrient levels did not show any significant difference in available potassium status of soil at harvest.

### 4.4.11 Available Zinc in Soil

Data pertaining to zinc content in soil as influenced by the different levels of vermicompost and micronutrients are presented in Table 4.30. Micronutrient levels and vermicompost levels significantly influenced the zinc content in soil. Whereas, their interaction did not find any significant effect.

Application of NPK and vermicompost recorded the highest zinc content in soil of 8.0 kg ha\(^{-1}\), which was significantly superior to application of NPK alone (7.4 kg ha\(^{-1}\)). However, it was on a par with application of vermicompost alone (8.1 kg ha\(^{-1}\)). Zinc content in soil did not differ significantly among application of NPK alone and application of vermicompost alone.
The zinc status in soil at harvest was significantly higher with application of ZnSO₄ and FeSO₄ over all the other treatments. However, it was on a par with soil application of ZnSO₄ alone. The lowest zinc content was recorded with no micronutrient application however; it was on a par with all the treatments of foliar application of micronutrients (S₃, S₅ and S₂).

### 4.4.12 Available Iron in Soil

Data pertaining to iron status in soil as influenced by different micronutrient and vermicompost levels are presented in Table 4.31. Micronutrient levels and vermicompost levels significantly influenced the iron content in soil at harvest.

Highest iron content of 9.4 kg ha⁻¹ was observed with application of NPK and vermicompost, which was significantly superior to application of vermicompost alone (8.6 kg ha⁻¹) and application of NPK alone (8.0 kg ha⁻¹). The lowest iron content was recorded with application of NPK alone.

Among the different micronutrient levels application of ZnSO₄ and FeSO₄ recorded the highest iron content, which was significantly superior to all other micronutrient levels. The lowest iron content was recorded with no micronutrient application.

### 4.5 Economics

Data pertaining to economics are presented in the table 4.32.

Gross returns increased with the soil application of ZnSO₄ and FeSO₄ at all the vermicompost levels. Maximum gross returns and net returns are
obtained with combined application of NPK and vermicompost at each level of micronutrient except at no micronutrient application. Benefit-cost ratio increased with the application of micronutrients at all vermicompost levels whereas, application of vermicompost alone and application of vermicompost along with soil application of ZnSO$_4$ recorded the negative benefit ratio. The highest net return per rupee investment was realized in case of foliar application of zinc and iron along with NPK alone and foliar application of zinc and iron along with combined application of vermicompost and NPK.

Integrated application of NPK and vermicompost and soil application of ZnSO$_4$ and FeSO$_4$ recorded the highest additional net returns compared to other levels.
Table 4.1: Plant height (cm) of soybean as influenced by vermicompost and micronutrients levels at 30DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S0</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>No micronutrient application</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁</td>
<td>NPK @ 30+60+40 kg ha⁻¹</td>
<td>29.3</td>
<td>31.3</td>
<td>29.2</td>
<td>29.3</td>
<td>31.4</td>
<td>30.8</td>
<td>30.2</td>
</tr>
<tr>
<td>M₂</td>
<td>Vermicompost @ 5 t ha⁻¹</td>
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<td>28.9</td>
<td>27.8</td>
<td>28.7</td>
<td>29.2</td>
<td>27.8</td>
<td>28.1</td>
</tr>
<tr>
<td>M₃</td>
<td>NPK @ 30+60+40 kg ha⁻¹ + Vermicompost @ 2.5 t ha⁻¹</td>
<td>31.5</td>
<td>33.9</td>
<td>31.3</td>
<td>31.7</td>
<td>34.8</td>
<td>31.5</td>
<td>32.5</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>28.9</td>
<td>31.4</td>
<td>29.5</td>
<td>29.9</td>
<td>31.8</td>
<td>30.1</td>
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<table>
<thead>
<tr>
<th></th>
<th>SEm+</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
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<td>Vermicompost levels</td>
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<td>1.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>0.6</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>1.0</td>
<td>NS</td>
<td></td>
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</tbody>
</table>
Table 4.2: Plant height (cm) of soybean as influenced by vermicompost and micronutrient levels at 60DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrient levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₀</td>
<td>S₁</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>41.6</td>
<td>42.9</td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>36.8</td>
<td>38.7</td>
</tr>
<tr>
<td>FeSO₄ @ 0.5%</td>
<td>44.3</td>
<td>45.8</td>
</tr>
<tr>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 10 kg ha⁻¹</td>
<td>40.9</td>
<td>42.5</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>SEm⁺</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No micronutrient application</td>
<td>0.3</td>
<td>1.1</td>
<td>2.8</td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
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<td>1.6</td>
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</tr>
<tr>
<td>FeSO₄ @ 0.5%</td>
<td>0.9</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 10 kg ha⁻¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
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</tr>
</tbody>
</table>

Table: Mean above different letters are significantly different at P=0.05.
Table 4.3: Plant height (cm) of soybean as influenced by vermicompost and micronutrients levels at maturity

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
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</thead>
<tbody>
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<td></td>
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<td>S₁</td>
</tr>
<tr>
<td></td>
<td>No micronutrient</td>
<td>42.4</td>
</tr>
<tr>
<td></td>
<td>application</td>
<td></td>
</tr>
<tr>
<td>M₁ NPK @ 30+60+40 kg ha⁻¹</td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>42.4</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FeSO₄ @ 0.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹ &amp;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FeSO₄ @ 10 kg ha⁻¹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄</td>
<td></td>
</tr>
<tr>
<td></td>
<td>@ 0.5%</td>
<td></td>
</tr>
<tr>
<td>M₂ Vermicompost @ 5 t ha⁻¹</td>
<td></td>
<td>37.3</td>
</tr>
<tr>
<td>M₃ NPK @ 30+60+40 kg ha⁻¹ +</td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>45.3</td>
</tr>
<tr>
<td></td>
<td>Vermicompost @ 2.5 t ha⁻¹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄</td>
<td></td>
</tr>
<tr>
<td></td>
<td>@ 0.5%</td>
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</table>

Mean 41.7 43.4 44.1 44.4 45.4 45.4

<table>
<thead>
<tr>
<th></th>
<th>SEm⁺</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>0.6</td>
<td>2.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Micronutrient levels</td>
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<tr>
<td>Vermicompost X Micronutrient</td>
<td>1.2</td>
<td>NS</td>
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Table 4.4: Dry matter accumulation (kg ha\(^{-1}\)) of soybean as influenced by vermicompost and micronutrients levels at 30 DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S0</td>
<td>S1</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>818</td>
<td>899</td>
</tr>
<tr>
<td>ZnSO(_4) @ 25 kg ha(^{-1}) 0.2%</td>
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<td>ZnSO(_4) @ 0.2% 0.5% FeSO(_4) @ 10 kg ha(^{-1})</td>
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<td></td>
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<tr>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</td>
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<td></td>
</tr>
<tr>
<td>M1 NPK @ 30+60+40 kg ha(^{-1})</td>
<td>697</td>
<td>752</td>
</tr>
<tr>
<td>Vermicompost @ 5 t ha(^{-1})</td>
<td>929</td>
<td>986</td>
</tr>
<tr>
<td>M2 NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>929</td>
<td>986</td>
</tr>
<tr>
<td>Mean</td>
<td>815</td>
<td>879</td>
</tr>
</tbody>
</table>

SEm\(\pm\) CD (P=0.05) CV%

| Vermicompost levels | 6.4  | 25.2 | 3.8 |
| Micronutrient levels| 15.2 | 43.9 |
| Vermicompost X Micronutrient | 26.4 | NS  |
Table 4.5: Dry matter accumulation (kg ha\(^{-1}\)) of soybean as influenced by vermicompost and micronutrients levels at 60 DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S(_0)</th>
<th>S(_1)</th>
<th>S(_2)</th>
<th>S(_3)</th>
<th>S(_4)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>No micronutrient application</td>
<td>2197</td>
<td>2293</td>
<td>2372</td>
<td>2368</td>
<td>2514</td>
<td>2505</td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>FeSO(_4) @ 0.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M(_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>No micronutrient application</td>
<td>1701</td>
<td>1784</td>
<td>1818</td>
<td>1809</td>
<td>1887</td>
<td>1872</td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FeSO(_4) @ 0.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M(_3) NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>No micronutrient application</td>
<td>2506</td>
<td>2669</td>
<td>2751</td>
<td>2722</td>
<td>2878</td>
<td>2871</td>
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<tr>
<td></td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FeSO(_4) @ 0.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2135</td>
<td>2249</td>
<td>2314</td>
<td>2300</td>
<td>2426</td>
<td>2416</td>
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<table>
<thead>
<tr>
<th></th>
<th>SEM+</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>43.0</td>
<td>168.9</td>
<td>5.6</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>37.7</td>
<td>108.9</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>73.5</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.6: Dry matter accumulation (kg ha\(^{-1}\)) of soybean as influenced by vermicompost and micronutrients levels at maturity

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S(_0)</td>
<td>S(_1)</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>3468</td>
<td>3635</td>
</tr>
<tr>
<td>ZnSO(_4) @ 25 kg ha(^{-1}). 0.2%</td>
<td>2629</td>
<td>2899</td>
</tr>
<tr>
<td>FeSO(_4) @ 0.5%</td>
<td>4124</td>
<td>4403</td>
</tr>
<tr>
<td>ZnSO(_4) @ 25 kg ha(^{-1}) &amp; FeSO(_4) @ 10 kg ha(^{-1})</td>
<td>3407</td>
<td>3645</td>
</tr>
<tr>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</td>
<td>91.1</td>
<td>357.6</td>
</tr>
<tr>
<td>CV%</td>
<td>91.3</td>
<td>263.7</td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>158.2</td>
<td>NS</td>
</tr>
</tbody>
</table>
Table 4.7: Number of nodules of soybean as influenced by vermicompost and micronutrients levels at 30 DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>S0 (No micronutrient application)</th>
<th>S1 (ZnSO₄ @ 25 kg ha⁻¹)</th>
<th>S2 (ZnSO₄ @ 0.2%)</th>
<th>S3 (FeSO₄ @ 0.5%)</th>
<th>S4 (ZnSO₄ @ 25 kg ha⁻¹ &amp; FeSO₄ @ 10 kg ha⁻¹)</th>
<th>S5 (ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁ NPK @ 30+60+40 kg ha⁻¹</td>
<td>6.0</td>
<td>7.2</td>
<td>6.9</td>
<td>6.4</td>
<td>8.0</td>
<td>6.3</td>
<td>6.8</td>
</tr>
<tr>
<td>M₂ Vermicompost @ 5 t ha⁻¹</td>
<td>5.8</td>
<td>7.0</td>
<td>6.8</td>
<td>6.2</td>
<td>7.8</td>
<td>6.2</td>
<td>6.6</td>
</tr>
<tr>
<td>M₃ NPK @ 30+60+40 kg ha⁻¹ + Vermicompost @ 2.5 t ha⁻¹</td>
<td>6.4</td>
<td>7.4</td>
<td>7.0</td>
<td>6.6</td>
<td>8.0</td>
<td>6.6</td>
<td>6.9</td>
</tr>
<tr>
<td>Mean</td>
<td><strong>6.1</strong></td>
<td><strong>7.2</strong></td>
<td><strong>6.9</strong></td>
<td><strong>6.4</strong></td>
<td><strong>7.9</strong></td>
<td><strong>6.4</strong></td>
<td></td>
</tr>
</tbody>
</table>

SEM⁺  CD (P=0.05)  CV%

| Vermicompost levels | 0.1 | NS | 4.2 |
| Vermicompost X Micronutrient | 0.2 | NS |
Table 4.8: Number of nodules of soybean as influenced by vermicompost and micronutrients levels at 60 DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₀</td>
<td>S₁</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ NPK @ 30+60+40 kg ha⁻¹</td>
<td>20.2</td>
<td>22.5</td>
</tr>
<tr>
<td>M₂ Vermicompost @ 5 t ha⁻¹</td>
<td>19.7</td>
<td>22.2</td>
</tr>
<tr>
<td>M₃ NPK @ 30+60+40 kg ha⁻¹ + Vermicompost @ 2.5 t ha⁻¹</td>
<td>20.8</td>
<td>23.3</td>
</tr>
<tr>
<td>Mean</td>
<td>20.2</td>
<td>22.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SEm⁺</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>0.4</td>
<td>NS</td>
<td>4.9</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>0.3</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>0.7</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.9: Dry weight (mg) of nodules as influenced by vermicompost and micronutrients levels at 30 DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S0</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No micron nutrient application</td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>ZnSO₄ @ 0.2%</td>
<td>FeSO₄ @ 0.5%</td>
<td>ZnSO₄ @ 25 kg ha⁻¹ &amp; FeSO₄ @ 10 kg ha⁻¹</td>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%</td>
<td></td>
</tr>
<tr>
<td>M₁ NPK @ 30+60+40 kg ha⁻¹</td>
<td></td>
<td>19.6</td>
<td>21.8</td>
<td>18.5</td>
<td>20.0</td>
<td>22.5</td>
<td>20.1</td>
<td>20.4</td>
</tr>
<tr>
<td>M₂ Vermicompost @ 5 t ha⁻¹</td>
<td></td>
<td>19.0</td>
<td>20.6</td>
<td>18.1</td>
<td>19.5</td>
<td>21.2</td>
<td>19.7</td>
<td>19.7</td>
</tr>
<tr>
<td>M₃ NPK @ 30+60+40 kg ha⁻¹ + Vermicompost @ 2.5 t ha⁻¹</td>
<td></td>
<td>19.9</td>
<td>22.1</td>
<td>20.9</td>
<td>20.4</td>
<td>22.9</td>
<td>20.6</td>
<td>21.2</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>19.5</td>
<td>21.5</td>
<td>19.1</td>
<td>20.0</td>
<td>22.2</td>
<td>20.1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SEm⁺</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>0.52</td>
<td>NS</td>
<td>7.7</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>0.53</td>
<td>1.54</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>0.92</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.10: Dry weight (mg) of nodules as influenced by vermicompost and micronutrients levels at 60 DAS

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S₀</th>
<th>S₁</th>
<th>S₂</th>
<th>S₃</th>
<th>S₄</th>
<th>S₅</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>No micronutrient application</td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>57.6</td>
<td>64.1</td>
<td>68.4</td>
<td>79.1</td>
<td>84.8</td>
<td>82.1</td>
<td>72.7</td>
</tr>
<tr>
<td>M₁ NPK @ 30+60+40 kg ha⁻¹</td>
<td>ZnSO₄ @ 0.2%</td>
<td>54.2</td>
<td>63.4</td>
<td>62.5</td>
<td>71.8</td>
<td>79.2</td>
<td>78.3</td>
<td>68.2</td>
</tr>
<tr>
<td>Vermicompost @ 5 t ha⁻¹</td>
<td>FeSO₄ @ 0.5%</td>
<td>59.7</td>
<td>70.8</td>
<td>69.7</td>
<td>82.3</td>
<td>85.7</td>
<td>81.8</td>
<td>75.0</td>
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<tr>
<td>M₂ NPK @ 30+60+40 kg ha⁻¹</td>
<td>FeSO₄ @ 10 kg ha⁻¹</td>
<td>Mean</td>
<td>57.2</td>
<td>66.1</td>
<td>66.9</td>
<td>77.7</td>
<td>83.2</td>
<td>80.7</td>
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<tr>
<td>Vermicompost X Micronutrient</td>
<td>Mean</td>
<td>SEm⁺</td>
<td>CD (P=0.05)</td>
<td>CV %</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>5.3</td>
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</tr>
<tr>
<td>Micronutrient levels</td>
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</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>0.9</td>
<td>NS</td>
<td></td>
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<td></td>
<td></td>
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</table>
Table 4.11: Days to 50% flowering of soybean as influenced by vermicompost and micronutrients levels

<table>
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<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S₀</th>
<th>S₁</th>
<th>S₂</th>
<th>S₃</th>
<th>S₄</th>
<th>S₅</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No micronutrient</td>
<td>35.0</td>
<td>34.0</td>
<td>33.67</td>
<td>33.3</td>
<td>34.0</td>
<td>33.3</td>
<td>33.9</td>
</tr>
<tr>
<td>M₁</td>
<td>application</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FeSO₄ @ 0.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹ &amp;</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>FeSO₄ @ 10 kg ha⁻¹</td>
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</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2% &amp;</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FeSO₄ @ 0.5%</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>34.89</td>
<td>34.22</td>
<td>33.56</td>
<td>33.56</td>
<td>35.33</td>
<td>34.22</td>
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<table>
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<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
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<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
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<td>0.3</td>
<td>NS</td>
<td>4.6</td>
</tr>
<tr>
<td>Micronutrient levels</td>
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<td>0.7</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td></td>
<td>1.3</td>
<td>NS</td>
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</tr>
</tbody>
</table>
Table 4.12: Number of pods per plant of the soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₀</td>
<td>S₁</td>
</tr>
<tr>
<td></td>
<td>No micronutrient application</td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
</tr>
<tr>
<td>M₁  NPK @ 30+60+40 kg ha⁻¹</td>
<td>41.2</td>
<td>43.6</td>
</tr>
<tr>
<td>M₂  Vermicompost @ 5 t ha⁻¹</td>
<td>22.6</td>
<td>31.2</td>
</tr>
<tr>
<td>M₃  NPK @ 30+60+40 kg ha⁻¹ + Vermicompost @ 2.5 t ha⁻¹</td>
<td>43.5</td>
<td>49.0</td>
</tr>
<tr>
<td>Mean</td>
<td>36.5</td>
<td>41.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>SEm⁺</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.3</td>
<td>4.9</td>
<td>9.7</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>1.9</td>
<td>5.1</td>
<td></td>
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</tbody>
</table>

V×M  3.4  6.0
M×V  3.7  6.5

**M X S:** To compare two main plot treatments means at an each level of sub plot treatment

**S X M:** To compare two sub plot treatment means at a given main plot treatment
Table 4.13: Number of seeds per pod as influenced by vermicompost and micronutrients levels

<table>
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<tr>
<th>Vermicompost levels</th>
<th>S₀</th>
<th>S₁</th>
<th>S₂</th>
<th>S₃</th>
<th>S₄</th>
<th>S₅</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>No micronutrient application</td>
<td>2.4</td>
<td>2.5</td>
<td>2.6</td>
<td>2.6</td>
<td>2.7</td>
<td>2.7</td>
<td>2.6</td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>2.3</td>
<td>2.4</td>
<td>2.6</td>
<td>2.5</td>
<td>2.4</td>
<td>2.4</td>
<td>2.5</td>
</tr>
<tr>
<td>FeSO₄ @ 0.5%</td>
<td>2.4</td>
<td>2.7</td>
<td>2.6</td>
<td>2.7</td>
<td>2.8</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%</td>
<td>2.4</td>
<td>2.5</td>
<td>2.6</td>
<td>2.6</td>
<td>2.7</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.4</td>
<td>2.5</td>
<td>2.6</td>
<td>2.6</td>
<td>2.7</td>
<td>2.6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEM⁺</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>NS</td>
<td>7.5</td>
</tr>
<tr>
<td>0.1</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.14: Test weight (g) of soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₀</td>
<td>S₁</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>15.2</td>
<td>15.6</td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>14.8</td>
<td>15.0</td>
</tr>
<tr>
<td>FeSO₄ @ 0.5%</td>
<td>15.7</td>
<td>15.9</td>
</tr>
<tr>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%</td>
<td>15.2</td>
<td>15.5</td>
</tr>
</tbody>
</table>

SEm⁺  CD (P=0.05)  CV%

| Vermicompost levels | 0.1 | 0.5 | 3.1 |
| Micronutrient levels | 0.2 | 0.6 |     |
| Vermicompost X Micronutrient | 0.4 | NS |     |
### Table 4.15: Seed yield (kg ha\(^{-1}\)) of soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>S(_0) No micronutrient application</th>
<th>S(_1) ZnSO(_4) @ 25 kg ha(^{-1})</th>
<th>S(_2) ZnSO(_4) @ 0.2%</th>
<th>S(_3) FeSO(_4) @ 0.5%</th>
<th>S(_4) ZnSO(_4) @ 25 kg ha(^{-1}) &amp; FeSO(_4) @ 10 kg ha(^{-1})</th>
<th>S(_5) ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</th>
<th>Mean</th>
<th>SE(\text{m})(^+)</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>1152</td>
<td>1344</td>
<td>1375</td>
<td>1368</td>
<td>1402</td>
<td>1390</td>
<td>1339</td>
<td>43.1</td>
<td>169.1</td>
<td>10.1</td>
</tr>
<tr>
<td>M(_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>512</td>
<td>635</td>
<td>687</td>
<td>659</td>
<td>721</td>
<td>710</td>
<td>662</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M(_3) NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>1322</td>
<td>1656</td>
<td>1702</td>
<td>1695</td>
<td>1863</td>
<td>1743</td>
<td>1663</td>
<td>83.8</td>
<td>242.1</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>995</td>
<td>1211</td>
<td>1255</td>
<td>1241</td>
<td>1329</td>
<td>1281</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SE\(\text{m}\)\(^+\):** To compare two main plot treatments means at each level of sub plot treatment  
**S X M:** To compare two sub plot treatment means at a given main plot treatment
Table 4.17: Harvest index of soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S&lt;sub&gt;0&lt;/sub&gt;</td>
<td>S&lt;sub&gt;1&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>No micronutrient</td>
<td>ZnSO&lt;sub&gt;4&lt;/sub&gt; @ 25 kg ha&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>M&lt;sub&gt;1&lt;/sub&gt; NPK @ 30+60+40 kg ha&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>42.3</td>
<td>38.2</td>
</tr>
<tr>
<td>M&lt;sub&gt;2&lt;/sub&gt; Vermicompost @ 5 t ha&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>43.2</td>
<td>40.1</td>
</tr>
<tr>
<td>M&lt;sub&gt;3&lt;/sub&gt; NPK @ 30+60+40 kg ha&lt;sup&gt;-1&lt;/sup&gt; + Vermicompost @ 2.5 t ha&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>39.5</td>
<td>39.4</td>
</tr>
<tr>
<td>Mean</td>
<td>41.7</td>
<td>39.2</td>
</tr>
</tbody>
</table>

**SEm<sup>+</sup>, CD (P=0.05), CV%**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SEm&lt;sup&gt;+&lt;/sup&gt;</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>1.1</td>
<td>NS</td>
<td>6.4</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>1.3</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>2.2</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.16: Haulm yield (kg ha\(^{-1}\)) of soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>S(_0) No micronutrient application</th>
<th>S(_1) ZnSO(_4) @ 25 kg ha(^{-1})</th>
<th>S(_2) ZnSO(_4) @ 0.2%</th>
<th>S(_3) FeSO(_4) @ 0.5%</th>
<th>S(_4) ZnSO(_4) @ 25 kg ha(^{-1})&amp; FeSO(_4) @ 10 kg ha(^{-1})</th>
<th>S(_5) ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>1789</td>
<td>2222</td>
<td>2143</td>
<td>2103</td>
<td>2896</td>
<td>2666</td>
<td>2303</td>
</tr>
<tr>
<td>M(_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>1465</td>
<td>1598</td>
<td>1656</td>
<td>1645</td>
<td>1739</td>
<td>1745</td>
<td>1641</td>
</tr>
<tr>
<td>M(_3) NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>2343</td>
<td>2876</td>
<td>2741</td>
<td>2780</td>
<td>3233</td>
<td>2474</td>
<td>2831</td>
</tr>
<tr>
<td>Mean</td>
<td>1866</td>
<td>2232</td>
<td>2180</td>
<td>2176</td>
<td>2623</td>
<td>2295</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SEm+</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>33.5</td>
<td>131.5</td>
<td>7.9</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>73.7</td>
<td>212.8</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>127.6</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.18: Protein content (%) of soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>S₀</th>
<th>S₁</th>
<th>S₂</th>
<th>S₃</th>
<th>S₄</th>
<th>S₅</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁ NPK @ 30+60+40 kg ha⁻¹</td>
<td>35.4</td>
<td>37.2</td>
<td>36.5</td>
<td>38.7</td>
<td>39.8</td>
<td>39.3</td>
<td>37.8</td>
</tr>
<tr>
<td>M₂ Vermicompost @ 5 t ha⁻¹</td>
<td>32.9</td>
<td>36.3</td>
<td>36.3</td>
<td>37.9</td>
<td>38.2</td>
<td>38.1</td>
<td>36.6</td>
</tr>
<tr>
<td>M₃ NPK @ 30+60+40 kg ha⁻¹ + Vermicompost @ 2.5 t ha⁻¹</td>
<td>39.1</td>
<td>39.7</td>
<td>39.9</td>
<td>39.8</td>
<td>41.0</td>
<td>40.2</td>
<td>39.9</td>
</tr>
<tr>
<td>Mean</td>
<td>35.8</td>
<td>37.7</td>
<td>37.6</td>
<td>38.7</td>
<td>39.7</td>
<td>39.2</td>
<td></td>
</tr>
</tbody>
</table>

SEm⁺  CD (P=0.05)  CV%

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>0.4</th>
<th>1.4</th>
<th>2.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronutrient levels</td>
<td>0.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>0.9</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.19: Oil content (%) of soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S0</td>
<td>S1</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>16.9</td>
<td>16.6</td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZnSO₄ @ 0.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FeSO₄ @ 0.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha⁻¹ &amp; FeSO₄ @ 10 kg ha⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>16.8</td>
<td>16.6</td>
</tr>
</tbody>
</table>

SEm⁺  | CD (P=0.05) | CV%  |
-------|-------------|------|
0.5    | NS          | 9.4  |
0.6    | NS          |      |
1.0    | NS          |      |

Vermicompost levels
Micronutrient levels
Vermicompost X Micronutrient
Table 4.27: Available nitrogen (kg ha\(^{-1}\)) content at harvest as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₀</td>
<td>S₁</td>
</tr>
<tr>
<td>No micronutrient</td>
<td>226.2</td>
<td>234.0</td>
</tr>
<tr>
<td>application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ NPK @ 30+60+40 kg ha(^{-1})</td>
<td>244.3</td>
<td>264.3</td>
</tr>
<tr>
<td>M₂ Vermicompost @ 5 t ha(^{-1})</td>
<td>270.3</td>
<td>276.3</td>
</tr>
<tr>
<td>M₃ NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>246.9</td>
<td>258.2</td>
</tr>
<tr>
<td>Mean</td>
<td>6.0</td>
<td>23.6</td>
</tr>
<tr>
<td>SEm±</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vermicompost X Micronutrient

| Vermicompost X Micronutrient | 14.8 | NS  |
Table 4.28: Available phosphorus (kg ha$^{-1}$) content at harvest as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₀</td>
<td>S₁</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>73.2</td>
<td>73.1</td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha$^{-1}$ @ 0.2%</td>
<td>66.2</td>
<td>66.5</td>
</tr>
<tr>
<td>FeSO₄ @ 10 kg ha$^{-1}$ @ 0.5%</td>
<td>74.4</td>
<td>74.7</td>
</tr>
<tr>
<td>Mean</td>
<td>71.3</td>
<td>71.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEM±</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>5.4</td>
<td>5.8</td>
</tr>
<tr>
<td>3.4</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>5.9</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

Vermicompost levels

Micronutrient levels

Vermicompost X Micronutrient
Table 4.29: Available potassium (kg ha\(^{-1}\)) content at harvest as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S(_0) No micronutrient application</td>
<td>S(_1) ZnSO(_4) @ 25 kg ha(^{-1})</td>
</tr>
<tr>
<td>M(_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>1274.7</td>
<td>1428.0</td>
</tr>
<tr>
<td>M(_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>1260.8</td>
<td>1196.7</td>
</tr>
<tr>
<td>M(_3) NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>1269.4</td>
<td>1540.3</td>
</tr>
<tr>
<td>Mean</td>
<td>1268.3</td>
<td>1388.3</td>
</tr>
</tbody>
</table>

SEm\(^+\) CD (P=0.05) CV%  
Vermicompost levels 30.9 NS 6.7  
Micronutrient levels 73.5 NS  
Vermicompost X Micronutrient 127.2 NS
Table 4.30: Available zinc (kg ha\(^{-1}\)) content at harvest as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S0</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 NPK @ 30+60+40 kg ha(^{-1})</td>
<td>No micronutrient application</td>
<td>4.7</td>
<td>11.5</td>
<td>4.6</td>
<td>5.1</td>
<td>11.8</td>
<td>6.4</td>
<td><strong>7.3</strong></td>
</tr>
<tr>
<td>M2 Vermicompost @ 5 t ha(^{-1})</td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td><strong>5.4</strong></td>
<td>11.5</td>
<td>6.1</td>
<td>6.2</td>
<td>12.6</td>
<td>6.7</td>
<td><strong>8.1</strong></td>
</tr>
<tr>
<td>M3 NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>ZnSO(_4) @ 0.2%</td>
<td>6.9</td>
<td>13.6</td>
<td>6.5</td>
<td>6.3</td>
<td>12.6</td>
<td>7.0</td>
<td><strong>8.8</strong></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td><strong>5.7</strong></td>
<td><strong>12.2</strong></td>
<td><strong>5.7</strong></td>
<td><strong>5.8</strong></td>
<td><strong>12.3</strong></td>
<td><strong>6.7</strong></td>
<td></td>
</tr>
</tbody>
</table>

SEM+ CD (P=0.05) CV%

| Vermicompost levels | 0.8 | 1.3 | 6.4 |
| Micronutrient levels | 0.8 | 2.3 |
| Vermicompost X Micronutrient | 1.4 | NS  |
Table 4.31: Available iron (kg ha\(^{-1}\)) content at harvest as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S0</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>No micronutrient application</td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td>5.6</td>
<td>6.5</td>
<td>6.0</td>
<td>6.4</td>
<td>15.8</td>
<td>7.8</td>
<td>8.0</td>
</tr>
<tr>
<td>ZnSO(_4) @ 0.2%</td>
<td>FeSO(_4) @ 0.5%</td>
<td>ZnSO(_4) @ 25 kg ha(^{-1}) &amp; FeSO(_4) @ 10 kg ha(^{-1})</td>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vermicompost @ 5 t ha(^{-1})</td>
<td>6.2</td>
<td>7.3</td>
<td>6.9</td>
<td>6.8</td>
<td>15.7</td>
<td>8.5</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>7.2</td>
<td>8.0</td>
<td>7.1</td>
<td>7.8</td>
<td>17.7</td>
<td>8.3</td>
<td>9.3</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.4</td>
<td>7.2</td>
<td>6.7</td>
<td>7.0</td>
<td>16.4</td>
<td>8.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SEm\(^+\) | CD (P=0.05) | CV% |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>0.4</td>
<td>NS</td>
</tr>
</tbody>
</table>
Table 4.20: Nitrogen uptake (kg ha$^{-1}$) in soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>S0</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No micronutrient application</td>
<td>ZnSO$_4$ @ 25 kg ha$^{-1}$</td>
<td>ZnSO$_4$ @ 0.2%</td>
<td>FeSO$_4$ @ 0.5%</td>
<td>ZnSO$_4$ @ 25 kg ha$^{-1}$ &amp; FeSO$_4$ @ 10 kg ha$^{-1}$</td>
<td>ZnSO$_4$ @ 0.2% &amp; FeSO$_4$ @ 0.5%</td>
<td></td>
</tr>
<tr>
<td>M1 NPK @ 30+60+40 kg ha$^{-1}$</td>
<td>61.1</td>
<td>68.3</td>
<td>70.3</td>
<td>68.9</td>
<td>71.8</td>
<td>71.1</td>
<td><strong>68.6</strong></td>
<td></td>
</tr>
<tr>
<td>M2 Vermicompost @ 5 t ha$^{-1}$</td>
<td>48.0</td>
<td>52.2</td>
<td>54.5</td>
<td>55.7</td>
<td>65.16</td>
<td>61.2</td>
<td><strong>56.1</strong></td>
<td></td>
</tr>
<tr>
<td>M3 NPK @ 30+60+40 kg ha$^{-1}$ + Vermicompost @ 2.5 t ha$^{-1}$</td>
<td>71.7</td>
<td>82.42</td>
<td>77.4</td>
<td>78.8</td>
<td>91.6</td>
<td>85.7</td>
<td><strong>81.3</strong></td>
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<tr>
<td>Mean</td>
<td>60.3</td>
<td>67.6</td>
<td>67.4</td>
<td>67.8</td>
<td>76.2</td>
<td>72.7</td>
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<table>
<thead>
<tr>
<th></th>
<th>SEm$^+$</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>2.8</td>
<td>11.2</td>
<td>12.5</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>5.2</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>8.9</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.21: Phosphorus uptake (kg ha\(^{-1}\)) in soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(S_0): No micronutrient application</td>
<td></td>
</tr>
<tr>
<td>(M_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>12.6</td>
<td>13.5</td>
</tr>
<tr>
<td>(M_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>10.0</td>
<td>11.7</td>
</tr>
<tr>
<td>(M_3) NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>15.3</td>
<td>15.4</td>
</tr>
<tr>
<td>Mean</td>
<td>12.6</td>
<td>13.5</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th></th>
<th>SEM+</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>0.3</td>
<td>1.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>0.7</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>1.2</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.22: Potassium uptake (kg ha\(^{-1}\)) in soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S(_0)</td>
<td>S(_1)</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>40.1</td>
<td>43.8</td>
</tr>
<tr>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td>35.9</td>
<td>36.9</td>
</tr>
<tr>
<td>FeSO(_4) @ 0.5%</td>
<td>43.7</td>
<td>44.6</td>
</tr>
<tr>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 10 kg ha(^{-1})</td>
<td>Mean</td>
<td>39.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S(_0)</td>
<td>S(_1)</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>1.2</td>
<td>4.7</td>
</tr>
<tr>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td>2.2</td>
<td>NS</td>
</tr>
<tr>
<td>FeSO(_4) @ 0.5%</td>
<td>3.8</td>
<td>NS</td>
</tr>
</tbody>
</table>
Table 4.23: Zinc uptake (g ha\(^{-1}\)) in soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S(_0)</td>
<td>S(_1)</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 0.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FeSO(_4) @ 0.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 25 kg ha(^{-1}) &amp; FeSO(_4) @ 10 kg ha(^{-1})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</td>
<td></td>
</tr>
<tr>
<td>M(_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>414.6</td>
<td>511.8</td>
</tr>
<tr>
<td>M(_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>422.8</td>
<td>513.8</td>
</tr>
<tr>
<td>M(_3) NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>438.8</td>
<td>540.6</td>
</tr>
<tr>
<td>Mean</td>
<td>425.4</td>
<td>522.0</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>SEm+</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>5.1</td>
<td>19.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>5.7</td>
<td>16.5</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>9.9</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.24: Iron uptake (g ha\(^{-1}\)) in soybean as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S(_0) No micronutrient application</td>
<td>S(_1) ZnSO(_4) @ 25 kg ha(^{-1})</td>
</tr>
<tr>
<td>M(_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>707.6</td>
<td>740.7</td>
</tr>
<tr>
<td>M(_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>677.7</td>
<td>710.8</td>
</tr>
<tr>
<td>M(_3) NPK @ 30+60+40 kg ha(^{-1}) + Vermicompost @ 2.5 t ha(^{-1})</td>
<td>721.3</td>
<td>765.8</td>
</tr>
<tr>
<td>Mean</td>
<td>702.2</td>
<td>739.1</td>
</tr>
</tbody>
</table>

SE\(_{M+}\) CD (P=0.05) CV%

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>4.5</th>
<th>17.9</th>
<th>2.1</th>
</tr>
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<tbody>
<tr>
<td>Micronutrient levels</td>
<td>8.3</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>14.3</td>
<td>NS</td>
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</table>
Table 4.25: Zinc content (mg kg\(^{-1}\) seed) in soybean seed as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>S(_0)</th>
<th>S(_1)</th>
<th>S(_2)</th>
<th>S(_3)</th>
<th>S(_4)</th>
<th>S(_5)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No micronutrient application</td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})</td>
<td>ZnSO(_4) @ 0.2%</td>
<td>FeSO(_4) @ 0.5%</td>
<td>ZnSO(_4) @ 25 kg ha(^{-1})&amp; FeSO(_4) @ 10 kg ha(^{-1})</td>
<td>ZnSO(_4) @ 0.2% &amp; FeSO(_4) @ 0.5%</td>
<td></td>
</tr>
<tr>
<td>M(_1) NPK @ 30+60+40 kg ha(^{-1})</td>
<td>53.9</td>
<td>83.6</td>
<td>82.7</td>
<td>69.6</td>
<td>95.9</td>
<td>113.2</td>
<td>83.2</td>
</tr>
<tr>
<td>M(_2) Vermicompost @ 5 t ha(^{-1})</td>
<td>66.2</td>
<td>102.8</td>
<td>91.6</td>
<td>87.3</td>
<td>94.6</td>
<td>111.9</td>
<td>92.4</td>
</tr>
<tr>
<td>M(_3) NPK @ 30+60+40 kg ha(^{-1})+ Vermicompost @ 2.5 t ha(^{-1})</td>
<td>86.4</td>
<td>116.2</td>
<td>110.1</td>
<td>96.9</td>
<td>142.9</td>
<td>141.5</td>
<td>115.7</td>
</tr>
<tr>
<td>Mean</td>
<td>68.8</td>
<td>100.9</td>
<td>94.8</td>
<td>84.6</td>
<td>111.2</td>
<td>122.2</td>
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<table>
<thead>
<tr>
<th></th>
<th>SEM+</th>
<th>CD (P=0.05)</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermicompost levels</td>
<td>3.2</td>
<td>12.7</td>
<td>9.9</td>
</tr>
<tr>
<td>Micronutrient levels</td>
<td>7.3</td>
<td>21.1</td>
<td></td>
</tr>
<tr>
<td>Vermicompost X Micronutrient</td>
<td>12.7</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.26: Iron content (mg kg⁻¹) in soybean seed as influenced by vermicompost and micronutrients levels

<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrients levels</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₀</td>
<td>S₁</td>
</tr>
<tr>
<td>No micronutrient application</td>
<td>91.7</td>
<td>101.1</td>
</tr>
<tr>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>98.3</td>
<td>101.1</td>
</tr>
<tr>
<td>FeSO₄ @ 0.5%</td>
<td>99.6</td>
<td>114.2</td>
</tr>
</tbody>
</table>

Mean 96.6 105.5 132.5 231.7 221.7 255.6

SEm⁺ CD (P=0.05) CV%

Vermicompost levels 6.6 25.9 11.3
Micronutrient levels 8.9 25.7
Vermicompost X Micronutrient 15.4 NS
<table>
<thead>
<tr>
<th>Vermicompost levels</th>
<th>Micronutrient levels</th>
<th>Actual yield (kg ha⁻¹)</th>
<th>Gross returns (Rs ha⁻¹)</th>
<th>cost of cultivation (Rs ha⁻¹)</th>
<th>Net returns (Rs ha⁻¹)</th>
<th>B:C ratio</th>
<th>Additional net return over control (Rs ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPK</td>
<td>No micronutrient</td>
<td>1152</td>
<td>46080</td>
<td>15,894</td>
<td>30,186</td>
<td>0.66</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>1344</td>
<td>53760</td>
<td>18,512</td>
<td>35,248</td>
<td>0.66</td>
<td>2,618</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2%</td>
<td>1375</td>
<td>55000</td>
<td>15,908</td>
<td>39,092</td>
<td>0.71</td>
<td>8,906</td>
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<tr>
<td></td>
<td>FeSO₄ @ 0.5%</td>
<td>1368</td>
<td>54720</td>
<td>15,927</td>
<td>38,793</td>
<td>0.71</td>
<td>8,607</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹ &amp; FeSO₄ @ 10 kg ha⁻¹</td>
<td>1402</td>
<td>56080</td>
<td>19,678</td>
<td>36,402</td>
<td>0.65</td>
<td>6,216</td>
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<tr>
<td></td>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%</td>
<td>1390</td>
<td>55600</td>
<td>15,941</td>
<td>39,659</td>
<td>0.71</td>
<td>9,473</td>
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<tr>
<td>Vermicompost alone</td>
<td>No micronutrient</td>
<td>512</td>
<td>20480</td>
<td>24,000</td>
<td>-3,520</td>
<td>-0.17</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>635</td>
<td>25400</td>
<td>26,618</td>
<td>-1,218</td>
<td>-0.05</td>
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<td>ZnSO₄ @ 0.2%</td>
<td>687</td>
<td>27480</td>
<td>24,014</td>
<td>3,466</td>
<td>0.13</td>
<td>3466</td>
</tr>
<tr>
<td></td>
<td>FeSO₄ @ 0.5%</td>
<td>659</td>
<td>26360</td>
<td>24,033</td>
<td>2,327</td>
<td>0.09</td>
<td>2,327</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹ &amp; FeSO₄ @ 10 kg ha⁻¹</td>
<td>721</td>
<td>28840</td>
<td>27,784</td>
<td>1,056</td>
<td>0.04</td>
<td>1056</td>
</tr>
<tr>
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<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%</td>
<td>710</td>
<td>28400</td>
<td>24,047</td>
<td>4,353</td>
<td>0.15</td>
<td>4353</td>
</tr>
<tr>
<td>NPK + vermicompost</td>
<td>No micronutrient</td>
<td>1322</td>
<td>52880</td>
<td>20,894</td>
<td>31,986</td>
<td>0.60</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹</td>
<td>1656</td>
<td>66240</td>
<td>23,512</td>
<td>42,728</td>
<td>0.65</td>
<td>10,742</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2%</td>
<td>1702</td>
<td>68080</td>
<td>20,905</td>
<td>47,175</td>
<td>0.69</td>
<td>15,189</td>
</tr>
<tr>
<td></td>
<td>FeSO₄ @ 0.5%</td>
<td>1695</td>
<td>67800</td>
<td>20,927</td>
<td>46,873</td>
<td>0.69</td>
<td>14,887</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 25 kg ha⁻¹ &amp; FeSO₄ @ 10 kg ha⁻¹</td>
<td>1863</td>
<td>74520</td>
<td>24,678</td>
<td>49,842</td>
<td>0.67</td>
<td>17,856</td>
</tr>
<tr>
<td></td>
<td>ZnSO₄ @ 0.2% &amp; FeSO₄ @ 0.5%</td>
<td>1743</td>
<td>69720</td>
<td>20,941</td>
<td>48,779</td>
<td>0.70</td>
<td>16,793</td>
</tr>
</tbody>
</table>
CHAPTER - V

DISCUSSION

The results from the studies on “Assessment of soybean need for zinc iron with and without vermicompost” are discussed in this chapter.

5.1 WEATHER AND SOIL

The experiment was laid out in fallow field after thorough ploughing and seed bed preparation, sowing was done on 8-12-2007. During the crop growth period an amount of 88.3 mm rainfall was received and distributed over three rainy days. Good amount of rainfall was (85.1 mm) received at pod formation stage and facilitated good yield. Weekly mean minimum and mean maximum temperatures during crop period ranged from 16.30°C to 22.57°C and 27.84°C to 32.02°C, respectively. The weekly average mean relative humidity ranged from 77.29 to 88.43 per cent and the average relative humidity during the crop period was 81.55 per cent.

The crop was grown on clay loam soil which was medium in organic carbon, low in available nitrogen and medium in available phosphorus and high in available potassium. Micronutrient analysis of soil indicated that the soil was deficient in zinc (0.57 ppm) and sufficient in iron (0.60 ppm).
5.2 GROWTH PARAMETERS OF SOYBEAN AS AFFECTED BY VERMICOMPOST AND MICRONUTRIENT LEVELS

Growth parameters of soybean were significantly influenced by the vermicompost levels. Application of NPK along with vermicompost significantly recorded the highest plant height (Table from 4.1 to 4.3) and drymatter accumulation (Table from 4.4 to 4.6) over application of NPK alone and vermicompost alone which is depicted graphically in Fig. 5.1 and 5.2. Vermicompost serves as potential source of plant nutrients and has important role in improving soil fertility and productivity. It increases the colonization of mycorrhizae, N\textsubscript{2} fixers and phosphate solubilizing actinomycetes. It improves the adsorptive power of soils for cations and anions and increases the availability of applied nutrients and benefits the crop during entire growth period. Vermicompost enhances the biological activity in soil and stimulates the growth and activity of microorganisms and improves the soil health. This may be the reason for significant increase in growth parameters due to application of vermicompost along with entire dose of NPK. These results are in accordance with the findings of Babhulkar et al. (2000); Thanunathan et al., (2002); Paradkar and Deshmukh (2004); Laxminarayana (2004); Dash et al. (2005) and Kanarase et al. (2006).

Application of vermicompost alone recorded the lowest plant height and drymatter accumulation than application of NPK alone. Vermicompost @ 5 t ha\textsuperscript{-1} without NPK may have added only N @ 19 kg ha\textsuperscript{-1}, P @ 30 kg ha\textsuperscript{-1} and K @ 25 kg ha\textsuperscript{-1}, respectively, which may not have met the nutrient needs of soybean compared with that of entire dose of NPK alone i.e. (30-60-40) kg NPK, respectively. This observation is according to the findings of Babhulkar et al. (2000) which stated that FYM alone may not be able to meet the nutrient requirements of soybean crop.
Application of micronutrients showed significant influence on growth parameters at 30 DAS, 60 DAS and at maturity. The highest growth parameters like plant height and drymatter were recorded with the soil application of ZnSO₄ and FeSO₄. This might be due to early supplementation of zinc and iron through soil application, which could meet the micronutrient needs compared to that of other treatments. Better vegetative growth and naturally assimilation of nutrients are better due to supply of micronutrients at early stage might have increased the plant growth in terms of height, drymatter production. The results are in agreement with the results reported by Saxena et al. (2001); Ramesh and Thirumurugan (2001); Paradakar and Deshmukh (2004) and Shirpukuar et al. (2006). However, soil application of ZnSO₄ and FeSO₄ was found on a par with foliar application of zinc and iron. Application of micronutrients either through soil or foliar application increased the growth parameters. Similar response either through soil or by foliar application of micronutrients was also observed by Singaravel (2001), who reported that differences in application of zinc and manganese by soil or foliar application were not significant.

Total nodule number and nodule dry weight were significantly influenced by soil application of zinc and iron when compared to no micronutrient application. The increase in nodule number and dryweight might be due to supply of zinc and iron which resulted in auxin production, root initiation and shoot elongation of plant causing stimulatory effect on production and development of nodules. These results were in confirmity with the findings of Kapur et al. (1975); Paradkar and Deshmukh (2004); Mohan Kumar et al. (2005) and Mondal and Poi (2006) with application of zinc and iron.
Vermicompost levels did not show any significant influence on days to 50% flowering. However, the lowest number of days to 50% flowering was recorded with the application of NPK alone than other vermicompost levels.

Though the differences were not significant, days to 50% flowering was 2 days earlier with foliar application of zinc and iron alone than the other micronutrient levels.

5.3 YIELD ATTRIBUTES AND YIELD OF SOYBEAN AS AFFECTED BY VERMICOMPOST AND MICRONUTRIENT LEVELS

5.3.1 Yield Attributes

Integrated application of NPK and vermicompost significantly recorded the highest yield attributes like number of pods per plant (Fig. 5.3), number of seeds per pod and test weight (Fig. 5.4) over application of NPK alone and application of vermicompost alone. Combined application of vermicompost along with NPK has several advantages than application of vermicompost and NPK alone. Vermicompost may have caused early release and availability of plant nutrients and reduces the loss of nutrients; which helped in acceleration of various metabolic processes and these in turn might have favoured the crop for producing highest number of yield attributes. These results are according to the earlier findings of Aruna and Narasa Reddy (1999); Pannerselvam et al. (1999); Thanunathan et al. (2002); Paradkar and Deshmukh (2004); Dash et al. (2005); Khutate et al. (2005); Babhulkar et al. (2000) and Tolanur (2009a).
Perusal of the data on yield attributes revealed that application of various micronutrients individually and in combination either through foliage or soil application had significantly benefitted the crop. Soil application of ZnSO$_4$ and FeSO$_4$ recorded the highest number of yield attributes than no micronutrient application. This may be due to utilization of iron which might have enhanced the availability of iron which is required for chlorophyll synthesis and increase the photosynthetic ability and in turn yield attributing characters. However, zinc plays a vital role in auxin production, root initiation and shoot elongation resulting in better vegetative growth and natural assimilation of nutrients which might have translocated to reproductive parts and ultimately resulting in improving the number of pods, seeds per pod and seed weight. These findings are in conformity with the findings of Kapur et al. (1975); Lallu and Shankar (1995); Srinath and Malarkodi (2000); Hugar and Kurdikeri (2000); Paradkar and Deshmukh (2004); Meena et al. (2006); Rathore et al. (2006) and Shirpukar et al. (2006).

Application of NPK and vermicompost along with zinc and iron through soil application significantly increased number of pods over the remaining treatments (Fig. 5.3). However, it was on a par with the foliar application of zinc and iron along with NPK and vermicompost. This may be due to availability of all nutrients, both macro and micronutrients, required for better growth of the plant. These observations are in accordance with the findings of Suryawanshi et al. (2006). Interestingly combined application of NPK and vermicompost without micronutrients recorded higher yield attributes over application of NPK along with micronutrients. The utility of vermicompost which was able to compensate the required zinc and iron requirement of the
crop is clearly reflected in these results. These are in agreement with the findings of Billore et al., (2005); Rajkhowa et al., (2000); Suryawanshi et al., (2006) and Shirpukar et al. (2006).

5.3.2 Yield

Both vermicompost and micronutrient levels had marked influence on the seed yield of soybean, which is depicted graphically in Fig. 5.5.

The highest seed yield obtained with combined application of vermicompost and NPK over NPK alone and vermicompost alone, might be due to prolonged availability of nutrients especially nitrogen, which might have influenced the seed yield through better source-sink relationship, resulting in higher production of photosynthates and increased their translocation to reproductive parts. As nitrogen being the most important essential plant nutrient needed for growth and development of plant increased the growth, yield attributes and finally augmented the seed yield. Similar findings were also reported by Saxena et al. (2001); Rajkhowa et al. (2000); Paradkar and Deshmukh (2004); Rajshree et al. (2005); Dash et al. (2005) and Mali and Gokhale (2007).

Soil application of ZnSO$_4$ and FeSO$_4$ produced the highest seed yield over no micronutrient application and it was on a par with foliar application of zinc and iron. The increase in seed yield with application of micronutrients was probably due to high drymatter accumulation which substantially improved the yield attributes like number of pods, seeds per pod and test weight. Further, it could also be due to increased nodulation which might have favoured in the formation of proteins and also may be due to better uptake of micronutrients
(Zn and Fe) compared to no micronutrient application. Similar findings were reported by Gupta and Vyas (1994); Devarajan and Palaniappan (1995); Saxena et al. (2001); Hugar and Kurdikeri (2000); Thiyageshwari and Ramanathan (2001); Paradkar and Deshmukh (2004); Subash et al. (2005); Mondal and Poi (2006) and Shelge et al. (2006).

Application of NPK and vermicompost along with soil application of zinc and iron recorded significantly higher seed yield (Fig. 5.5). However, foliar application of zinc and iron along with NPK and vermicompost recorded the highest seed yield which was on a par with soil application of micronutrients. This might be due to the reason that application of vermicompost alone cannot meet the heavy demand of nutrients because of their quantity and restricted nutrient availability. Similarly, application of NPK, Zn and Fe alone in the form of chemical fertilizers may pose problems like toxicity due to high amount of salts as a residue of fertilizers, deterioration of the physical properties of soil, impairing the aeration and soil-water-plant relationship resulted in decreasing productivity. Whereas, complementary use of organic manures and mineral fertilizers may meet the goal of adequate and balanced supply of required N, P, K and micronutrients. These results were supported by the findings of Babhulkar et al. (2000); Subhash and Rani (2005); Suryawanshi et al. (2006) and Shirpukar et al. (2006).

Both vermicompost and micronutrient levels had marked influence on the haulm yield, (Fig. 5.6). Combined application of NPK and vermicompost recorded the highest haulm yield over application of NPK and vermicompost alone. The increase in haulm yield was the consequence to increase in drymater production due to steady availability of nutrients (Khutate et al. 2005)
Haulm yield varied significantly due to micronutrients. Soil application of ZnSO₄ and FeSO₄ recorded the highest haulm yield over no micronutrient application; however, it was on a par with foliar application of zinc and iron. The favorable effect of zinc and iron might be due to their direct influence on nitrogen fixation and quantity of auxin production which in turn enabled the plants to grow better and accumulate more drymatter resulting in more haulm yield. These findings are in agreement with those of Hugar and Kurdikeri (2000); Saxena et al. (2001) and Mondal and Poi (2006).

5.4 QUALITY PARAMETERS OF SOYBEAN AS AFFECTED BY THE VERMICOMPOST AND MICRONUTRIENT LEVELS

5.4.1 Protein Content

Combined application of NPK and vermicompost recorded significantly the highest protein content over application of NPK and vermicompost alone (Table 4.18). This might be due to supply of higher rates of nitrogen in turn more protein might have been synthesized. The results are in conformity with the results of Aruna and Narasa Reddy (1999) and Singh et al. (2003).

The highest protein content was recorded with application of zinc and iron through soil application and was on a par with that of foliar application (39.7 %). Application of ZnSO₄ increases the availability of zinc, as it is a constituent of essential components dehydrogenase and proteinase, whereas, iron plays a vital role in nitrogen fixation which might have resulted in increase in protein content. These findings are in accordance with those of Kapur et al. (1995); Gupta and Vyas (1991); Sonune et al. (2001); Mohan Kumar et al. (2005) and Rathore et al. (2006).
5.4.2 Oil Content

Application of vermicompost alone recorded the highest oil content than other vermicompost levels but the difference was not significant. This was according to the findings of Rajshree et al. (2005).

Oil content of soybean was not significantly affected by the micronutrient levels. However, soil application of ZnSO$_4$ and FeSO$_4$ recorded the highest oil content. It might be due to fact that zinc increases the activity of NADPH dependent dehydrogenase involved in fat synthesis and might have influenced the oil content. Mohan Kumar et al. (2005) and Meena et al. (2006) also reported similar findings.

5.4.3 Uptake of Nutrients

Critical perusal of data pertaining to uptake of macro and micronutrients revealed that uptake of NPK are increased significantly due to application of NPK and vermicompost over application of NPK alone and vermicompost alone. Steady and increased availability of nutrients from vermicompost might have resulted in increased uptake of nutrients by plant. These results were in conformity with the findings of Rajkhowa et al. (2000) and Tolanur (2009a).

Combined application of vermicompost and NPK increased uptake of iron and zinc in plant and seed (Fig. 5.7 and 5.8) It may be due to the application of vermicompost which caused higher utilization of zinc and iron mainly due to its beneficial effects in mobilizing the native nutrients to increase their availability. Meena et al. (2006) also reported similar results.
Foliar spray of zinc and iron recorded increased uptake of zinc and iron by soybean plant and seed. However, it was on a par with soil application of zinc and iron. This might be due to uptake of a particular nutrient was more when that nutrient was foliage applied. These results were in conformity with those of Arora et al. (1985) and Devarajan and Palaniappan (1995).

5.4.4 Available Nutrient Status of Soil

The data on available nutrients after harvest of crop revealed that availability of nitrogen, phosphorus and potassium were the highest with the combined applications of NPK and vermicompost. It may be due to more availability of nutrients after harvest, as vermicompost decreases the nutrient losses by increasing the adsorbing capacity of the soil. Similar findings were also reported by Babhulkar et al. (2000); Thanunathan et al. (2002); Paradkar and Deshmukh (2004); Laxminarayana (2004) and Rajashree et al. (2005). Data pertaining to available micronutrients after harvest of crop revealed that the availability of zinc and iron was higher with the combined application of NPK and vermicompost along with soil application of zinc and iron.

From the above discussion, the following conclusions can be drawn.

1. There was a significant influence of zinc and iron on growth, yield and quality of soybean

2. Application of vermicompost was found to be beneficial when it was applied along with NPK compared to application of vermicompost alone.

3. Application of vermicompost eliminated the zinc and iron needs of soybean along with NPK fertilizers over application of NPK alone along with micronutrients.
Fig. 5.1 : Plant height (cm) of soybean as influenced by vermicompost and micronutrients levels at maturity
Fig. 5.2: Drymatter accumulation (kg ha\(^{-1}\)) of soybean as influenced by vermicompost and micronutrients levels at maturity.

- M\(_1\) – NPK
- M\(_2\) – Vermicompost
- M\(_3\) – NPK + Vermicompost
Fig. 5.3: Number of pods per plant of the soybean as influenced by vermicompost and micronutrients levels
Fig. 5.4: Test weight (g) of soybean as influenced by vermicompost and micronutrients levels

M_1 – NPK; M_2 – Vermicompost; M_3 – NPK + Vermicompost
Fig. 5.5: Seed yield (kg ha⁻¹) of soybean as influenced by vermicompost and micronutrients levels.
Fig. 5.6: Haulm yield (kg ha⁻¹) of soybean as influenced by vermicompost and micronutrients levels
Fig. 5.7: Zinc content (mg kg\(^{-1}\) seed) in soybean seed as influenced by vermicompost and micronutrients levels
Micronutrient levels

Iron content (mg kg$^{-1}$ seed)

S$0$ S$1$ S$2$ S$3$ S$4$ S$5$

Fig. 5.8: Iron content (mg kg$^{-1}$) in soybean seed as influenced by vermicompost and micronutrients levels
Fig. 3.1: Weekly weather prevailed during the crop growth period
CHAPTER – VI

SUMMARY

A field experiment entitled “Assessment of the soybean need for zinc and iron with and without vermicompost” was conducted at the Agricultural College Farm, Bapatla on clay loam soils during rabi 2007-08.

The experiment was laid out in split-plot design with 3 replications. The treatments consisted of three vermicompost levels viz., application of NPK alone @ 30 + 60 + 40 kg ha\(^{-1}\) (M\(_1\)) vermicompost application alone @ 5 t ha\(^{-1}\) (M\(_2\)) and combined application of NPK (30 + 60 + 40 kg ha\(^{-1}\)) and vermicompost @ 2.5 t ha\(^{-1}\) (M\(_3\)) assigned to main-plots and six micronutrient levels i.e. No micronutrients application (S\(_0\)), soil application of ZnSO\(_4\) @ 25 kg ha\(^{-1}\) (S\(_1\)), foliar application of ZnSO\(_4\) @ 0.2% at 30 DAS (S\(_2\)) foliar application of FeSO\(_4\) @ 0.5% at 30 DAS (S\(_3\)), soil application of ZnSO\(_4\) @ 25 kg ha\(^{-1}\) and FeSO\(_4\) @ 10 kg ha\(^{-1}\) (S\(_4\)) and foliar application ZnSO\(_4\) @ 0.2% and FeSO\(_4\) @ 0.5% at 30 DAS (S\(_5\)) assigned to sub-plots. The test cultivar used was JS-335. The salient findings emerged from this investigation are briefly summarized below.

Plant height and drymatter accumulation recorded with combined application of NPK and vermicompost was significantly higher than that of NPK and vermicompost alone. Growth parameters with vermicompost alone are found to be lower than NPK alone. No significant differences were observed among vermicompost levels in number and dryweight of nodules at 30 DAS, whereas, at 60 DAS the highest nodule dryweight was recorded with
integrated application of NPK and vermicompost than other levels. Days to 50% flowering was not significantly influenced by vermicompost levels.

The maximum plant height was recorded with the soil application of ZnSO$_4$ @ 25 kg ha$^{-1}$ and FeSO$_4$ @ 10 kg ha$^{-1}$ at all the stages of crop growth. However, it was comparable with all other micronutrient levels except no micronutrient treatment. Similarly, at maturity higher drymatter accumulation was recorded with the soil application of ZnSO$_4$ and FeSO$_4$ over no micronutrient application and comparable with all other micronutrient levels.

Soil application of ZnSO$_4$ and FeSO$_4$ recorded the highest number of nodules per plant, however, it was comparable with all other micronutrient levels except with no micronutrient application. The highest nodule dry weight per plant was recorded with the soil application of ZnSO$_4$ and FeSO$_4$ and it was on a par with soil application of ZnSO$_4$ alone at 30 DAS. At 60 DAS the highest nodule dry weight was recorded with the soil application of ZnSO$_4$ and FeSO$_4$ which was on a par with foliar application of ZnSO$_4$ and FeSO$_4$. Days to 50% flowering was not significantly influenced by micronutrient levels.

Combined application of NPK and vermicompost recorded the highest number of pods per plant, which was significantly superior to NPK and vermicompost alone. Vermicompost alone recorded the lowest number of pods per plant.

The higher number of pods per plant was produced with soil application of ZnSO$_4$ and FeSO$_4$ over no micronutrient application. Integrated application NPK and vermicompost recorded the highest test weight. The lowest test weight was obtained with vermicompost alone which was on a par with application of NPK alone. Application of ZnSO$_4$ and FeSO$_4$ gave significantly higher test weight over no micronutrient application.
Combined application of vermicompost and NPK positively influenced the seed yield over application of NPK alone and vermicompost application, whereas, application of vermicompost alone recorded the lowest seed yield which was significantly inferior to that of other treatments.

The maximum seed yield was obtained with the application of ZnSO$_4$ and FeSO$_4$ which was significantly superior to no micronutrient application, however, it was comparable with foliar application of zinc and iron and rest of the treatments.

Application of NPK and vermicompost along with soil application of ZnSO$_4$ and FeSO$_4$ recorded the highest seed yield of 1863 kg ha$^{-1}$ which was on a par with all other levels of micronutrient application.

Maximum protein content of 40 per cent was recorded with application of NPK and vermicompost which was significantly superior to application of NPK alone and vermicompost alone. Soil application of ZnSO$_4$ and FeSO$_4$ resulted higher protein content in soybean over no micronutrient application and it was on a par with all other levels of micronutrient application. Oil content in soybean did not show significant variation due to vermicompost and micronutrient levels.

Application of NPK and vermicompost recorded the highest NPK uptake which was significantly superior to that of NPK and vermicompost alone. Micronutrient levels did not show any significant difference in NPK uptake.
Available nutrients status of soil in respect of both macro and micronutrients (NPK, Zn and Fe) after harvest of crop in the experiment was the highest with the treatment receiving NPK and vermicompost and treatments receiving zinc and iron through soil application.

Economics of various treatments revealed that the highest net return per rupee invested was obtained with foliar application of zinc and iron at each level of vermicompost. The highest net returns were obtained with the combined application of NPK and vermicompost along with the soil application of zinc and iron.

From this study, it can be concluded that,

1. Application of zinc and iron along with NPK significantly affected the growth parameters, yield attributes, yield and quality of soybean when compared with the application of NPK alone.

2. Application of vermicompost was found beneficial when it was applied along with NPK compared to application of vermicompost alone.

3. Vermicompost when applied along with NPK, eliminated the need for application of zinc and iron for soybean compared with application of NPK alone together with micronutrients.
ABSTRACT

Name of the Author: J. INDIRA PRIYADARSHINI
Title of the Thesis: Assessment of the soybean [Glycine max (L.) Merrill] need for zinc and iron with and without vermicompost
Submitted for the Award of: Master of Science in Agriculture
Faculty: Agriculture
Major field of study: AGRONOMY
Major Advisor: Dr. M. MARTIN LUTHER
University: Acharya N.G. Ranga Agricultural University
Year of Submission: 2010

A field experiment was conducted on clay loam soil of the Agricultural College Farm, Bapatla to assess the soybean [Glycine max (L.) Merrill] need for zinc and iron with and without vermicompost during rabi, 2007-08. The treatments consisted of three vermicompost levels (application of NPK alone, combined application of NPK and vermicompost and application of vermicompost alone) assigned to main plots and six micronutrient levels (no micronutrient application, soil application of ZnSO₄ @ 25 kg ha⁻¹, foliar application of ZnSO₄ @ 0.2%, foliar application of FeSO₄ @ 0.5%, soil application of ZnSO₄ & FeSO₄ @ 25 kg ha⁻¹ and 10 kg ha⁻¹ and foliar application of ZnSO₄ @ 0.2% and FeSO₄ @ 0.5%) assigned to sub-plots arranged in split-plot design and the treatments were replicated thrice.
In general, growth parameters like plant height and drymatter accumulation were found to be the highest with the combined application of NPK and vermicompost over NPK alone and vermicompost alone. No significant differences were observed among vermicompost levels for number and dryweight of nodules at 30 DAS; however, at 60 DAS the highest number and nodule dryweight was recorded with integrated application of NPK and vermicompost. Days to 50% flowering was not significantly influenced by different treatments. Yield attributes, seed and haulm yield of soybean were the highest with combined application of NPK and vermicompost over NPK alone and vermicompost alone. Quality parameters like protein, zinc and iron contents in seed were the highest with the integrated application of NPK and vermicompost. Oil content of soybean was not significantly influenced by the vermicompost levels. Uptake of nutrients and available nutrients in soil at harvest were superior with combined application of NPK and vermicompost.

The maximum plant height, highest drymatter accumulation, more number and dryweight of nodules were recorded with the soil application of ZnSO$_4$ and FeSO$_4$. But, it was comparable with foliar application of zinc and iron. No significant difference was observed for days to 50% flowering with micronutrient levels. The highest number of pods, more test weight and increased seed and haulm yield were recorded with soil application of ZnSO$_4$ and FeSO$_4$ over no micronutrient application and it was on a par with foliar application of zinc and iron. The maximum protein content was recorded with the soil application of ZnSO$_4$ and FeSO$_4$. Conversely, oil content was not significantly influenced by micronutrient levels. No significant difference in NPK uptake and available NPK content of soil at harvest were found with
micronutrient levels, whereas, zinc and iron uptake by plant and seed were significantly influenced by micronutrient levels. The highest zinc and iron uptake was recorded with foliar application of zinc and iron and it was on a par with soil application of zinc and iron.

Thus the present study indicated that application of NPK along with vermicompost was found significantly superior to NPK alone and vermicompost alone in increasing growth parameters, yield attributes, yield and quality parameters. Soil application of ZnSO₄ + FeSO₄ increased growth parameters, yield attributes, yield and quality parameters, and was comparable with foliar application of zinc and iron. Combined application of NPK and vermicompost along with zinc and iron either by soil application or by foliar application significantly increased the seed yield of soybean compared to no micronutrient application, whereas, integrated application of NPK and vermicompost without micronutrient application was found to be similar in increasing the growth, yield and quality parameters as that of combined application of NPK, vermicompost along with micronutrient application.
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*Original not seen

Note: The pattern of Literature Cited presented above is in accordance with the guidelines for thesis presentation, Acharya N. G. Ranga Agricultural University, Hyderabad.
## APPENDICES

### CALENDAR OF OPERATIONS

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<td>1.</td>
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<td>3.</td>
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<td>8.</td>
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