Effect of Soil and Foliar Application of Nutrients on Cowpea [*Vigna unguiculata* (L.) Walp]

THESIS

Submitted to the

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

In partial fulfilment of the requirements for the Degree of

MASTER OF SCIENCE

In

AGRICULTURE

(AGRONOMY)

By

AMIT CHOUHAN

Department of Agronomy

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

College of Agriculture, Gwalior (M.P.)

2019

CERTIFICATE - I

This is to certify that the thesis entitled **"Effect of Soil and Foliar Application of Nutrients on Cowpea [Vigna unguiculata (L.) Walp]"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURE (AGRONOMY)** of the **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior** is a record of the bonafide research work carried out by **Mr. Amit Chouhan, ID. No. 17111101** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

Place: Gwalior **(Dr. S.P.S. Tomar)**

Date: **Chairman of the Advisory Committee**

MEMBERS OF STUDENT'S ADVISORY COMMITTEE

Chairman (Dr. S. P. S. Tomar) .....

Member (Dr. S.S. Bhadauria) ……..

Member (Dr. S. K. Trivedi) ……..……

Member (Dr. V.B. Singh) ……..……

CERTIFICATE - II

This is to certify that the thesis entitled "**Effect of Soil and Foliar Application of Nutrients on Cowpea [Vigna unguiculata (L.) Walp]**" submitted by **Mr. Amit Chouhan ID. No. 17111101** to the **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior** in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURE (AGRONOMY)** has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination on the same.

Place: Gwalior **(Dr. S. P. S. Tomar)**

Date: **Chairman of the Advisory Committee**

MEMBERS OF THE ADVISORY COMMITTEE

Chairman (Dr. S.P.S.Tomar) : **.....**

Member (Dr. S.S. Bhadauria) : **…….**

Member (Dr. S.K Trivedi) : **……..**

Member (Dr. V.B. Singh) : **……..…….**

Head of the Department : **……..**

Dean of the College : **……**

Director of Instructions : **……...**

ACKNOWLEDGEMENT

The author of this manuscript praises the omniscient and almighty "GOD" and his parents, who provided his this opportunity of submitting the present thesis for award of M.Sc. (Ag.) Agronomy, Degree.

The word can never express indebtedness but I can take this opportunity to express my deepest and heartfelt sense of gratitude to reverend, chairman of Advisory committee, ***Dr. S. P. S. Tomar****, Professor Department of Agronomy and Dean Student Welfare RVSKVV Gwalior, College of Agriculture, Gwalior, (M.P.) for suggesting the problem, providing necessary facilities and for his valuable guidance, continuous encouragement, angular vision, clarity of the conception and painstaking work during the course of investigation and finalization of this manuscript. He has been a constant source of inspiration and his love and affection to me will ever be remembered.*

I wish to render my sincere thanks to the members of the thesis Advisory Committee ***Dr. S.S. Bhadauria****, Assistant Professor, Technical Officer, RVSKVV, Gwalior,* ***Dr. S.K. Trivedi****, Professor Department of Soil science,* ***Dr. V.B. Singh****, Professor and Head, Department of Statistics, College of Agriculture, Gwalior for their kind help and constant advisement.*

I also feel great pleasure to express my heartfelt thanks to the Honourable Vice Chancellor of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Prof. ***Dr S.K. Rao****, Dean faculty of Agriculture,* ***Dr. Mridula billore****, Director of Research Services,* ***Dr. M.P. Jain****, Director Instructions,* ***Dr. A.K. Singh****, Registrar,* ***Dr. D.L. Kori*** *and Dean, College of Agriculture,* ***Dr. S.K. Verma*** *for providing necessary facilities in carrying out this piece of research work.*

I am deeply obliged and indebted to ***Dr. G.S. Rawat****, professor and head, Department of Agronomy,* ***Dr. D.S. Sasode****, Senior Scientist,* ***Dr. Janmejay Sharma****, Scientist,* ***Dr. Ekta Joshi****, Scientist,* ***Dr. Varsha Gupta****, Scientist, Department of Agronomy, College of Agriculture, Gwalior for his unique help and fruitful direction for the success of this study.*

I cannot avoid to express my sincere thanks to Shri ***G.S. Yadav****, Shri* ***Sunil Kushwah****,Shri* ***Jagdish Sharma*** *and Shri* ***Harikesh Mahor*** *for their valuable help and co-operation during the course of investigation.*

I appreciate and express my cordial thanks to my respected seniors ***Sachin Balpande, Roop Singh Dangi, Sudarshan Cicham, Ramkesh Patel, Dileep Mandloi,*** *collegeous and friends* ***Dileep Kumre, Dharmendra parmar, kampoter singh, Bharti parmar, Doly Yadav, Suresh Singar, Rahul Birla, Subham Choudhary ,Vikas Baghel, Jitendra Porwal, Vinod Jatav, Pradeep Maida, Mithun Thakur, Sanjay Bhura, Monu Rajore*** *and juniors* ***Babulal Barde, Anil Mehta, Karan Chouhan*** *for their friendly co-operation and encouragement.*

Lastly, but not least I pay my dutiful thanks from the core of my heart to my respected father Shri ***Pappu Chouhan****, and mother Smt.* ***Dhanu Chouhan*** *and my younger brother* ***Vishal Chouhan*** *and my cousins* ***Arun, Sawan, Mukesh, Balram, Lucky, Shubham, Mandeep, Krish*** *for their love, affection, blessing and constant inspiration to continue my study.*

Place: *Gwalior*
Date: ***(Amit Chouhan)***

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Symbol	Legend
a.i.	Active ingradient
&	And
@	At the rate of
^{o}C	Degree Celsius
C.D.	Critical Difference
Cm	Centimeter
C.V.	Coefficient of Variation
DAS	Days after sowing
d.f.	Degree of Freedom
et al.	And others
Etc	and the rest
fig.	Figure (s)
G	Gram
Ha	Hectare
HI	Harvest Index
i.e.	That is
K	Potassium
Kg	Kilogram (s)
kg/ha	Kilogram per hectare
L	Litre
MSS	Mean sum of square
Mg	Miligram
M	Meter (s)
N	Nitrogen
No	Number (s)
NS	Non significant
P	Phosphorus
T	Tonne
R.V.S.K.V.V.	Rajmata Vijaya Raje Scindia Krishi Vishwa Vidyalaya
RH	Relative humidity
₹	Rupees
S.E.(m.)±	Standard error of mean
S.S.	Sum of Square
viz.	Namely
√	Square root
%	Per cent
±	Plus or Minus
PE	Pre emergence
Ppm	Part per million

Chapter - I

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is an annual legume of tropical and subtropical area, commonly known as *lobia*. It is one of the most important multipurpose grain legume extensively cultivated in arid and semi-arid tropics of India. It is drought tolerant and warm weather crop, which is well adapted to the drier regions of the tropics. Cowpea is a poor men's source of protein. Cowpea is probably a native of central Africa. On dry weight basis, cowpea grain contains 23.4 percent protein, 1.8 percent fat and 60.3 percent carbohydrate and a rich source of calcium and iron. It is mainly grown in Africa covering about 90 per cent of the total world acreage. In India, cowpea is grown in an area of 3.9 million hectares particularly in western, central and peninsular regions, with a production of 2.21 million tonnes and productivity is about 567 kg/ha.In M.P., The cultivated area of cowpea is about 5391 hectares with a productivity of about 488 kg/ ha (CSLR, 2017) which is quite low.

Cowpea is grown for forage, green pod and grain purpose. It fits well in a variety of cropping systems and is grown as cover crop, mixed crop, catch crop and green manure crop. It is an annual herb with a strong tap root system with different growth habits *i.e.* erect, semi erect, trailing or climbing, bushy annual with glabrous stem. The trifoliate leaves arise alternately and terminal leaflet is frequently longer and of larger area than that of asymmetrical lateral leaflets.

It is usually grown as *kharif* crop, however can be grown as a *rabi,* spring or summer crop in different parts of the country. The crop is known for initial fast growth with dropping leaves which suppress weed growth initially. Initially fast growth helps in extensive root development and early establishment of crop in wake of drought like situation. It also has the useful ability to fix atmospheric nitrogen through its root nodules and it grow well in poor soils with more than 85 percent sand and with less than 0.2 percent organic matter and low levels of phosphorus. It also has the excellent ability against soil erosion from rain water and being denoted as prominent cover crop.

In addition, it is shade tolerant and therefore, compatible as an intercrop with maize, millets, sorghum, sugarcane and cotton. This makes cowpea an important component of traditional intercropping system, especially in the complex and elegant subsistence farming systems of dry regions. Cowpea is not being cultivated by the farmers as a sole crop on large acreage in M.P. It is mainly grown as inter crop, legume crop, fodder crop and vegetable crop also.

Productivity of cowpea in our country is very low. So, there is need to take proper agronomic practices to enhance the productivity of cowpea and foremost important among them is foliar application of organic and inorganic sources of nutrients exploiting genetic potential of crop. This is considered to be an efficient and economic method of supplementing part of nutrient requirement at critical growth stages of the crop. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating uptake of nutrients by the plant. Since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cell facilitating easy and rapid utilization of nutrients. So foliar nutrition on cowpea helps in achieving the optimum grain yield of cowpea.

Hence, keeping the above in view the present investigation was under taken to increase yield and to reduce the risk of aberrant weather condition and evaluate the "**Effect of Soil and Foliar Application of Nutrients on Cowpea [*Vigna unguiculata* (L.) Walp]"** with the following objectives**:**

1) To assess the effect of soil and foliar application of nutrients on growth and yield of cowpea.
2) To find out the best source and method of nutrients application in cowpea.
3) To work out the economics of the treatments.

Chapter - II

REVIEW OF LITERATURE

Cowpea [*Vigna unguiculata* (L.) Walp] is one of the most important crop of rainfed areas, grown in throughout the country. Research work has been conducted on different aspects at various places in the country. In this chapter the relevant literature on **"Effect of Soil and Foliar Application of Nutrients on Cowpea [*Vigna unguiculata* (L.) Walp]**" has been reviewed.

Kandagal *et al*. (1990) reported that application of urea @ 2 % spray at pre bloom stage in mung bean recorded significantly higher number of flowers.

Ghildiyal (1992) found that foliar application of urea increased number of pods per plants in mung bean.

Srinivasan and Ramasamy (1992) revealed the response of cowpea to foliar nutrition of 2 percent urea and 2 percent DAP sprayed on 20 and 30 DAS. Spraying of 2 percent DAP produced similar yield to that of soil application of N and P and the higher yield than urea spray.

Shinde and Jadhav (1995) revealed that foliar application of NAA 5 ppm in cowpea produced the highest seed yield (1.53 t ha^{-1}), which was 48 per cent higher than control.

Singh and Sharma (1996) observed that foliar application of $GA_3$40 ppm and NAA 20 ppm produced the highest seed yield of 1.19 and 1.32 t ha^{-1} in the rainy and dry season, respectively in cowpea cv, ArkaGarima.

Ganiger *et al.*(1999) stated that the treatments NAA (250 and 500 ppm) and TIBA (25 and 50 ppm) recorded significantly more seed yield (1730, 1751, 1801 and 1722 kg/ha, respectively) as compared to control (1346 kg/ha) and other treatments in cowpea.

Haqand Mallarino (2000) revealed that early foliar application of N, P and K increased plant growth and development which resulted increased total dry matter of soybean crop.

Kumaran and Subramanian (2001) reported thatgrain and haulm yield (1116 and 3351 kg/ha, respectively) was recorded higher in application of 100% recommended dose of NPK + DAP 2% + TNAU pulse wonder 5.0 kg/ha on black gram.

Nayak (2001) reported that the effects of potash mobilize on brinjal has recorded an increased potash uptake and plant biomass in potash mobilizes treated plant as compared to the control plant.

Parasuraman (2001) conducted the field experiment to study the effect of seed pelleting with diammonium phosphate and potassium dihydrogen phosphate and foliar spray with diammonium phosphate on the growth and the yield of rainfed cowpea (*Vigna unguiculata*). Results revealed that soil application of recommended inorganic fertilizers (RIF) + 2% DAP spray twice (first at flowering and second at 15 days after the first spray) showed the significantly highest net income (₹3,471/ha) and benefit: cost ratio (1.96) over other treatments.

Sujatha (2001) reported that foliar application of salicylic acid (100ppm) on green gram at 75 DAS increased plant height (50.4 cm), root length (16.9 cm), number of leaves (18.4) and Leaf area index (LAI) (1.30).

Chandrasekhar and Bangarusamy (2003) revealed that foliar application of 18:18:18 (NPK) 2% result of improvement in grain yield and net income with high B:C ratio in black gram.

Chandrashekhar and Bangarusamy (2003) observed that, foliar application of 2% DAP +salicylic acid (100 ppm) + KCl (1%) + NAA (40 ppm) significantly increased the number of pods plant-1(19.45) and seed yield (1443.38 kg ha-1). However, these treatments were on par with 2% DAP (podsplant-1 13.2 and seed yield 1162.41 kg ha-1) in green gram.

Ganiger *et al.* (2003) reported that foliar spray of urea (2%) at 35 days after sowing increased the growth and yield of cowpea.

Ravanhar *et al.* (2003) observed in four legume crops (Soybean, Green gram, Groundnut and Pigeion pea) and four levels of nitrogen (0, 15, 30 and 45

kg/ha) at university farm Akola, Maharastra, India during the *kharif-rabi* season of 1997-98 that the dry matter and grain yield increased with increase in level of nitrogen. The percentage increase in grain yield was 6.5, 18.4 and 29.9 with application of 15, 30 and 45 kg N/ha respectively, over the control. Soybean exhibited highest nitrogen use efficiency of 10.2 kg grain/kg nitrogen as compared to other legume crops.

Velayutham *et al*. (2003) reported that application of NPK and S at 20,50,20 and 20 kg/ha along with sodium molybdate at 3.0 kg/ha to soil has recorded significantly higher yield (2.3 t/ha) and was on par will all the other treatments, except application of recommended dose of NPK and S (RDF) at 20,50,20and 20 kg/ha in urd bean.

Yadav *et al.* (2003) found that seed soaking in 500ppm thiourea solution followed by two foliar spray (at vegetative and flowering stages) was most effective and increase the seed yield of cowpea by 26 per cent over control.

Anitha *et al*. (2004) reported that thiourea application consistently increased the cowpea productivity under rainfed conditions. Soaking seeds in 500ppm thiourea solution followed by two sprays (at vegetative and flowering stages) was most effective and increased the seed yield by 26% over control.

Krishanaveni *et al*. (2004) observed that foliar application of 2% DAP + 0.5% ZnSO4 at 15,30and 45 DAS recorded the higher plant height and chlorophyll content in green gram on clay loam soilat Agriculture College and Research Institute, Madurai.

Anitha *et al.* (2005) studied the response of foliar application of FeSO4 and ZnSO4 on productivity of cowpea. They opinioned that combined foliar spray of 0.5% FeSO4 and ZnSO4 at 45days after sowing recorded 43.09% higher seed yield compared to unsprayed.

Reddy *et al.* (2005) reported that a significant increase in the plant height was observed with 2% urea spray at 30, 40 and 60 DAS in urd bean over absolute control (no spray).

Sritharan *et al.* (2005) conducted experiment at Coimbatore to study the effect of foliar spray of nutrients and plant growth regulators for the yield maximization in black gram and they revealed that the foliar spray of 2% urea recorded the highest yield of 955.2 kg/ha and proved significantly superior over other treatment combinations.

Veerabhadrappa and Yeledhalli (2005) reported that basal application of 100% RDF (25 kg N,75 kg P2O5 and 25 kg K2O) with foliar spray of N, P, K, Ca and S at 1% each at 60 DAS recorded significantly higher pod yield (2692 kg ha-1), haulm yield (4753 kg ha-1) and yield attributing characteristics such as number of pods plant-1 (21.52), shelling percentage (76.34) and growth attributing parameters like leaf area plant-1 (10.10 dm2 plant-1), total dry matter production (39.90 gplant-1) compared to control. This was on par with the basal application of 100% RDF with foliar spray of N, P, K, Ca and S at 1% each at 45 DAS.

Dixit and Elamathi (2007) revealed that significantly higher seed yield of cowpea (1277 kg/ha) was reported with foliar spray of 2% DAP, which was 23.9% higher over water sprayed but remained at par with 2% urea (1189 kg/ha) 2% KCL (1177 kg/ha).

Singh (2007) reported that seed soaking + foliar spray of 500ppm and

1000ppm thiourea in moth bean showed the significant increase in the concentration and uptake of nitrogen and molybdenum in seed and straw and the protein content in seed over control and rest of the treatments.

Deshmukh *et al.* (2008) conducted an experiment at PDKV, Akola and results revealed that plant height and dry matter accumulation increased significantly at harvest in plots receiving 1% urea spray at pre-flowering + 25% pod initiation + pod development on rajmah over two spray at 25% pod initiation + pod development.

Singh (2008) carried out an field experiment during 2002-03 and 2003-04 at AICRP, R. A. K College of Agriculture, Sehore (Madhya Pradesh), to study the effect of phosphorus and PSB on black gram.The result indicated

that, application of 20 kg P2O5 + PSB gave18.69 % more yield over 20 kg P2O5 application. The application of 40 kg P2O5 + PSB inoculation proved best treatment over rest of the treatments with respect to Plant height (26.1 cm), number of root nodules per plant (31.8), dry weight of root nodules/per plant (33.0), pods per plant (30.7), seed yield (651 kg /ha) and net return (Rs.2624 /ha).

Maity and Bera (2009) reported that foliar application of salicylic acid influences different physiological and biochemical aspects of green gram plant by increasing assimilation rate which revealed increasing in chlorophyll content and hill reaction activity in the leaf.

A field experiment was conducted by Patel *et al.* (2009) at Main Pulse research station, sardar Krishi nagar, to know the effect of foliar application of ZnSO4 and FeSO4 on productivity of cowpea, they revealed that foliar application of ZnSO4 at 0.5% during 25 and 45 days after sowing recorded the increment in seed yield by 21% compared to unsprayed check.

Rajavel and Vincent (2009) investigate that foliar spray of 2% urea recorded the highest yield (955 kg/ha) followed by foliar spray of KCl 1% along with soil application of humic acid @20 kg/ha (926 kg/ha). Application of PGR and nutrients increased the growth characters viz., Crop Growth Rate (CGR), Net Assimilation Rate (NAR), Leaf Area Development (LAD) at all growth stages. The yield enhancement may be due to improved morphological, physiological and biochemical parameters. The tested chemicals particularly 2% urea was found effective towards yield maximization in black gram.

Azarpour *et al.*(2011) reported that the effect of foliar spray on cowpea plants with humic acid at the concentration of 50 mg/litre in presence of the N fertilizer (45 kg/ha) produced the highest values of seed yield , number of pods per plant, number of seeds per pod, pod length, seed length and seed width.

Choudhary and Yadav (2011) studied the effect of fertility levels and foliar nutrition on cowpea productivity and revealed that highest number of nodules, observed with the application of 2 per cent urea spray.

Ebrahim *et al.* (2011) conducted the experiment to study the effects of urea under foliar spraying on yield and yield components of cowpea and they reported that foliar spray of urea at 50 g/l recorded significantly higher seed yield (1486 kg/ha), plant height (72.75 cm), number of pods per plant (37.12) and number of seeds per pod (15.05) as compared to other treatments.

Khalilzadeh *et al*. (2012) results showed that all traits were significantly affected by treatments except the number of secondary roots. Foliar application of urea and organic manure substantially improved the plant height, leaf area, shoot and root dry weight, root and shoot length, volume and number of roots in green gram.

Mondal and Mondal (2012) showed that foliar application of urea three times at 10 days interval from the beginning of flowering increased the yield in soybean.

Mostafavi (2012) reported positive effect of micronutrients foliar application on grain yield, number of pod/plant and 1000 grain weight.

Afshari *et al*. (2013) found that the effects of salicylic acid on protection of cowpea under water stress conditions. Salicylic acid was sprayed when plants had approximately ten fully expanded leaves. Plants treated with salicylic acid showed the highest values for net photosynthesis rate, transpiration rate, proline concentration and highest leaf area and also improve the plant functions in both normal and stress conditions.

Ali and Mahmoud (2013) conducted an experiment the results showed that foliar application of salicylic acid 500ppm enhanced significantly plant height, number of branches per plant, number of pods per plant, number of seeds per pod, 1000 seed weight, seed weight per plant and seed yield per hectare as compared with control in mung bean.

Hemn Othman Salih (2013) conducted an experiment under green house condition to investigate Fe, Band Zn foliar application effects on nutrient concentration and seed protein of cowpea. His study revealed that the effect of different treatments at 1% level on nutrient concentration and seed protein were significant.

Mahla *et al.* (2013) reported that N application had significant improvement in number, weight and length of pod in cluster bean. Among the tested treatments, highest seed yield was recorded with application of 20 kg N/ha combined with foliar application of urea @ 1% at vegetative and flowering stages, which was significantly superior over all treatments except basal application of nitrogen 20 kg/ha along with 1% urea foliar spray at flowering stage treatment.

Vinothkumar *et al.*(2013) reported that foliar spray of 2% DAP twice at flower initiation and pod formation stages of crop growth resulted in significantly higher number of pods per plant (62.50), no. of seeds per pod, seed index and higher grain yield (1460 kg/ha). It was on par with 2% urea phosphate and TNAU pulse wonder spray. The foliar spray of 2% DAP on soybean also recorded significantly higher net return of Rs 20,090 with B:C ratio of 2.22.

Deshmukh *et al.*(2014) conducted a field experiment on cluster bean observed that growth, yield and quality parameters like number of clusters per plant, number of pods plant, pod yield per plant (g), pod yield per plot (kg) and pod yield per hectares (q ha^{-1}), pod length and pod width were significantly increased with the application of Azotobactor + Rhizobium + PSB + VAM.

Gupta and Saxena (2014) study the effect of resource management in cowpea for yield maximization under rainfed conditions. Results of three years pooled data revealed that foliar application of urea either @ 1% or @ 2% and mulching @ 3 t/ha at 25-30 DAS of crop significantly increased yield attributes (pods/plant, seeds/pod and seed index) and seed yield of cowpea. Foliar application of 2% urea recorded maximum values of yield attributes, seed yield, net returns and B:C ratio. The significant increase in pods/plant, seeds/pod and seed index due to foliar application of 2% urea were 7.64 and 16.34, 4.38 and 9.30 and 5.23 and 6.23 per cent respectively over normal planting and control. Further, the maximum value of pooled grain yield (9.26 q/ha), net returns (₹21892/ha) and B:C ratio (1.77) were recorded under

foliar application of 2% urea while the least were observed under control (5.47 q/ha, ₹9299/ha and 0.85).

Gowthami *et al. (*2014) studied the effect of foliar application of potassium, boron and zinc on growth and seed yield of soybean. They reported that foliar application of potassium nitrate @2 per cent+boric acid @50ppm+zincsulphate @1 per cent (T_7) at 30 and 60 DAS was found to be superior at, test weight by potassium nitrate @2 per cent boric acid @50ppm at 30 and 60 DAS (T_4), boric acid@50ppm at@ 50ppm+zinc sulphate @1 per cent at 30 and 60 DAS (T_6) and potassium nitrate @ 2 per cent+zinc sulphate @1per cent at 30 and 60 DAS.

Kumar and Kaushik (2014) while working on cluster bean at Udaipur found that application of 500ppm thiourea (seed soaking + foliar spray) significantly increased the growth parameters *viz*., dry matter accumulation, crop growth rate and relative growth rate over control.

Malesha *et al*. (2014) found that five concentrations of water soluble fertilizer NPK (19:19:19) *i.e.*no foliar spray (control), 0.25%, 0.5%, 0.75% and 1.0% applied at three critical crop growth stages (peak flowering, pod development and at pod filling stage). The result reveals that grain yield (1661 kg/ha) was significantly higher with foliar application of 1.0% NPK (19:19:19) followed by 0.75% and 0.50% (1518 and 1454 kg/ha respectively). But there was no significant difference observed due to the stages of spray application. The higher yield with 1.0% WSF was due to higher number of pods per plant (121.8), pod weight per plant (105.5 g), grain yield per plant (19.9 g), plant height, higher number of branches, leaf area and higher total dry matter production at harvest in pigeon pea.

Marimuthu and Surendran (2015) revealed that application of 100% recommended dose of NPK + DAP 2% + TNAU pulse wonder 5.0 kg/ha was recorded significantly higher plant height (37.62 cm), number of pods/plant (37.15), yield of black gram (1162 kg/ha), and benefit cost ratio (2.98) over other treatments. The lowest black gram yield (730 kg/ha) was recorded in control.

Senthikumar (2015) conducted a field experiment to investigate the effect of foliar spray of nutrients and plant growth regulator on morphological traits, biochemical parameter and yield of black gram. Foliar spray of 2% DAP, 100ppm salicylic acid +2% DAP, 0.2% Boric acid +2% urea and control were imposed at 25 DAS and 15 days after first spray. Among the treatments foliar spray of 2% urea had the performed effect in improving the growth attributes, chlorophyll content, soluble protein and nitrate reduces activity.

Singhal *et al*. (2015) conducted a field experiment to find out the effect of foliar application of water soluble fertilizers on growth, yield and economics of vegetable cowpea. The application of banana pseudostem enriched sap @ 1% resulted in achieving significantly highest plant height (56.33 cm), number of pods per plant (13.33), yield per plant (104.67g), dry seed yield (1453 kg/ha), dry plant yield (1658 kg/ha) as well as commercial pods yield (9.71 t/ha) of cowpea and was found at par with mixed fertilizer NPK (19:19:19) @ 0.5% in all cases. From the economics point of view, for securing maximum return, an application of mixed fertilizer NPK (19:19:19) @ 0.5% was found superior with the highest BCR of 3.4:1.

Mona and Azab (2016) reported that the effects of foliar application of NPK compound with Fe, Zn and Mn at different doses on cowpea plants. In addition, soluble fertilizers NPK (19:19:19) and 500ppm Fe, 300ppm Zn and 300ppm Mn were applied. Four treatments of fertilization were tested: control (no fertilization), (50%), (100%), and (125%). The NPK fertilizers were sprayed every 15 days. The results revealed that foliar fertilization of NPK with Fe, Zn and Mn reflected increases in vegetative growth, yield and its components and nutrient concentration of cowpea plant compared with control.

Prajapati and Modi (2016) conducted an experiment under hydroponics condition using micronutrient containing nutrient solution to evaluate the effect of potassium solubilizing bacteria KSB-8 (*Enterobacto rhormaechei*), the results indicated that a remarkable increase in root length, flowering, fruit setting, fruit maturing, K content and chlorophyll content. Thus, it might be concluded that KSB-8 (*Enterobactor hormaechei*) could be used as crop-enhancer and bio-fertilizer for cucumber (*Cucumis sativas*) and other K rich crops under hydroponic condition.

Dey *et al.* (2017) conducted a field experiment to find out the influence of Urea, KCl, Zn placement and spray on growth of Cowpea crop. Application of various levels of KCl, Zinc and Urea which significantly increased dry matter production/plant, plant height, number of branches/plant, number of trifoliate/plant, total nodule/plant. Foliar nutrient sprays *viz*., 2% urea, 2% KCL, 1.5% ZnSO4. Foliar spray treatment with the aqueous solution of nutrients was done to the 15 and 30 DAS of Cowpea crop. Significant increase was recorded in plant height, dry matter production. Maximum growth was recorded when sprayed with 2% urea spray followed by 2% KCl at flowering and 15 days later is the viable nutrient management package to the Cowpea for getting higher income through higher productivity.

Banasode and Math (2018) study the effect of foliar feeding of water soluble fertilizers on growth and economics of soybean in a Vertisol. Among different treatments, two foliar sprays of 1.0 per cent NPK (19:19:19) produced significantly higher growth parameters like number of branches per plant (5.20), total dry matter production (60.35 g/plant at 55, 75 DAS and harvest), higher B: C ratio. This was closely followed by treatment which received urea (1%) and KNO3 (2%) and one spray of 19:19:19 (1%) at 60 DAS. Lower values were recorded in control.

Chapter - III

MATERIAL AND METHODS

The present research, **"Effect of Soil and Foliar Application of Nutrients on Cowpea [*Vigna unguiculata* (L.) Walp]"** was carried out during the *kharif* season of 2018 under the edaphic and climatic conditions of Gwalior (M.P.). The materials used and the methods employed during the course of investigation are given in detail in this chapter:

3.1 Experimental site

The experiment was conducted on the Research Farm, College of Agriculture; Gwalior (M.P.).The topography of the field was uniform with proper drainage.

3.2 Climate and weather condition

Gwalior is located at $26^0$13' North latitude and $78^0$14' East longitude and 208 metre above sea level. It lies in northern tract of Madhya Pradesh, enjoying sub-tropical climate. The summer is hot and dry, May and June are the hottest months and their temperature varies from 38.5^0C to 47^0C, respectively. December and January constitutes the cooler months of the year, temperature ranges from 2.5^0C to 4^0C. Maximum temperature goes up to 47^0C during summer and minimum goes as low as to 2^0C during winter.

The average rainfall ranges between 750 to 800 mm. Most of which is received in the months of July, August and September, with few showers in winter months. The weather condition was normal during crop season with an average maximum and minimum temperature during growing period remained as 38.8^0C and 14.4^0C, respectively. The total rainfall received during the crop period from July to October 2018 was 669 mm. The relevant meteorological data are presented in Table 3.1 and depicted in Fig 3.1 to 3.3.

3.3 Soil

The soil of experimental field was sandy clay loam. Few soil samples of the surface soil up to 15 cm depth were taken randomly before sowing and a composite sample was made after mixing the entire samples and was analyzed in the laboratory for mechanical and chemical composition. Data obtained are presented in Table 3.2 and 3.3.

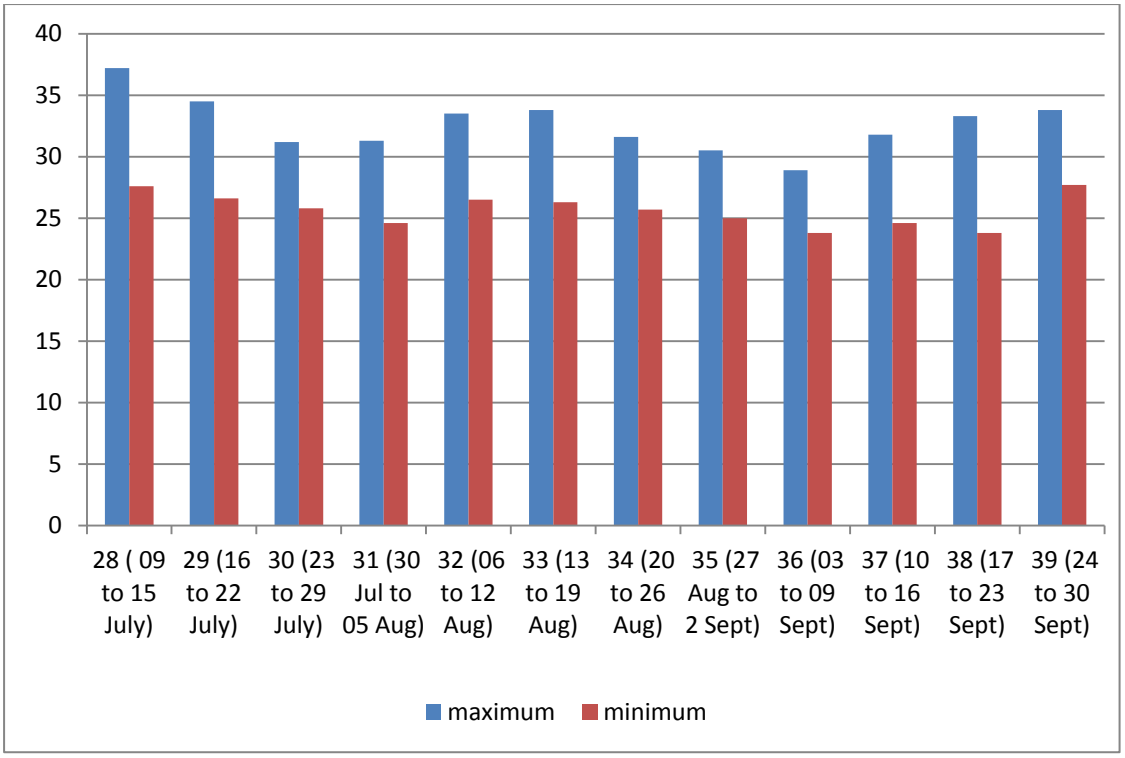


Figure 3.1: Temperature data during the crop season (July 2018 to September 2018)

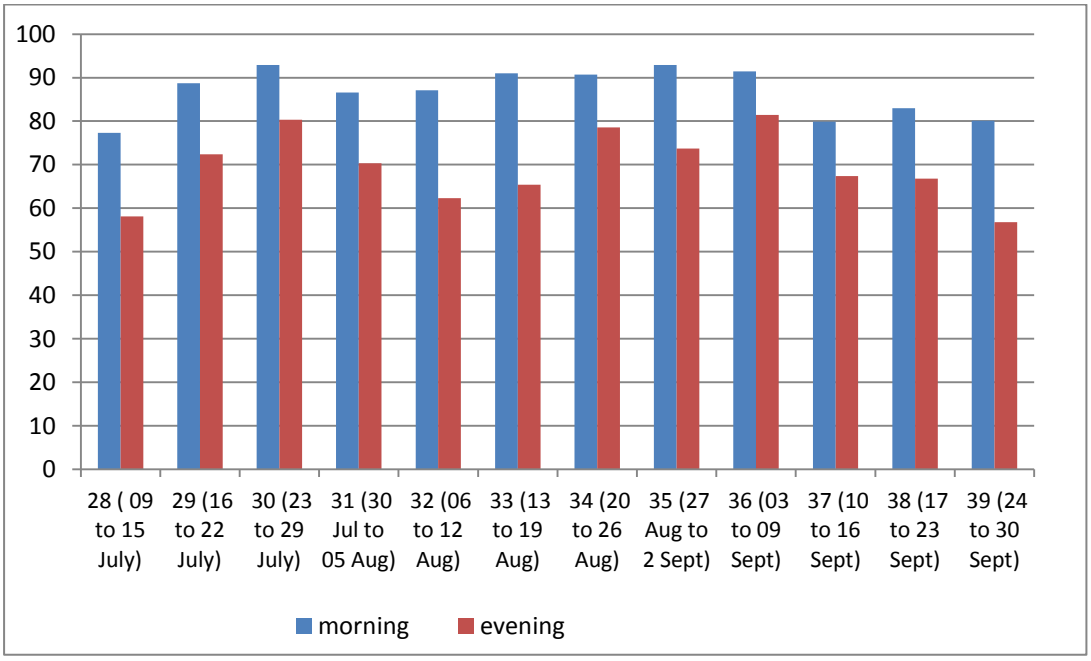


Figure 3.2: Humidity data during the crop season (July 2018 to September 2018)

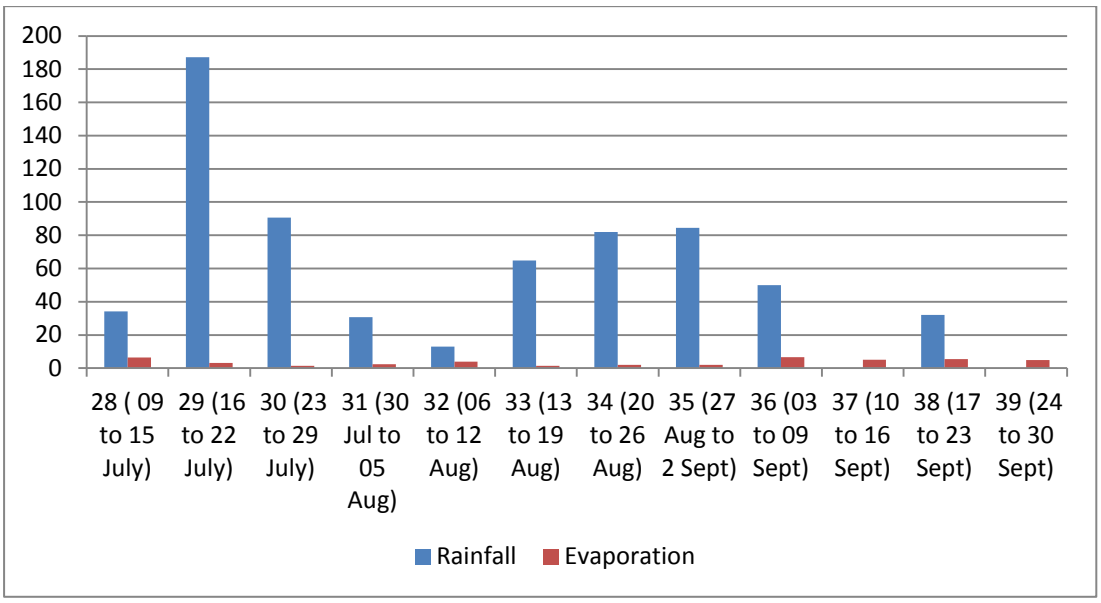


Figure 3.3: Rainfall and Evaporation data during the crop season (July 2018 to September 2018)

Table 3.1: Meteorological data during the crop season (July 2018 to September 2018)

Met. Week	Dates	Temperature (°C)		Humidity (%)		Rainfall (mm)	Evaporation (mm)
		Max.	Min.	Morning	Evening		
28	09 to 15 Jul.	37.2	27.6	77.3	58.1	34.2	6.4
29	16 to 22 Jul.	34.5	26.6	88.7	72.4	187.2	3.2
30	23 to 29 Jul.	31.2	25.8	92.9	80.3	90.6	1.4
31	30 Jul to 05 Aug.	31.3	24.6	86.6	70.3	30.8	2.4
32	06 to 12 Aug.	33.5	26.5	87.1	62.3	13.0	4.0
33	13 to 19 Aug.	33.8	26.3	91.0	65.4	64.8	1.5
34	20 to 26 Aug.	31.6	25.7	90.7	78.6	82.0	2.1
35	27 Aug. to 2 Sept.	30.5	25.0	92.9	73.7	84.4	2.0
36	03 to 09 Sept.	28.9	23.8	91.4	81.4	50.0	6.6
37	10 to 16 Sept.	31.8	24.6	79.9	67.4	0	5.0
38	17 to 23 Sept.	33.3	23.8	83.0	66.8	32.0	5.4
39	24 to 30 Sept.	33.8	27.7	80.1	56.8	0	4.9

Source: Meteorological observatory, College of Agriculture, Gwalior (M.P.)

3.3.1 Mechanical composition of the soil

A perusal of the data presented in Table 3.2 shows that the percentage of sand was more in comparison to other fractions. Thus, the soil is categorized as sandy clay loam with low aggregation.

Table 3.2: Mechanical composition of the soil

Component	Percentage by weight	Method employed
Sand	58.60	By International Pipette Method (Piper, 1950)
Silt	20.40	
Clay	21.00	
Textural class	Sandy Clay Loam	

3.3.2 Chemical composition of the soil

The chemical composition of the soil collected from 0-15 cm depth before sowing of cowpea is presented in Table 3.3.

The data pertaining to various chemical components, presented in Table 3.3, clearly showed that soil of the experimental field was rich in potash content, but low in organic carbon, available nitrogen and medium in

General Field View

available phosphorus content. It is slightly alkaline in reaction and had moderate cation exchange capacity.

Table 3.3: Chemical composition of the soil

S. No.	Soil component	Content	Method used
1	Cation Exchange Capacity	16.21	Ammonium Acetate Method
2	Ph	7.70	Blackman's Glass Electrode pH meter (Muhur *et al.,* 1965)
3	Electrical Conductivity (ds/m) at 25^{o}C	0.40	Solubridge Method (Richard, 1954)
4	Organic Carbon (%)	0.45	Walkley and Black's Rapid Titration Method (Piper, 1950).
5	Available Nitrogen (kg/ha)	210.3	Alkaline Permanganate Method (Subbiah and Asiza, 1956)
6	Available Phosphorus (kg/ha)	13.50	Olsen's Method (Olsen *et al.,* 1954)
7	Available potassium (kg/ha)	251.6	Flame Photometer (Muhur *et al.,* 1965)

3.4 Cropping history of the experimental field

The crops grown in the experimental field during the past three years are presented in Table 3.4.

Table 3.4: History of the experimental field

Year	*Kharif* season	*Rabi* season
2015-16	Cluster bean	Wheat
2016-17	Cluster bean	Wheat
2017-18	Cluster bean	Wheat
2018-19	Cowpea (Present experiment)	Mustard

3.5 Experimental details

The experiment was laid out in the randomized block design with 10 treatments and each treatment was replicated three times. The details of layout plan and treatments are given as below:

Technical programme of work:

Location : College of Agriculture, Gwalior (M.P.)

1. Design : Randomized Block Design
2. Number of replications : 03
3. Number of treatments : 10
4. Total No. of Plots : 30
5. Plot Size
   (a) Gross : 5.0m x 3.15m
   (b) Net : 4.0m x 2.25m
6. Distance between plots : 1.0m
7. Distance between replications : 1.5m
8. Distance between rows : 45cm
9. Distance between plants : 10cm
10. Variety : PGCP-24
11. Seed rate : 25 kg/ha

Treatments:

T_1 : Control (water spray)

T_2 : PSB soil applied+ NAA 20 ppm spray at flower initiation stage

T_3 : DAP 0.5% spray at flower initiation and 10 days after 1st spray

T_4 : MOP 0.5 % spray at flower initiation and 10 days after 1st spray

T_5 : NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray

T_6 : Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray

T_7 : KMB soil applied + NAA 20 ppm spray at flower initiation stage

T_8 : Thiourea @ 500 ppm spray at vegetative and flowering stage

T_9 : PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage

T_{10} : Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray

3.6: Details of variety

Variety	**PGCP−24**
Year of Identification	2019
Average Yield	1132 kg/ha
Maturity	Early Maturity (70-75 days)

Characteristics	For Summer/Spring in north zone, For rice fallows in south zone, Resistance to cowpea mosaic virus, Tolerance to thrips and pod borers, Seed colour is black and white.
Plant Type	Bushy type, broad and dark green leafs.

3.7 Details of foliar nutrients

(1) PSB:

Phosphate solubilizing bacteria (PSB) are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds. P-solubilization ability of rhizosphere microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition. It is generally accepted that the mechanism of mineral phosphate solubilization by PSB strains is associated with the release of low molecular weight organic acids, through which their hydroxyl and carboxyl groups chelate the cations bound to phosphate, thereby converting it into soluble forms. PSB have been introduced to the Agricultural community as phosphate Biofertilizer. Phosphorus (P) is one of the major essential macronutrients for plants and is applied to soil in the form of phosphate fertilizers. However, a large portion of soluble inorganic phosphate which is applied to the soil as chemical fertilizer is immobilized rapidly and becomes unavailable to plants. Currently, the main purpose in managing soil phosphorus is to optimize crop production and minimize P loss from soils. PSB have attracted the attention of agriculturists as soil inoculums to improve the plant growth and yield. When PSB is used with rock phosphate, it can save about 50% of the crop requirement of phosphatic fertilizer. The use of PSB as inoculants increases P uptake by plants. Simple inoculation of seeds with PSB gives crop yield responses equivalent to 30 kg P2O5/ha or 50 percent of the need for phosphatic fertilizers. Alternatively, PSB can be applied through fertigation or in hydroponic operations. Many different strains of these bacteria have been identified as PSB, including *Pantoea agglomerans* (P5), *Microbacterium laevaniformans* (P7) and *Pseudomonas putida* (P13) strains are highly efficient insoluble phosphate solubilizers. Recently, researchers at

Colorado State University demonstrated that a consortia of four bacteria (sold commercially as Mammoth P), synergistically solubilize phosphorus at a much faster rate than any single strain alone**.**

(2) NAA:

Naphthalene Acetic Acid(NAA) is a synthetic plant hormone in the auxin family and is an ingredient in many commercial plant rooting horticultural products; it is a rooting agent and used for the vegetative propagation of plants from stem and leaf cuttings. It is also used for plant tissue culture.The hormone NAA does not occur naturally, and, like all auxins, is toxic to plants at high concentrations.

(3) DAP:

Diammonium phosphate (DAP) (chemical formula $(NH_4)_2HPO_4$, IUPAC name diammonium hydrogen phosphate) is one of a series of water-soluble ammonium phosphate salts that can be produced when ammonia reacts with phosphoric acid. DAP is used as a fertilizer.When applied as plant food, it temporarily increases the soilpH, but over a long term the treated ground becomes more acidic than before upon nitrification of the ammonium. It is incompatible with alkaline chemicals because its ammonium ion is more likely to convert to ammonia in a high-pH environment. The average pH in solution is 7.5-8.The typical formulation is 18-46-0 (18% N, 46% P_2O_5, 0% K_2O).

(4) MOP:

Muriate of potash (MOP), also known as potassium chloride contains 60% potash. Potash is essential for plant growth and quality. It plays a vital role in the production of proteins and sugars. It also protects against draught by maintaining plants water content which in turn is a benefit for photosynthesis as leafs maintain their shape/vigor. We source product globally from the highest standard producers, below you will find typical analysis.

(5) NPK (18:18:18):

18:18:18 mix is a balanced liquid NPK fertilizer, suitable for all crops, during all stages of plant growth. 18:18:18 mix liquid fertilizer provides an additional source of nitrogen, phosphorous and potassium during the growing season. 18:18:18 mix liquid fertilizer is in the form readily absorbed by plant tissue. 18:18:18 mix is manufactured by utilizing quality raw materials to provide

a very agronomically efficient source of N: P: K. The quality of the raw materials used to formulate 18-18-18 mix maximized plant nutrient solubility.

Composition

Analysis % (W/W) (W/V)

Nitrogen total (N) 13.1% 18%

Phosphorus (P_2O_5) 13.1% 18%

Potassium (K_2O) 13.1% 18%

(6) Zinc Sulphate:

Zinc sulphate is an inorganic compound and dietary supplement. As a supplement it is used to treat zinc deficiency and to prevent the condition in those at high risk. Zinc Sulphate which contains 36 per cent zinc is the most commonly used zinc fertilizer. Zinc sulphate is applied both to soil (at 30 to 50 kgs per hectare) and plant (0.5 per cent as spray). Zinc oxide containing 78 per cent zinc, is used for seed treatment. Organic compounds have also been used successfully to correct deficiency of zinc. These include several zinc chelates like EDTA type or zinc poly flavanoid or lignin-sulfonate types.

(7) KMB:

KMB contains Potash Mobilizing Bacteria which regulates the formation of amino acids and proteins in the roots. KMB plays a vital role in uptake of Potassium and other elements particularly Nitrogen Phosphorus and Calcium. KMB increases the resistance of the crops to hot and dry conditions and insect pests and diseases. It increases the stiffness of the straw in cereals and therefore the loading of cereal is reduced. It improves the quality of fruits and grains.

(8) Thiourea:

Thiourea is an organosulfur compound with the formula $SC(NH_2)_2$. It is structurally similar to urea, except that the oxygen atom is replaced by a sulfur atom, but the properties of urea and thiourea differ significantly.

(9) Neem coated urea:

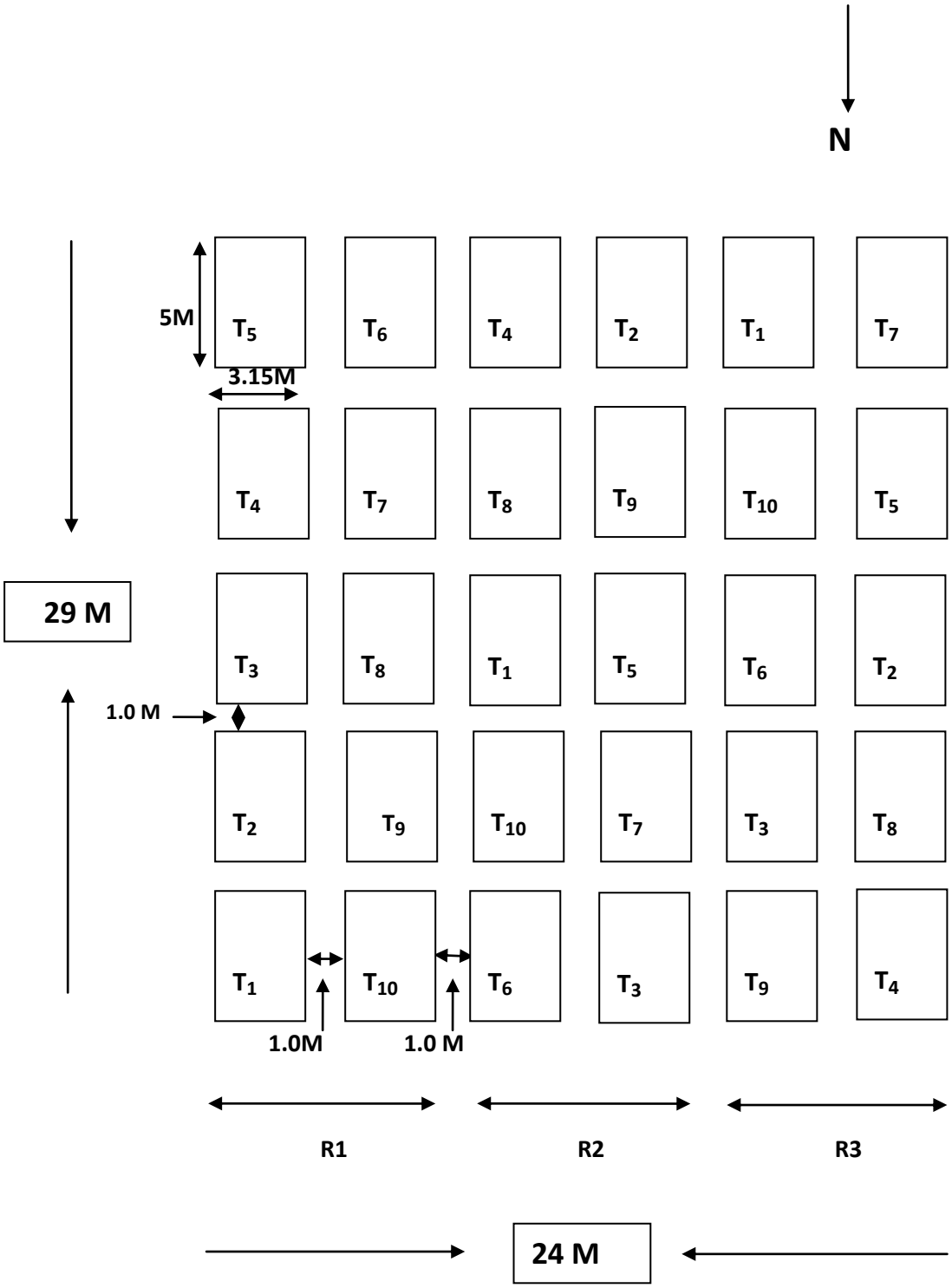
Urea coated with neem oil is neem coated urea. Only about 30 to 40% of N_2 in the urea is utilized by the plants. Coating of neem oil helps in gradual release of nitrates into soil. This may work as a bio pesticide.

(10) Salicylic acid :

Salicylic acids activate genes in some plants that produce chemicals that aid in the defense against pathogenic invaders. Salicylic acid contains GA and IAA which promotes cell replication. Trade name of salicylic acid is aspirin. Salicylic acid (from Latin *salix*, willow tree, from the bark of which the substance used to be obtained) is a monohydroxy benzoic acid, a type of phenolic acid and a beta hydroxy acid. This colorless crystalline organic acidis widely used in organic synthesis and functions as a plant hormone. It is derived from the metabolism of salicin.

Figure 3.4 Plan of layout

Layout plan



3.8 Details of field operations

The schedule of field preparation, crop management and post harvest operation are briefly presented in table 3.5.

Table 3.5: Schedules of field preparation

S.No.	Operations	Date	Remark
1	Land preparation		
	Ploughing	14/07/18	By tractor
	Harrowing and planking	14/07/18	By tractor
	Layout	15/07/18	Manual
	Sowing	15/07/18	Manual
2	Inter-culture operations		
	Gap filling	22/07/18	Manual
	First weeding with *khurpi*	30/07/18	Manual
	Thinning	30/07/18	Manual
	Second weeding with wheel hoe	16/08/18	Manual
3	Foliar spray of nutrients		
	a) Foliar application of thiourea (T_8) only T_8 treated plots at vegetative stage	07/08/18	Manual
	b) Foliar application of nutrients (In all treated plots except control plot) first time.	18/08/18	Manual
	c) Foliar application of nutrients (In all treated plots except control plot) second time.	28/08/18	Manual
4	Plant protection		
	a) Weedicide spray Valor 32 (30% Pendimethalin+2% Imazethapyr) as pre-emergence	15/07/18	Manual
	b) Insecticide spray Rogor (Dimethoate 30 EC) Spray	04/09/18	Manual
5	Harvesting		Manual
	First picking	25/09/18	
	Second picking	30/09/18	Manual
6	Threshing	10/10/18	Manual

Land preparation for Sowing of Cowpea

Picking of Cowpea

3.8.1 Preparation of field

The field was prepared by ploughing with cultivator and cross ploughing by disc harrow. Planking was done with each ploughing for well levelling and to make soil friable to insure proper germination.

3.8.2 Fertilizer application

An uniform dose of 20:40:20 NPK kg/ha were applied as basal through urea, SSP and MOP, respectively, in all the experimental plots. The required quantity of fertilizers for each plot was computed, weighed and placed in the furrows opened by *kudali* at the time of sowing at a depth of 4-5 cm below the seeds.

3.8.3 Seed treatment

The seeds were treated with fungicide carbendazim @2.5g/kg seed.

3.8.4 Time and method of sowing:

The lines were marked at desired distance and shallow furrow were opened with the help of *kudali* at 45 cm row distance for sowing of Cowpea. The seeds were drilled manually in the furrows using the recommended seed rate @ 25 kg/ha. The sowing was done on 15th July 2018.

3.8.5 After care

Within one week of sowing gap filling and within two weeks of sowing thinning were done at required places and plant to plant distance was maintained *i.e*. 10 cm for maintaining the required plant population per hectare. The intercultural operations and weeding was done once at 15 days after sowing to keep the crop free from weeds in all treatments, after that, weeding was done using wheel hoe. Timely plant protection measures were adopted whenever necessary.

3.8.6 Foliar application of treatments

The required quantity of foliar nutrients and water for each plot were calculated to prepare solution and sprayed uniformly by hand sprayer using conical shaped nozzle. Foliar application of nutrients was done at 23, 33 and 43 days after sowing.

Table 3.6: Doses and application of treatments

Sr. No	Treatments	Concentration	Application time
1	Control (water spray).	--	--
2	PSB soil applied+ NAA 20 ppm spray at flower initiation stage	0.31ml/l + 20 mg/l of water	33 & 43 DAS
3	DAP 0.5% spray at flower initiation and 10 days after 1st spray	5 g/l of water	33 & 43 DAS
4	MOP 0.5 % spray at flower initiation and 10 days after 1st spray	5 mg/l of water	33 & 43 DAS
5	NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray	10 g/l of water	33 & 43 DAS
6	Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray	2.5 g/l of water	33 & 43 DAS
7	KMB soil applied + NAA 20 ppm spray at flower initiation stage	0.31ml/l + 20 mg/l of water	33 & 43 DAS
8	Thiourea @ 500 ppm spray at vegetative and flowering stage	0.5 g/l of water	23& 43 DAS
9	PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage	0.31ml/l + 0.31ml/l + 20 mg/l of water	33 & 43 DAS
10	Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray	10 g/l of water + 75 mg/l of water	33 & 43 DAS

3.8.7 Harvesting and Threshing

The pods of cowpea crop were picked from the plant when the pods were fully ripened and turned wheatish-yellow. The first picking of pods was done on 25thseptember and second picking on 30thseptember. At the time of picking of pod, the plant of one border row from each side and 50 cm on remaining two sides of the plot were removed and the pods from the net plot was harvested, collected separately in bag and tagged. After pods picking remaining biomass was left in the respected plots for 10 days to allow in sun-drying and weighing to record biological yield. Pods were threshed by beating with sticks with the help of manual labour and finally seeds were winnowed by

using *supas*. Threshed seeds were sun-dried for 2-3 days to reduce the moisture content and then the seed yield per plot was recorded.

The five tagged plants, for recording the post-harvest observations, were harvested separately from the net experimental plots on 2nd September by manual labour. The net experimental plot was harvested by sickles and the harvested material of each plot was tied in bundles. Bundles were kept as such for drying for 3 – 4 days, and then weighed to record biological yield per plot.

3.9 Experimental observations

Various observations were recorded during the growth period of the crop and data were recorded at various stages.

3.9.1 Pre harvest studies

1) Plant population/metrerow length

With an object to see the effect of different treatments on germination this observation was taken after 20 DAS when the germination was completed and at harvest. Plant population was recorded on per metre row length at three places randomly in each plot.

2) Plant height

Plant height was measured in order to estimate the effect and extent of the plant growth due to various treatments. Height of five randomly selected plants in each plot was measured at 20 DAS and then 20 days interval up to maturity. Height was measured in cm from the soil surface to the main stem (apical).

3) Number of branches per plant

The number of branches per plant were counted from randomly selected five plants in each plot at 20 DAS and subsequently at an interval of 20 days up to maturity.

4) Number of leaves per plant

The number of leaves per plant were counted from randomly selected five plants in each plot at 20 DAS and subsequently at an interval of 20 days up to maturity.

5) Dry matter accumulation per plant (g)

Dry weight per plant was recorded from randomly selected five plants in each plot at 20 DAS and subsequently at an interval of 20 days up to maturity with the help of electronic balance.

3.9.2 Physiological parameters

1) Crop growth rate (CGR)

The average daily increment in plant growth is an important characteristic. It is the rate of dry matter production per unit ground area per unit time (Watson, 1952). It was calculated by using the formula and expressed as g/m^2/day.

Crop Growth Rate (CGR) = $\frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{A}$

Where,

W_1 = Dry weight of plant (g) at time t_1

W_2 = Dry weight of plant (g) at time t_2

$t_2 - t_1$= Time interval in days

A = Unit land area occupied by the plant (1m^2)

2) Relative growth rate (RGR)

It is an index of the amount of growing material per unit dry weight of the plant per unit time. It expresses the dry weight increase in time interval in relation to the initial weight and is expressed in mg/g/day. It is also called efficiency index. It is proposed by Fisher (1921).

Relative growth rate at various stages was calculated as follows:-

Relative Growth Rate (RGR) = $\frac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)}$

Where,

Log_e = Natural log 2.3026

W_1 = Dry weight of plant (g) at time t_1

W_2 = Dry weight of plant (g) at time t_2

$t_2 - t_1$ = Time interval in days

3) Absolute Growth Rate (g/day):

Absolute growth rate (AGR) is the dry matter production per unit time (g/day), which was calculated by using the formula as given by Radford (1967).

$$\text{Absolute Growth Rate (g/day)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = Dry weight of the plant (g) at time t_1

W_2 = Dry weight of the plant (g) at time t_2

4) Leaf area index (LAI):

Leaf area index (LAI) is a dimensionless quantity that characterizes plant canopies. It is defined as the one-sided green leaf area per unit ground surface area (LAI = leaf area**/**ground area) in broadleaf canopies.It is unit less measure.

3.9.3 Post harvest studies

1) Number of pods/plant

The numberof pods per plant were counted from randomly selected five plants of each plot just before the harvesting.

2) Number of seeds/pod

The pods were picked up from randomly selected five plants of each plot, threshed carefully by hand and counted the average number of seeds per pod.

3) Pod length (cm)

Length of 10 randomly selected pods from five tagged plants of each plot was measured and then average was worked out.

4) Seed yield/plant (g)

After threshing, total yield of five tagged plant per plot was weighed and the resultant was divided by five and the seed yield per plant was obtained.

5) Stover yield per plant (g)

Weight of stover collected from five tagged plants was recorded and their average was worked out to have stover yield/plant in gram.

6) Seed index (g)

From representative sample of grain yield from each plot, 100 grains were counted and weighed by electronic balance. While counting, broken seeds were discarded but shriveled grains were taken in account.

7) Seed yield (kg/ha)

Yield of seed from net plot was threshed separately to obtain clean grains. The plot wise grain yield was recorded after drying the seed under sun to a standard moisture condition. The seed yield of crop per plot was then converted to yield per hectare (kg/ha) using conversion factor 555.555.

8) Stover yield (kg/ha)

Stover yield was obtained after subtracting the grain yield per plot from the gross weight of bundle (biological yield) and then converted in kg/ha using conversion factor 555.555.

9) Biological yields (kg/ha)

The total produce obtained from each plot was collected separately and weighed. Finally an average was calculated.

10) Harvest index (%)

It was calculated by using the following formula.

$$HI = \frac{\text{Economical yield (grain)}}{\text{Biological yield (grain+straw)}} \times 100$$

3.9.4) Qualitative parameters of cowpea seed

Procedure for estimating protein content

Protein was computed by multiplying the N content of seed with a conversion factor of 6.25. Nitrogen in plant sample (seed) was determined by KEL PLUS nitrogen estimation system (PELICAN Equipments).

Plant samples were collected and dried in oven at 70^0C. Dried samples were ground in an electric grinder. These samples were used for the analysis of nitrogen.

Pelicans KEL PLUS System are developed and designed to perform the Kjeldahl method for estimation of nitrogen which consists of the following three process: 1. Digestion, 2. Distillation, and 3. Titration

1. Digestion Process

In this process, 0.5g of plant sample was transferred to the digestion tube. 10 ml of concentrated sulphuric acid and 2g of digestion activator (Salt mixture) to the sample were added. Digestion tubes were loaded in to the digester and the digestion block was heated. At the end of digestion process, the sample turned colourless or light green colour.

2. Distillation process

During distillation, the ammonium radicals are converted to ammonia under excess alkali condition after neutralizing the acid in the digested sample with 40% alkali (NaOH) on heating. In DISTYL-EM, the digested samples are heated by passing steam and the ammonia librated due to the addition of 40% NaOH is dissolved in 4% boric acid. The boric acid consisting of ammonia is taken for titration.

3. Titration Process

The solution of boric acid and mixed indicator containing the “distilled off” ammonia was titrated with the standardized H_2SO_4. The titration value of a blank solution of boric acid and mixed indicator was determined.

$$\% \text{ Nitrogen} = \frac{(\text{Sample titer - Blank titer}) \times \text{Normality of } H_2SO_4 \times 14 \times 100}{\text{Sample weight (g)} \times 1000}$$

Protein was computed by multiplying the N content of seed with a conversion factor of 6.25.

Protein yield

Protein yield was computed by multiplying the protein content in seed with seed yield and divided by 100.

Protein yield (kg/ha) = protein content in seed (%) ×seed yield (kg/ha)/100

3.10 Soil analysis (before and after experiment)

Before and after experiment, soil samples *i.e*., one from each treatment were taken and analyzed for major nutrients *viz*., nitrogen, phosphorus and potash in the Soil Science Laboratories, RVSKVV, College of Agriculture, Gwalior (M.P.). The methods used in the determination of all these nutrients in the soil are given as below.

Lab Analysis of Soil Samples

3.10.1 Available nitrogen (N) in soil

Available-N was determined by 'Alkaline Permanganate' method (Subbiah and Asija, 1956). A 20 g soil was weighed and put into an one liter round bottomed flask and added 100 ml each of potassium permanganate (0.32%) and sodium hydroxide (2.5%) solutions. Distillation was carried out for half an hour, and the distillate was collected in 250 ml conical flask containing 20 ml of boric acid (2%). Mixed indicator (green + methyl red) was used. Distillate was titrated against N/50 H_2SO_4.

$$\text{Available - N (kg/ha)} = \frac{14\times \text{Normality of } H_2SO_4 \times \text{T.V.} \times 2.24\times10^6}{\text{Weight of sample} \times 1000}$$

3.10.2 Available Phosphorus (P) in soil

Available-P was determined by following the procedure of Olsen *et al.* (1954). Weighed 2.5 g soil into a 100 ml conical flask and added 0.5 g of Dacro G-60 and 50 ml of sodium bicarbonate (0.5N solution adjusted to pH 8.5). Shaking was done for half an hour on a mechanical shaker and filtered through Whatman No. 1 filter paper. Measured 5 ml of extract into a 25 volumetric flask, and 5 ml of chloromolybdic acid was added and stirred slowly. Reaction was allowed for 30 minutes and diluted upto 20 ml with distilled water. Added 1 ml of dilute stannous chloride and dilute to the mark of 25 ml and shaken immediately. Read the blue colour of Klett Summer son calorimeter using 660 mμ red filter. Standard curve was prepared.

Available – P (kg/ha) = Klett reading × slope of the curve × 22.4

3.10.3 Available Potassium (K) in Soil

Weighed 5 g soil in a 50 ml volumetric flask and added 25 ml of neutral normal ammonium acetate. Shaking for five minutes on mechanical shaker was done and filtered through Whatman No.1 filter paper. Estimated potassium on a flame Photometer by adjusting on the scale as 0 ppm K on 0 and 100 ppm K on 100.

Available – K (kg/ha) = Flame Photometer ppm K on 100.

3.11 Economics

The economics of various treatments was worked out taking into account the existing market rate of various production factors and produce during the course of investigation. The details with respect to economic analysis have been given in Table 4.14.

3.11.1 Cost of cultivation (₹/ha)

Cost of cultivation is an important factor for economic analysis. It can be calculated by considering prevailing market price of inputs, wages and actually cost involved on various aspects during the course of investigation.

3.11.2 Gross monetary returns (₹/ha)

Gross monetary returns are the total earnings from crop produce (grain + straw) in terms of ₹/ha. The gross monetary return was calculated by considering the prevailing price of the produce at time of harvesting.

3.11.3 Net monetary returns (₹/ha)

The net monetary returns (₹/ha) was calculated after deducting all the expenditure (₹/ha) from gross return. It was obtained by subtracting cost of cultivation from gross return. Net monetary returns represent the actual income of farmer.The net monetary returns (₹/ha) for different treatments were calculated with the following formula:

Net monetary returns (₹/ha) = Gross returns (₹/ha) – Cost of cultivation (₹/ha)

3.11.4 Benefit Cost Ratio (BCR)

It was calculated treatment wise. The gross income per hectare of each treatment was divided by the cost of cultivation of respective treatments.

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross Return}}{\text{Cost of Cultivation}}$$

3.12 Statistical analysis

The data obtained on various parameters were tabulated and subjected to statistical analysis by the method suggested by Snedecor and Cochran (1967). The influence of treatment was tested with ‘F’ test wherever ‘F’ test shown their significance. The levels of treatment were compared by critical difference at 5% level of probability. The skeleton of analysis of variance and formula used for various estimations are given below:

Table 3.7: The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	F cal	Ftab %	S.Em±	C.D. at 5%
Replication(r) Treatment (t) Error	(r-1)=2 (t-1)=9 (r-1)(t-1)=18						
Total	rt-1 =29						

The following formula was used for various estimations:

1. Standard error

$$SEm \pm = \sqrt{\frac{EMS}{r}}$$

2. C.D. = SEm ± x $\sqrt{2}$ x t18 (at 5% level of significance)

3. C.V. (%) = $\frac{\sqrt{EMS}}{\text{Grand mean}}$ x 100

Where,

r = Number of replications

t = Number of treatments

D.F. = Degree of freedom

SS = Sum of square

MSS = Mean sum of square

EMS = Error mean squares

SEm ± = Standard error of mean

C.D. = Critical difference

C.V. (%) = Coefficient of variance

Chapter - IV

RESULTS

The Soil and Foliar Application of Nutrients were assessed on the growth, productivity and yield attributing characters of cowpea [*Vigna unguiculata* (L.) Walp] in the present research; conducted at the Research Farm, College of Agriculture, Gwalior (M.P.) during *kharif* season 2018. The results obtained there are presented in the following pages under separate levels of study.

The data recorded were statistically analyzed and the summary tables have been given along with the text and analysis of variance tables have been appended in the last of the present manuscript of thesis. The responses of certain characters have also been illustrated with diagrams and curves for convenience of easy understanding.

4.1: Pre harvest studies

4.1.1 Plant population/metre row length

Table 4.1: Plant population as influenced by different treatments

Treatments	Plant population/m row length	
	Initial	Final
T_1: Control (water spray).	10.90	10.53
T_2 : PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	11.10	10.70
T_3 : DAP 0.5 % spray at flower initiation and 10 days after 1st spray.	10.97	10.60
T_4 :MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	11.00	10.50
T_5 : NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	11.60	11.00
T_6 : Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	11.47	10.93
T_7 : KMB soil applied + NAA 20 ppm spray at flower initiation stage.	11.40	10.80
T_8 :Thiourea @ 500 ppm spray at vegetative and flowering stage.	10.73	10.57
T_9:PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	11.07	10.87
T_{10}:Neem coated urea 1%+salicylic acid 75ppm spray at flower initiation and 10 days after 1st spray.	11.43	11.37
S.E.(m)±	**0.43**	**0.26**
C.D.(at 5%)	**NS**	**NS**

The plant population of cowpea was counted at initial and at harvest stages in various treatments as shown in Table 4.1.

The data recorded at each stage was statistically analyzed and the data showed that the effect of foliar application of nutrients on plant population was found non-significant at both the stages of crop growth. All the treatments showed more or less same the plant population in cowpea (Fig.4.1). However, the plant population ranged from 10.90 to 11.60 and 10.50 to 11.37 at initial and at final, respectively

4.1.2 Plant height (cm)

The height of plant is an important character of the vegetative phase and indirectly influences the yield parameters. Plant height as a measure of crop growth was recorded at successive stages of crop growth *i.e*. 20, 40, 60 DAS and at harvest. The analyzed data is presented in Table 4.2.

The rate of growth in height was higher in the beginning up to 60 DAS, thereafter, it was slowed down. The increase in the height was at the higher rate between 20, 40, 60 day harvest stage. The height of the plant was found maximum at harvest stage.The statistical analysis of data at all observation stages given in Table 4.2 revealed that the plant height was significantly affected by the different treatments at all the stages except 20 DAS (Fig. 4.2).

At 20 DAS effect of foliar application of nutrients on plant height was found non-significant. At 40 DAS the maximum height was recorded under treatment T_{10} (Neem coated urea 1% salicylic acid 75 ppm spray at flower initiation stage) (43.13 cm), which was statistically at par with treatment T_5 (NPK (18:18:18) 1 % spray at flower initiation and 10 days after) (40.87 cm). The minimum height was recorded in control treatment (T_1) (32.47 cm).

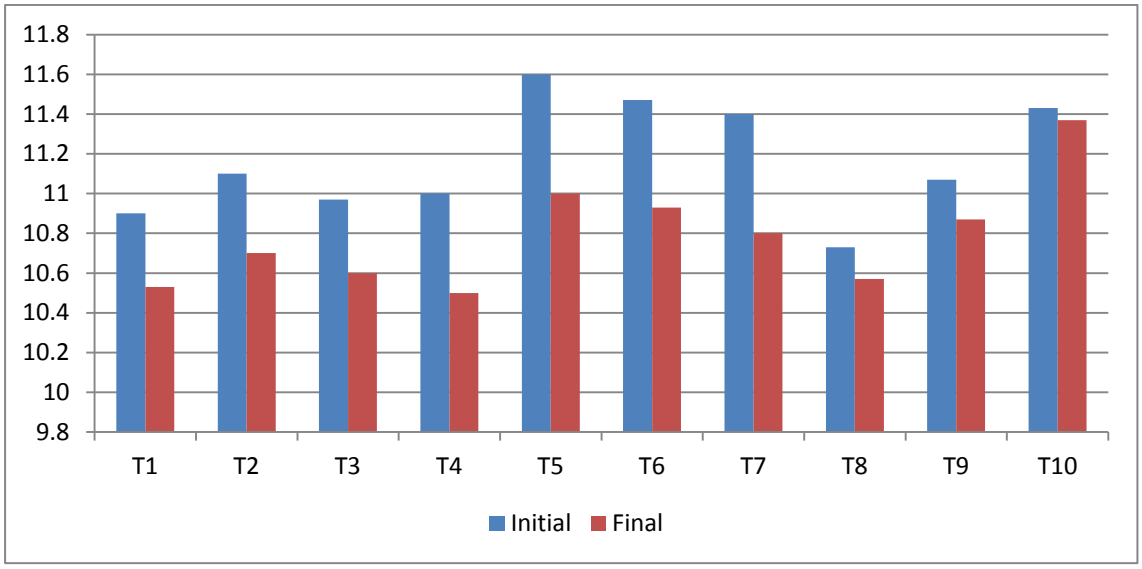


Figure 4.1: Plant population as influenced by different treatments

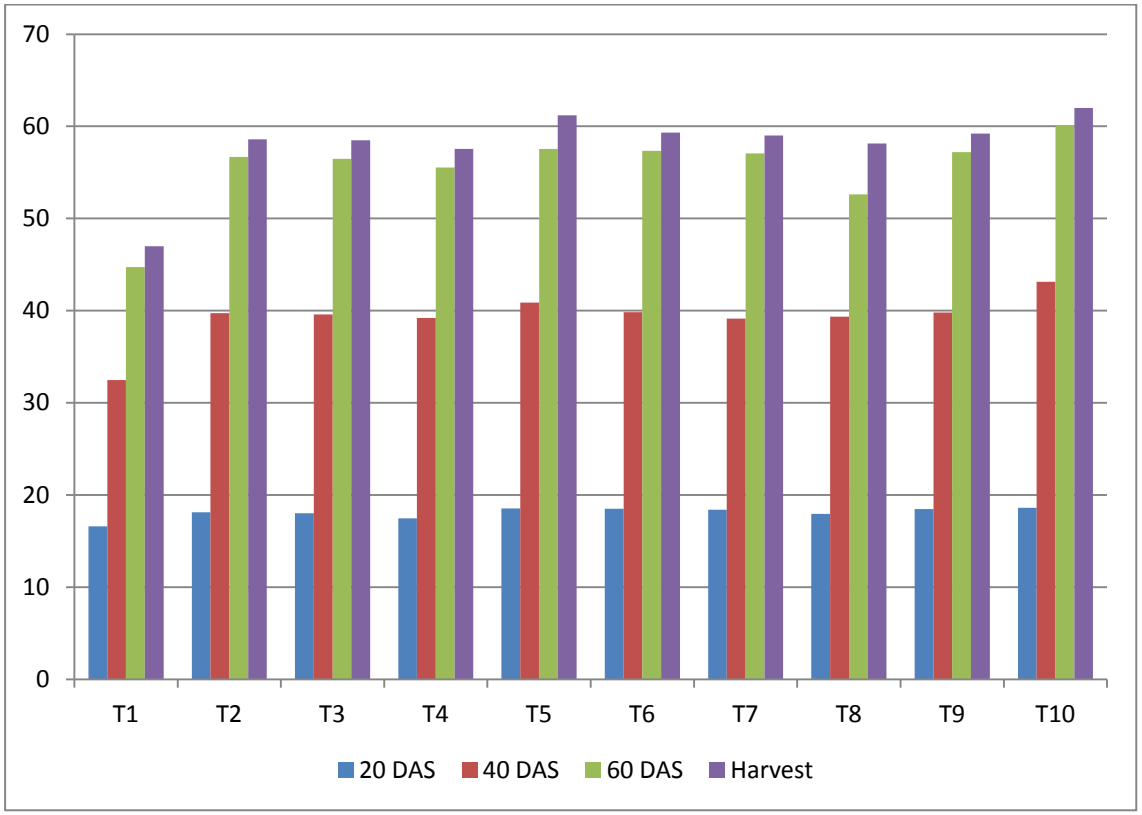


Figure 4.2: Plant height (cm) as influenced by different treatments

Table 4.2: Plant height (cm) as influenced by different treatments

Treatments	Plant height (cm)			
	20 DAS	**40 DAS**	**60 DAS**	**Harvest**
T_1: Control (water spray).	16.60	32.47	44.73	47.00
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	18.13	39.73	56.67	58.60
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	18.00	39.60	56.47	58.47
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	17.47	39.20	55.53	57.53
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	18.53	40.87	57.53	61.20
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	18.50	39.83	57.33	59.33
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	18.40	39.13	57.07	59.00
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	17.93	39.33	52.60	58.13
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	18.47	39.80	57.20	59.20
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	18.60	43.13	60.13	62.00
S.E.(m)±	**0.54**	**0.80**	**1.13**	**1.10**
C.D.(at 5%)	**NS**	**2.36**	**3.35**	**3.27**

The maximum height at 60 DAS was also recorded in T_{10} (Neem coated urea 1% salicylic acid 75 ppm spray at flower initiation stage) (60.13 cm), which was statistically at par with treatment T_5 (57.53 cm), T_6 (57.33 cm),T_9 (57.20cm) and T_7 (57.07 cm).The minimum height was recorded in control treatment (T_1) (44.73 cm).

At harvest stage the highest height was also recorded under treatment T_{10} (Neem coated urea 1% salicylic acid 75 ppm spray at flower initiation stage) (62.00 cm), which was statistically at par with treatment T_5 (61.20 cm), T_6 (59.33 cm), T_9 (59.20 cm), and T_7 (59.00 cm) and superior than rest of the treatments. The minimum height was recorded in control treatment (T_1) (47.00 cm).

4.1.3 Number of branches/plant

The data pertaining to number of branches /plant at successive growth stages of crop are exhibited in Table 4.3 and illustrated diagrammatically in Fig. 4.3. The formation of branches per plant was augmented steadily in all the treatments with the advancement of plant growth upto 60 days stage. The branches were increased by more than two-fold upto the 60 DAS, there after constant till harvest stage in all the soil and foliar application of nutrient treatments.

The number of branches per plant were counted in different treatments at 20, 40, 60 DAS and harvest stage were statistically analysed. The analysis of variance was worked out for all the crop growth stages and then presented in the Appendix section. The soil and foliar application of nutrients exerted significant impact upon this parameter at all the growth stages.The significantlyhigher number of branches (3.93, 9.33, 10.27 and 10.33 /plant at 20, 40, 60 DAS and harvest stage, respectively) were recorded under the application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}), followed by NPK (18:18:18) 1 % flower initiation and 10 days after 1st spray (T_5), Zinc sulphate 0.25 % spray flower initiation and 10 days after 1st spray (T_6), PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage (T_9) ,KMB soil applied + NAA 20 ppm spray at initiation stage (T_7) and all these treatments were statistically at par with each other at all the growth stages. Significantly lowest number of branches was recorded with control plot (T_1) at all stages.

Table 4.3: Number of branches/plant as influenced by different treatments

Treatments	Number of branches/plant			
	20 DAS	40 DAS	60 DAS	Harvest
T_1: Control (water spray).	2.13	5.67	6.53	6.63
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	2.20	8.40	9.27	8.60
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	2.44	8.33	9.20	9.27
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	2.47	7.93	9.07	8.93
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	3.00	8.93	10.13	10.23

T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	2.73	8.67	9.60	9.70
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	2.60	8.53	9.40	9.57
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	2.17	8.00	9.13	9.20
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	2.63	8.47	9.47	9.63
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	3.93	9.33	10.27	10.33
S.E.(m)±	**0.21**	**0.31**	**0.31**	**0.33**
C.D.(at 5%)	**0.63**	**0.93**	**0.92**	**0.98**

4.1.4 Number of leaves/plant

The number of leaves per plant counted at various growth stages from 20 DAS to harvest. The data recorded at each stage was statistically analyzed and presented in Table 4.4 and depicted in Fig. 4.4.

The data on number of leaves per plant revealed that all the treatments except control treatment have positive effect on number of leaves per plant and all the stages were significantly affected by the treatments except harvest stage.

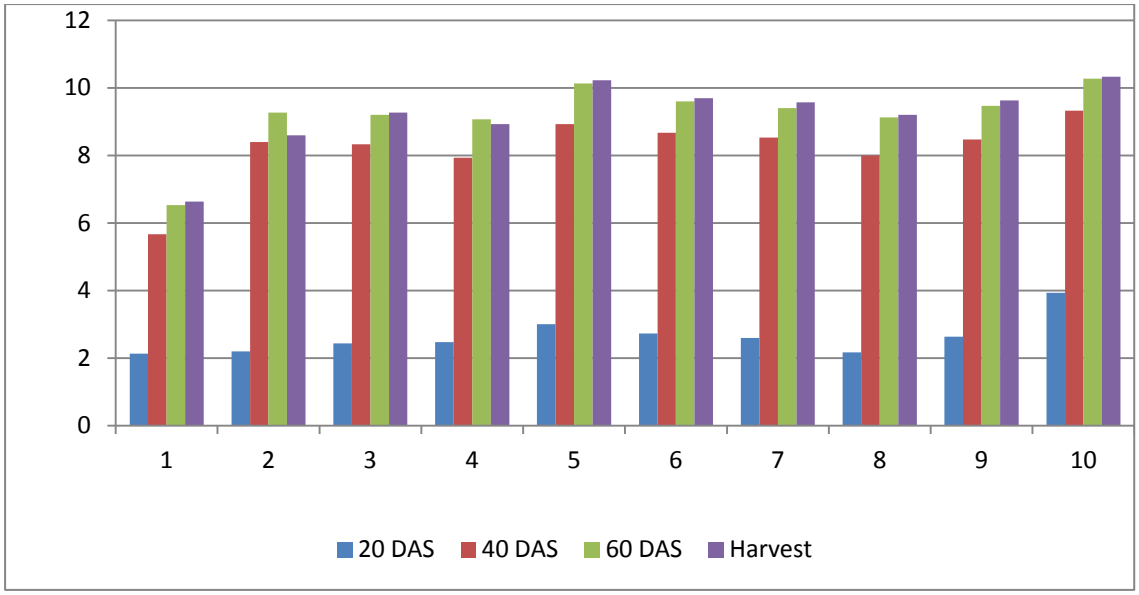


Figure 4.3: Numberof branches/plant as influenced by different treatments

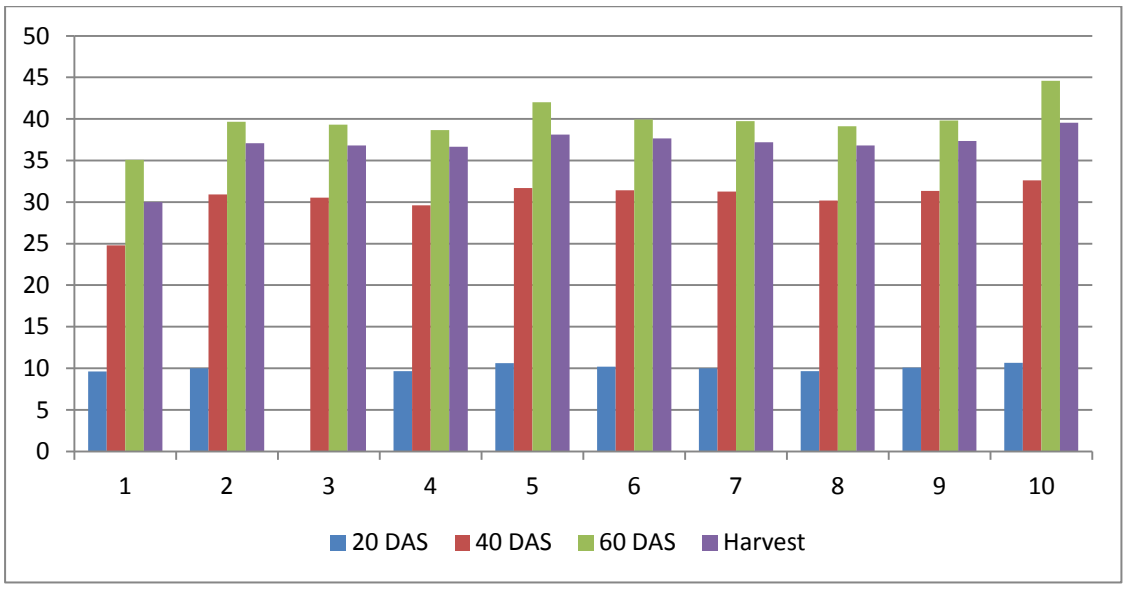


Figure 4.4: Number of leaves/plant as influenced by different treatments

Table 4.4: Number of leaves/plant as influenced by different treatments

Treatments	Number of leaves/plant			
	20 DAS	40 DAS	60 DAS	Harvest
T_1: Control (water spray).	9.60	24.80	35.07	30.00
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	10.00	30.93	39.67	37.07
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	9..87	30.53	39.33	36.80
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	9.67	29.60	38.67	36.67
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	10.60	31.67	42.00	38.13
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	10.20	31.40	39.93	37.67
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	10.00	31.27	39.73	37.20
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	9.67	30.20	39.13	36.80
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	10.07	31.33	39.80	37.33
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	10.67	32.60	44.57	39.53
S.E.(m)±	**0.40**	**1.03**	**0.45**	**0.53**
C.D.(at 5%)	**NS**	**3.07**	**1.34**	**1.58**

At 20 DAS, effect of foliar application of nutrients on number of leaves/plant was found non-significant. At 40 DAS, the highest number of leaves was recorded under treatment T_{10} (Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray) (32.60 cm), which was statistically at par with all treatment combination except control treatment.The minimum number of branches/plant was recorded in control treatment (T_1) (24.80 cm) .

The maximum number of leaves at 60 DAS was also recorded in T_{10} (Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray) (44.57 cm) and The minimum number of branches/plant was recorded in control treatment (T_1) (35.07 cm) .The maximum number of leaves at harvest was also recorded in T_{10} (Neem coated Urea1% + salicylic

acid 75 ppm spray at flower initiation and 10 days after 1st spray) (39.53 cm), which was statistically at par withT_5 (38.13 cm) and superior than rest of the treatments. The minimum number of leaves/plant was recorded in control treatment (T_1) at both the stages (60 DAS and harvest stage).

4.1.5: Dry weight per plant (g)

The dry weight per plant was recorded at different stages of crop growth is presented in Table 4.5 and depicted in Fig. 4.5.

Table 4.5: Dry weight per plant (g) as influenced by different treatments

Treatments	Plant dry weight (g)			
	20 DAS	40 DAS	60 DAS	Harvest
T_1: Control (water spray).	3.17	11.27	14.60	16.27
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	3.63	17.93	26.00	31.00
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	3.43	17.40	25.60	30.60
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	3.37	18.87	24.80	32.13
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	3.77	21.40	33.47	40.93
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	3.73	20.60	32.73	39.47
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	3.67	20.47	31.07	37.73
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	3.27	15.53	20.93	24.73
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	3.70	20.47	33.13	39.20
T_{10} :Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	3.90	23.67	39.80	48.87
S.E.(m)±	**0.35**	**0.85**	**1.09**	**1.46**
C.D.(at 5%)	**NS**	**2.52**	**3.25**	**4.33**

The data revealed that dry matter production of plant increased with the growth of the plants from 20 DAS to harvest stage. A linear increase in dry weight per plant was observed with the advancement in age of crops. The effect of foliar spray treatments on dry weight per plant was found non-significant at 20 DAS

stage of crop. The different treatment gave significant influence on the parameter at 40, 60 DAS and harvest stage. At 40 DAS the maximum dry weight per plant was recorded under treatment T_{10} (23.67) which was at par with treatment T_5 (21.40) and superior than rest of the treatments. The minimum dry weight per plant was recorded in control treatment T_1 (11.27).

The highest dry weight per plant at 60 DAS was found under treatment T_{10} (39.80).The minimum dry weight per plant was recorded in control treatment (14.60).

At harvest the maximum dry weight per plant was also recorded under treatment T_{10} (48.87). The minimum dry weight per plant was noted in control treatment T_1 (16.27).

4.2: Physiological parameters

4.2.1 Crop growth rate (g/m^2/day)

For the assessment of average daily increment in stand biomass, crop growth rate is an important characteristic, which is termed as rate of dry matter production. It was determined as rate of dry matter accumulation by crop stand per unit ground area per unit time.

The observations on CGR were recorded at 0-20, 20-40, 40-60 and 60 DAS to harvest interval stages of the crop. The data presented in Table 4.6 and depicted in Fig. 4.6 revealed that the CGR at 0-20 days Intervals was found non-significant.

It was observed that application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) had significantly higher crop growth rate at 20-40 days interval (22.11), and at this interval it was at par with application of NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray T_5 (19.67) and significantly superior than rest of the treatments.

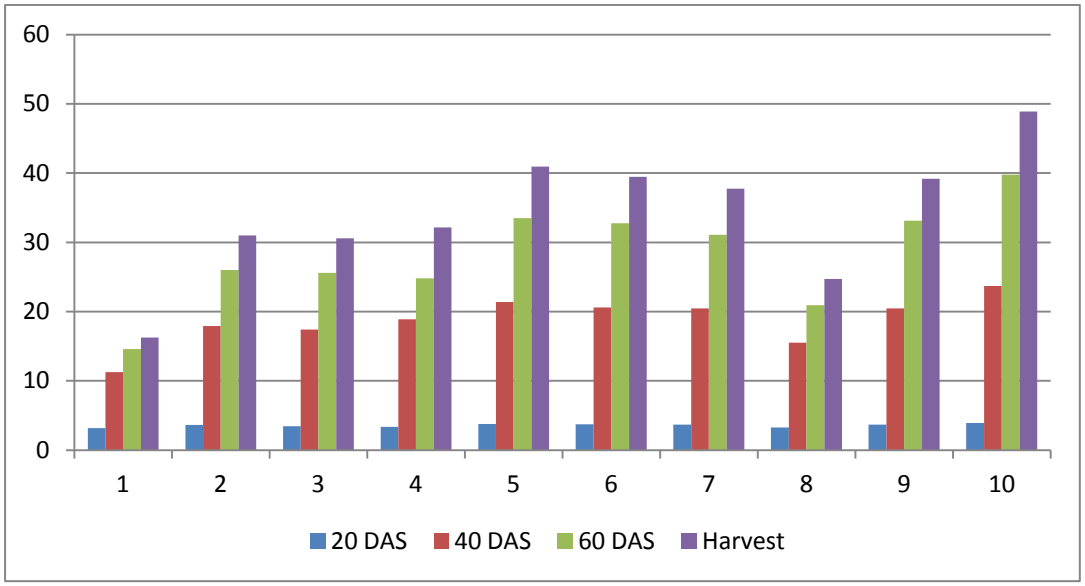


Figure 4.5: Dry weight per plant (g) as influenced by different treatments

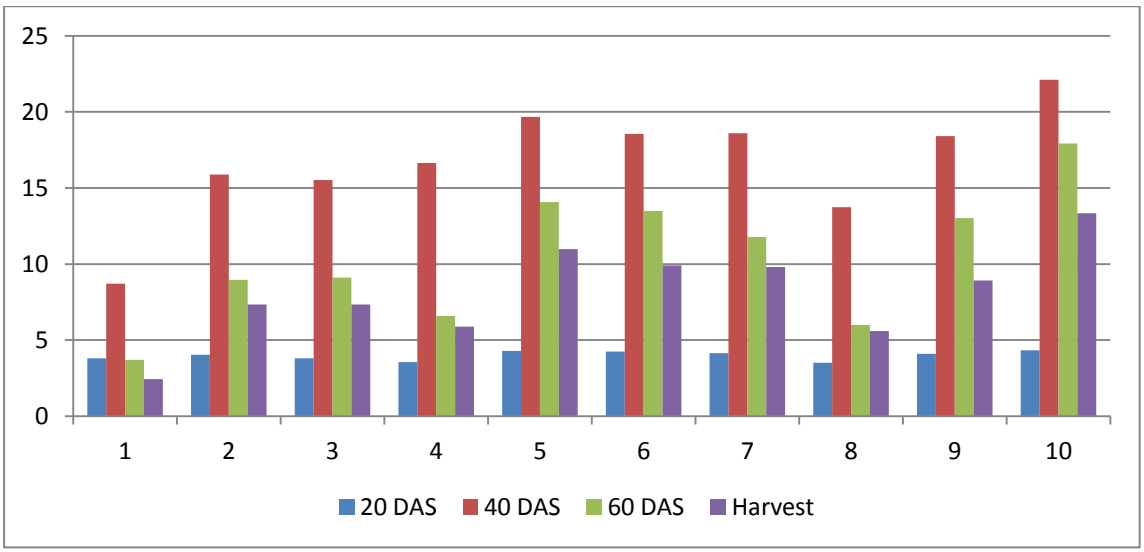


Figure: 4.6 Effect of treatments on crop growth rate (g/m^2/day)

Table: 4.6 Effect of treatments on crop growth rate (g/m^2/day)

Treatments	CGR (g/m^2/day)			
	0-20 DAS	**20-40 DAS**	**40-60 DAS**	**60 DAS-Harvest**
T_1: Control (water spray).	3.81	8.70	3.70	2.45
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	4.04	15.89	8.96	7.35
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	3.81	15.52	9.11	7.35
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	3.56	16.63	6.59	5.88
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	4.29	19.67	14.07	10.98
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	4.25	18.56	13.48	9.90
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	4.15	18.59	11.78	9.80
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	3.52	13.74	6.00	5.59
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	4.11	18.41	13.03	8.92
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	4.33	22.11	17.93	13.33
S.E.(m)±	**0.36**	**1.08**	**0.80**	**0.82**
C.D.(at 5%)	**NS**	**3.19**	**2.37**	**2.45**

At 40-60 days interval treatment T_{10} had also significantly higher crop growth rate (17.93). The minimum crop growth rate was recorded in control treatment (3.70).

At 60 DAS to harvest stage treatment T_{10} had also significantly higher crop growth rate (13.33), and at this interval it was at par with treatment T_5 (10.98). The minimum crop growth rate was noted in control treatment (2.45).

4.2.2: Relative growth rate (mg/g/day)

It is an index of the amount of growing per unit dry weight of plant per unit time. The relative growth rate (RGR) at any stage is ratio of the increase in biomass on per unit of biomass. It is also called efficiency index.

The observations were recorded at 0-20, 20-40, 40-60 and 60 DAS to harvest interval stages of the crop. The data presented in Table 4.7 and depicted in Fig. 4.7 revealed that the RGR during 20-40, 40-60 DAS and 60 to harvest interval of the crop was influenced significantly due to different foliar spray treatments. It was found non-significant at 0-20 days interval.

It was observed that application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray Neem coated urea 2% spray at flower initiation (T_{10}) gave significantly higher relative growth rate (92.11) at 20-40 days interval, and at this interval it was found at par with treatments T_5 (87.89), T_7 (85.22) and T_6 (83.34) and superior than rest of the treatments. The minimum relative growth rate was recorded in control treatment (60.61).

Table: 4.7 Effect of treatments on relative growth rate (mg/g/day).

Treatments	RGR (mg/g/day)			
	0-20 DAS	20-40 DAS	40-60 DAS	60 DAS-Harvest
T_1: Control (water spray).	56.25	60.61	12.98	7.21
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	63.43	80.77	18.70	11.73
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	61.66	81.09	19.38	11.89
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	68.00	78.83	13.69	9.97
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	67.92	87.89	24.12	13.40
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	67.87	83.34	23.19	12.48
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	65.68	85.22	20.91	12.97
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	56.25	80.89	14.87	11.83
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	67.27	82.98	22.52	11.20
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	68.00	92.11	26.00	13.68
S.E.(m)±	**4.98**	**2.95**	**1.68**	**0.87**
C.D.(at 5%)	**NS**	**8.77**	**4.98**	**2.58**

At 40-60 days interval treatment T_{10} had significantly higher relative growth rate (26.00), and at this interval it was at par with treatment T_5 (24.12), T_6 (23.19) and T_9 (22.52) and superior than rest of the treatments. The minimum relative growth rate was recorded in control treatment (12.98).

At 60 DAS to harvest stage treatment T_{10} had also significantly higher relative growth rate (13.68), and at this interval it was at par with treatment T_5 (13.40), T_7 (12.97), T_6 (12.48), T_3 (11.89), T_8 (11.83), T_2 (11.73) and T_9 (11.20) . The minimum relative growth rate was recorded in control treatment (7.21).

4.2.3: Absolute growth rate (g/day)

It is an index of the amount of growing per unit dry weight of plant per unit time. The relative growth rate (RGR) at any stage is ratio of the increase in biomass on per unit of biomass. It is also called efficiency index.

The observations were recorded at 0-20, 20-40, 40-60 and 60 DAS to harvest interval stages of the crop. The data presented in Table 4.8 and depicted in Fig. 4.8 revealed that the AGR during 20-40, 40-60 and 60 DAS to harvest interval of the crop was influenced significantly due to different foliar spray treatments. It was found non-significant at 0-20days interval.

Table: 4.8 Effect of treatments on Absolute growth rate (g/day).

Treatments	AGR (g/day)			
	0-20 DAS	**20-40 DAS**	**40-60 DAS**	**60 DAS-Harvest**
T_1: Control (water spray).	0.08	0.39	0.17	0.11
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	0.12	0.72	0.40	0.33
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	0.11	0.70	0.41	0.33
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	0.13	0.75	0.30	0.27
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	0.12	0.89	0.63	0.50
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	0.13	0.84	0.61	0.45
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	0.12	0.84	0.53	0.44
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	0.11	0.62	0.27	0.25
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	0.11	0.83	0.60	0.40
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	0.13	1.00	0.81	0.60
S.E.(m)±	**0.01**	**0.03**	**0.04**	**0.03**
C.D.(at 5%)	**NS**	**0.10**	**0.11**	**0.09**

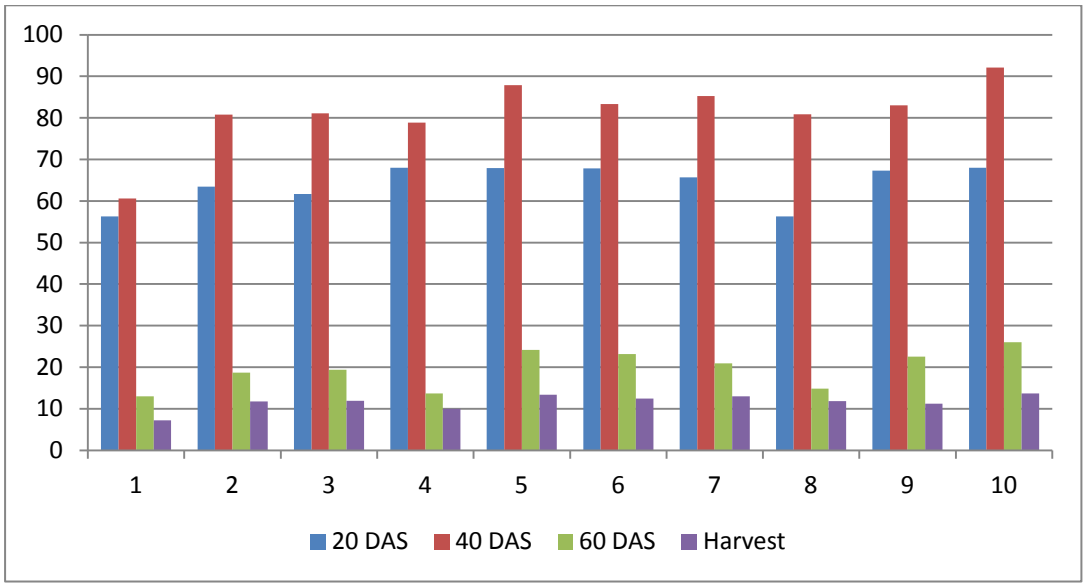


Figure: 4.7 Effect of treatments on relative growth rate (mg/g/day)

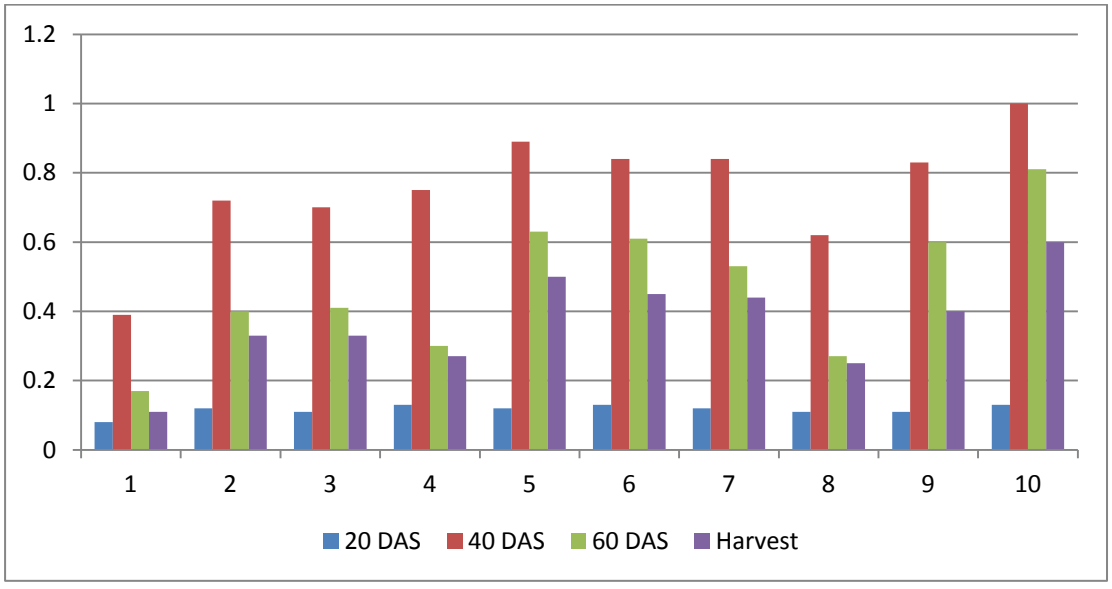


Figure: 4.8 Effect of treatments on Absolute growth rate (g/day)

At 20-40 days interval treatment T_{10} had significantly higher absolute growth rate (1.00). The minimum absolute growth rate was recorded in control treatment (0.39).

At 40-60 days interval treatment T_{10} had significantly higher absolute growth rate (0.81). The minimum absolute growth rate was recorded in control treatment (0.17).

At 60 DAS to harvest stage treatment T_{10} had also significantly higher relative growth rate (0.60). The minimum crop growth rate was noted in control treatment (0.11).

4.2.4 Leaf area index

Leaf area index (LAI) is a dimensionless quantity that characterizes plant canopies.

The observations on LAI were recorded at 20, 40, 60 DAS and harvest interval stages of the crop. The data presented in Table 4.9 and depicted in Fig. 4.9 revealed that the LAI during 20 DAS of the crop was found non-significant. It was influenced significantly due to different foliar spray treatments at 40, 60 DAS and harvest stage.

It was observed that application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher leaf area index (3.57) at 40 DAS, and at this interval it was found at par with treatments application NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) (3.33) and (T_6) (3.30) and superior than rest of the treatments.

At 60 DAS was also recorded in T_{10} (Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray) (4.01), which was statistically at par with treatment T_5 (3.92),T_6 (3.88) and T_9 (3.75).The minimum leaf area index was noted in control treatment (T_1) (2.52) .

At harvest stage foliar application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave

significantly higher leaf area index (1.33) which was statistically at par with rest of the treatments except control treatment (T_1).

Table: 4.9 Effect of treatments on Leaf Area Index

Treatments	LAI			
	20 DAS	**40 DAS**	**60 DAS**	**Harvest**
T_1: Control (water spray).	1.80	1.93	2.52	0.89
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	1.88	2.57	3.55	1.27
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	1.88	2.56	2.99	1.25
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	1.86	2.32	2.85	1.17
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	1.91	3.33	3.92	1.31
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	1.90	3.30	3.88	1.30
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	1.89	2.59	3.59	1.28
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	1.87	2.47	2.92	1.19
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	1.90	2.99	3.75	1.29
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	1.93	3.57	4.01	1.33
S.E.(m)±	**0.10**	**0.13**	**0.10**	**0.06**
C.D.(at 5%)	**NS**	**0.39**	**0.28**	**0.19**

4.3: Post harvest studies

4.3.1 Number of pods/plant

The number of pods per plant is an important parameter which has direct relation to seed yield per plant and production per unit area.

The data given in Table 4.10 and depicted in Fig.4.10 revealed that the effect of soil and foliar spray treatments on number of pods/plant was found significant over control.

The highest number of pods per plant (27.40) were produced by application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}), which was statistically at par with treatment T_5 (NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray) (25.27) and superior than rest of the treatments. The minimum number of pods per plant (16.00) were produced in control treatment (T_1).

4.3.2 Length of pod (cm)

Pod length was also affected significantly with the treatments. The data given in Table 4.10 and Figure 4.11 revealed that foliar application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) produced maximum length of pod (18.87) which was statistically at par with treatment T_5 (18.73 cm), T_6 (18.50 cm),T_9 (18.40 cm), T_7 (18.13 cm), T_2 (18.07 cm), T_3 (17.60 cm) and T_8 (17.47 cm) and significantly superior than rest of the treatments. The minimum length of pod (14.47 cm) was recorded under control treatment (T_1).

4.3.3 Number of Seeds/pod

Seeds per pod were also affected significantly with the treatments. The data given in Table 4.10 and Figure 4.10 revealed that foliar application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) produced maximum seeds per pod (13.07) which was significantly superior than rest of the treatments.The minimum number of seeds per pod (9.00) were recorded in control treatment (T_1).

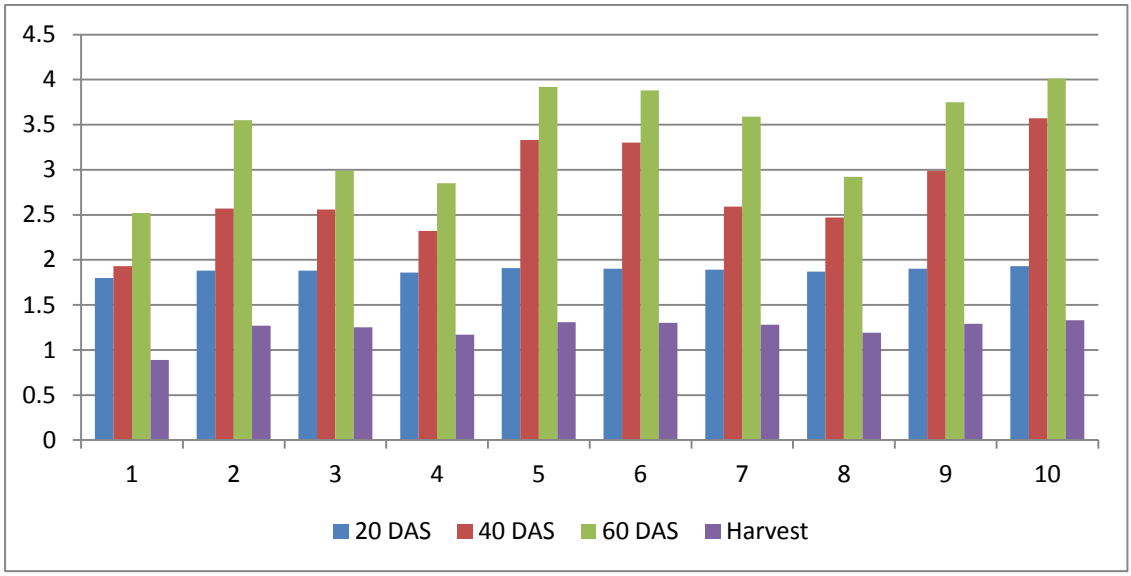


Figure: 4.9 Effect of treatments on Leaf Area Index

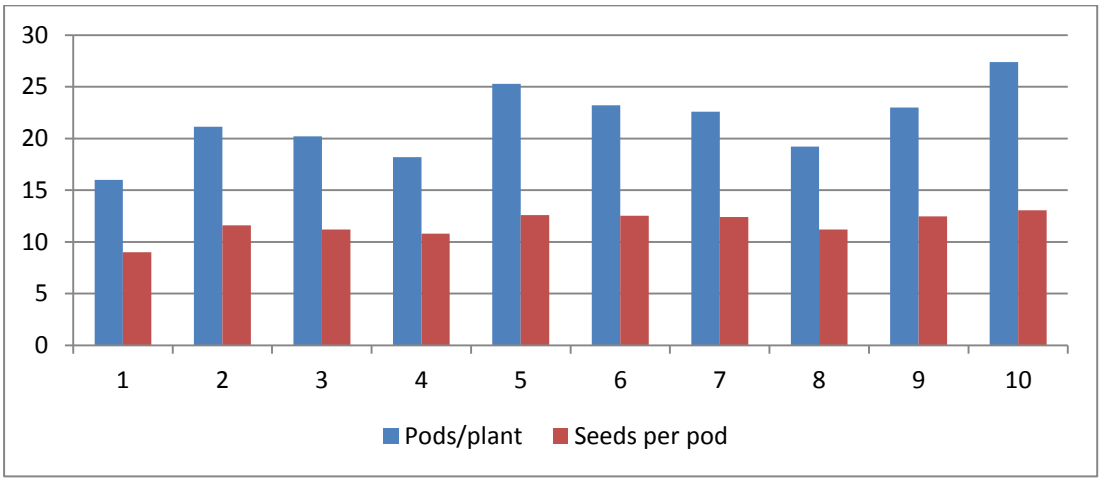


Figure 4.10: Number of pods/plant and seeds/pod as influenced by different treatments

Table 4.10: Yield attributing characters as influenced by different treatments

Treatments	Yield attributing characters			
	Number of pods/ Plant	**Pod length (cm)**	**Number of seeds/ pod**	**100 seeds weight (g)**
T_1: Control (water spray).	16.00	14.47	9.00	10.83
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	21.13	18.07	11.60	12.30
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	20.20	17.60	11.20	12.27
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	18.20	16.83	10.80	12.00
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	25.27	18.73	12.60	12.80
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	23.20	18.50	12.53	12.63
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	22.60	18.13	12.40	12.30
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	19.20	17.47	11.20	12.20
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	23.00	18.40	12.47	12.47
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	27.40	18.87	13.07	13.07
S.E.(m)±	**0.82**	**0.50**	**0.13**	**0.22**
C.D.(at 5%)	**2.42**	**1.47**	**0.38**	**0.66**

4.3.4 100 seed weight (g)

The seed index was influenced by the quality and quantity of seed yield of the particular area. The observations on this parameter were analyzed statistically and the data presented in Table 4.10 and Fig. 4.12 revealed that the effect of foliar application of nutrients on seed index was found significant. The higher seed index (13.07 g) was obtained in treatment application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days

after 1st spray (T_{10}), it was statistically at par with treatment T_5 (12.80 g), T_6 (12.63 g), and T_9 (12.47 g).

The minimum seed index (10.83) was noted in control treatment (T_1).

4.3.5 Seed yield/plant (g)

The seed yield per plant of cowpea significantly varied due to foliar application of nutrients, the data related to grain yield presented in Table 4.11 and depicted in Fig. 4.12.

The application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher grain yield per plant (25.93 g) than other treatments. It was statistically at par with treatment application of NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray T_5 (24.97). The minimum seed yield per plant (15.53 g) was noted in control treatment (T_1).

Table 4.11: Seed yield (g/plant) and Stover yield (g/plant) as influenced by different treatments

Treatments	Seed yield (g/plant)	Stover yield (g/plant)
T_1: Control (water spray).	15.53	19.07
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	20.03	27.73
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	19.20	25.73
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	16.00	22.27
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	24.97	33.27
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	22.17	31.20
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	20.13	27.93
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	18.53	22.53
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	21.80	30.80
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	25.93	34.87
S.E.(m)±	**0.60**	**1.11**
C.D.(at 5%)	**1.77**	**3.30**

4.3.6 Stover yield/plant (g)

The stover yield per plant of cowpea also significantly varied due to foliar application of nutrients, the data related to stover yield is presented in Table 4.11 and depicted in Fig. 4.12.

The application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiationand 10 days after 1st spray (T_{10}) gave significantly higher stover yield per plant (34.87 g) than other treatments. It was statistically at par with treatment application of NPK (18:18:18) 1 % spray at flower initiationand 10 days after 1st spray T_5 (33.27 g). The minimum stover yield per plant (19.07 g) was recorded in control treatment (T_1) Figure 4.11: Seed yield (g/plant), Stover yield (g/plant) and 100 seeds weight (g) as influenced by different treatments

4.3.7 Seed yield (kg/ha)

The seed yield per unit area is an important scale for agronomic assessment of the crop. The suitability of the treatment are best judged by their efficiency to produce higher yield. Yield of any crop is the ultimate results of interaction of the biotic and environmental factors. The superiority or inferiority of any treatment could be judged by magnitude of changes brought about in the productivity.

The data recorded on seed yield in kg/plot was converted into seed yield in kg/ha by multiply conversion factor 555.555 for different treatments and illustrated through Table 4.12 and Fig.4.13 the data revealed that all the foliar nutrients gave significant response on seed yield over control treatments (T_1).

The significantly higher seed yield (1607 kg/ha) was recorded with the application of Neem coated Urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) which was statistically at par with treatment T_5 NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (1513 kg/ha).The minimum seed yield (1055 kg/ha) was recorded in control treatment (T_1).

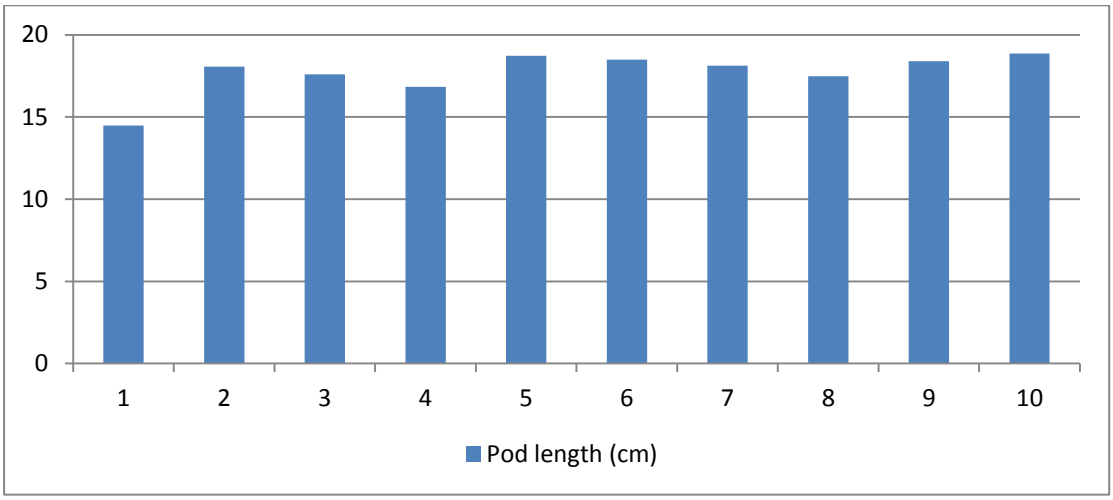


Figure 4.11: Length of pod (cm) as influenced by different treatments

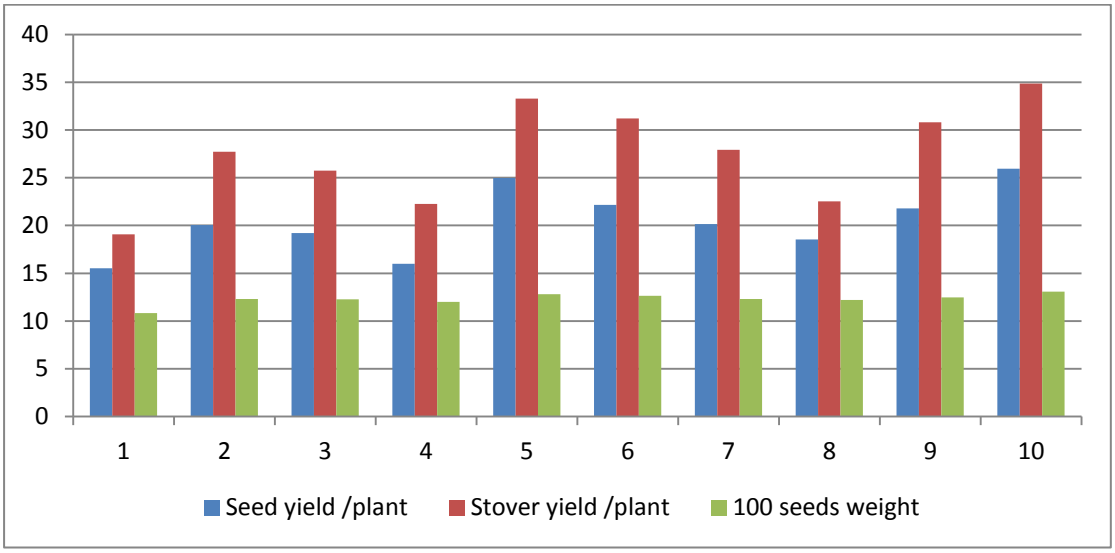


Figure 4.12: Seed yield (g/plant), Stover yield (g/plant) and 100 seeds weight (g) as influenced by different treatments

Table 4.12: Seed yield (kg/ha), Stover yield (kg/ha), Biological yield (kg/ha) and Harvest index (%) as influenced by different treatments

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
T_1: Control (water spray).	1055	2945	4000	26.38
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	1405	2891	4296	32.70
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	1269	2990	4259	29.79
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	1183	2965	4148	28.51
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	1513	2950	4463	33.90
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	1502	2905	4407	34.08
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	1413	2902	4315	32.74
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	1303	2938	4241	30.72
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	1471	2862	4333	33.94
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	1608	3003	4611	34.87
S.E.(m)±	**34.97**	**71.29**	**115.53**	**0.87**
C.D.(at 5%)	**103.91**	**211.82**	**NS**	**2.58**

4.3.8 Stover yield (kg/ha)

The data on stover yield in kg/plot under different treatments was converted into stover yield in kg/ha by multiply with the conversion factor 555.555. Data on stover yield of cowpea as affected by different treatments.Stover yield is directly related with increase in vegetative growth of the plant.

The data presented in Table 4.12 and depicted through Fig.4.13. The data indicated that the effect of foliar application of nutrients on stover yield kg/ha was found significant as compared to control (T_1).

The application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher stover yield (3003kg/ha) than other treatments.The minimum stover yield (2862kg/ha) was recorded in control treatment (T_9).

4.3.9 Biological yield (kg/ha)

The data related to biological yield presented in Table 4.12 and depicted in Fig.4.13. The application of Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher biological yield kg/ha (4611) than other treatments. It was statistically at par with treatment T5 (4463 kg/ha), T_6 (4407 kg/ha) T_9 (4333 kg/ha), T_7 (4314 kg/ha) and T_2 (4296 kg/ha). The minimum biological yield kg/ha (4000) was obtained in control treatment (T_1).

4.3.10 Harvest index (%)

The data presented in Table 4.12 and illustrated through Fig.4.14 indicated that the effect of foliar application of nutrients on harvest index was found non-significant. Harvest index (HI) ranged from 26.38 to 34.87 per cent according to the mean values. The maximum harvest index was recorded (34.87.%) with the application Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}).

4.4 Effect of treatments on quality parameters

4.4.1 Protein content (%) in seed

The data recorded on the protein content were presented in table 4.13 and depicted in fig. 4.15. The protein content of grain was also affected significantly under different treatments. The significantly higher protein content was recorded (23.27) under Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}), which was at par withT_5 (22.97), and T_6 (22.73). The minimum protein content was recorded in control treatment (20.37).

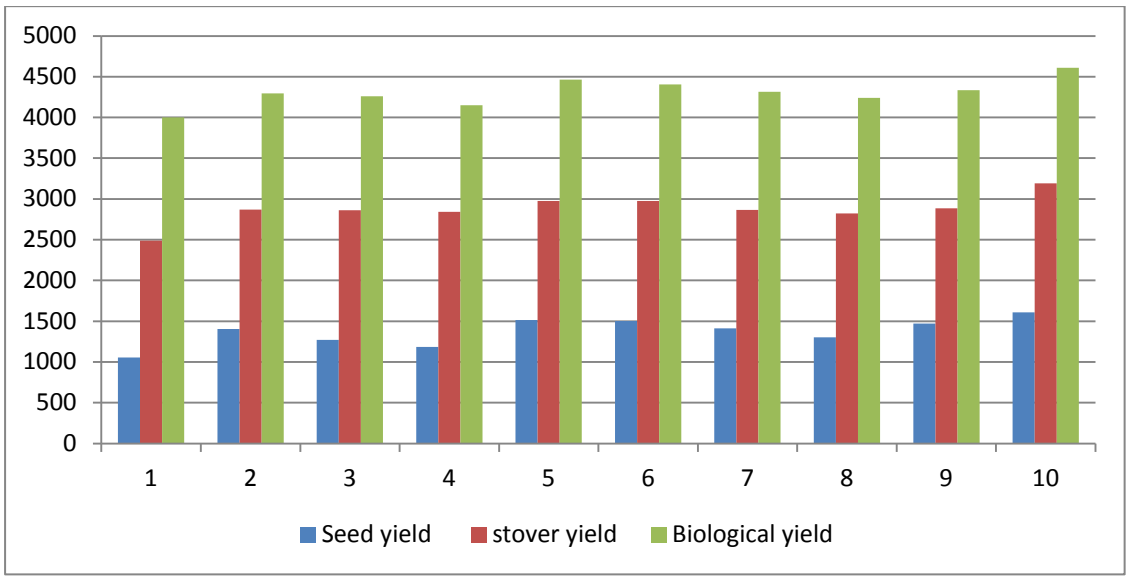


Figure 4.13: Seed yield (kg/ha), Stover yield (kg/ha) and Biological yield (kg/ha) as influenced by different treatments

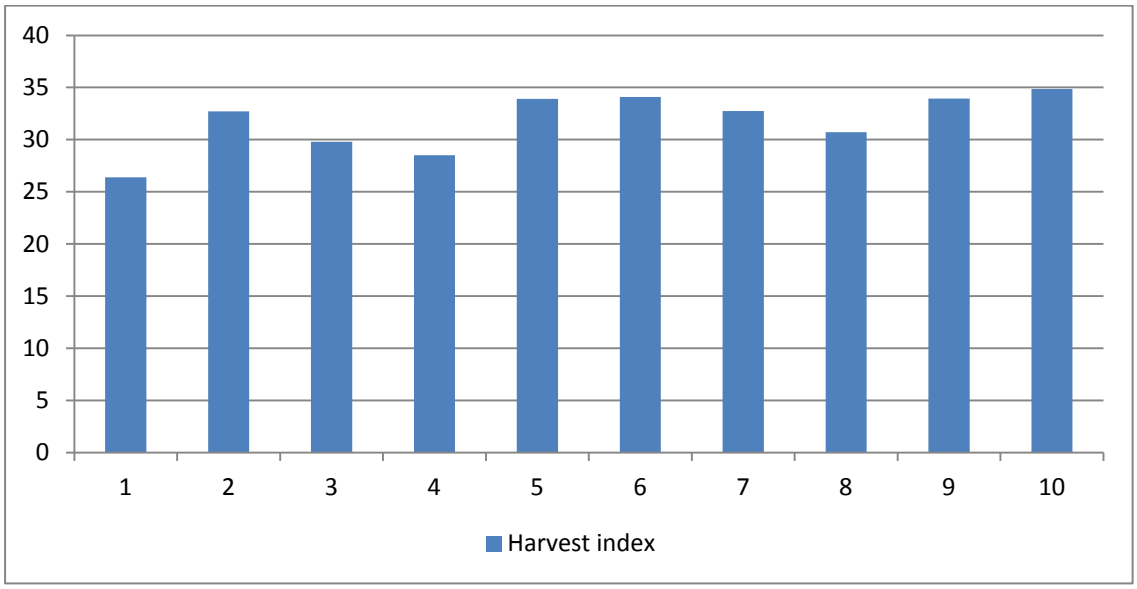


Figure 4.14: Harvest index (%) as influenced by different treatments

Table 4.13 Protein content (%) in seed and protein yield (kg/ha) as influenced by different treatments

Treatments	Protein % in seed	Protein yield (kg/ha)
T_1: Control (water spray).	20.37	221.67
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	21.67	316.83
T_3: DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	22.50	286.10
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	22.07	265.63
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	22.97	347.53
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	22.80	341.33
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	21.63	319.07
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	21.80	293.50
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	22.40	332.68
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	23.27	372.15
S.E.(m)±	**0.37**	**8.27**
C.D.(at 5%)	**1.11**	**24.57**

4.4.2 Protein yield (kg/ha)

Protein yield (kg/ha) was worked out with help of protein content (%). The data recorded on the protein yield were presented in table 4.13 and depicted in fig. 4.16. The protein yield was also affected significantly under different treatments.The maximum proteinyield was recorded (372.15) under Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiationand 10 days after 1st spray (T_{10}), which was significantly superior over all other treatments. The minimum protein yield was recorded in control treatment T_1 (239.87).

4.5 Soil analysis (before and after experiment)

Before and after experiment, soil samples *i.e*., one sample from whole experimental plot before experiment and one sample from each treated plotafter

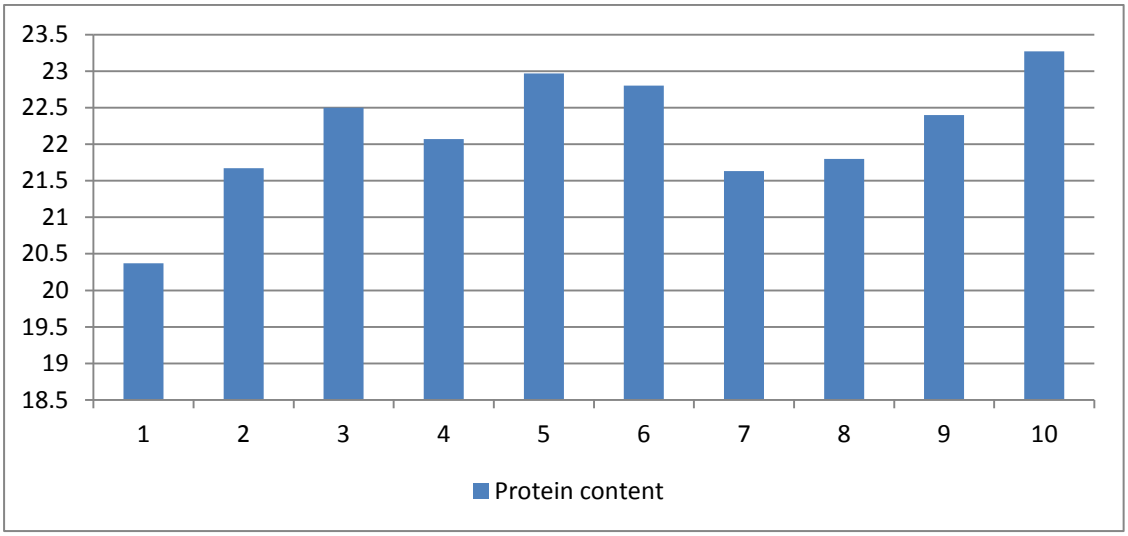


Figure 4.15 Protein content (%) in seed as influenced by different treatments

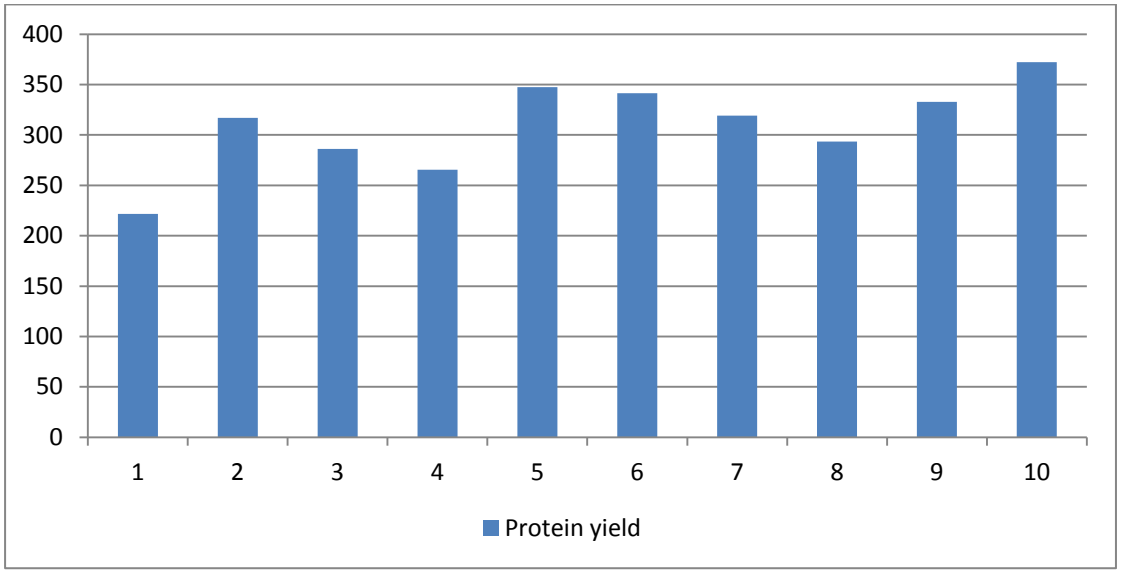


Figure 4.16: Protein yield (kg/ha) as influenced by different treatments

experiment were taken and analyzed for major nutrients *viz*., nitrogen, phosphorus and potassium.The data on the uptake of nitrogen (N), phosphorus (P) and potassium (K) after experiment affected by different treatments are presented in Table 4.14 and depicted graphically in Fig.4.17

After experiment maximum uptake of nitrogen (86.9 kg/ha) by cowpea crop was found under treatment (T_5) NPK 18:18:18) 1 % spray at flower initiation and 10 days after 1^{st} spray followed by treatment (T_9) NPK (18:18:18) 1% spray at flower initiation and 10 days after 1^{st} spray (78.7kg/ha).

Table 4.14 Soil analysis (before and after experiment)

Treatments	Nutrient available before experiment (kg/ha)			Nutrient added through different fertilizers & treatments (kg/ha)			Total nutrient (before experiment + added through different fertilizers & treatments (kg/ha)			Nutrient available after experiment (kg/ha)			Uptake of nutrients (kg/ha)		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1: Control (water spray).	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	167.4	12.9	222.4	62.9	40.6	49.2
T_2 :PSB soil applied + NAA 20 ppm spray at flower initiation stage.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	154.3	10.7	200.5	76	42.8	71.1
T_3 : DAP 0.5 % spray at flower initiation and 10 days after 1st spray.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	161.7	11.6	209.4	68.6	41.9	62.2
T_4 :MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	166.9	12.4	217.6	63.4	41.1	54
T_5 :NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	143.4	9.3	183.5	86.9	44.2	88.1
T_6 : Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	160.8	12.2	219.7	69.5	41.3	51.9
T_7 :KMB soil applied + NAA 20 ppm spray at flower initiation stage.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	155.4	11.1	203.5	74.9	42.4	68.1
T_8 :Thiourea @ 500 ppm spray at vegetative and flowering stage.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	164.3	11.9	210.9	66	41.6	60.7
T_9:PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	151.6	10.5	198.1	78.7	43	73.5
T_{10}:Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	210.3	13.5	251.6	20	40	20	230.3	53.5	271.6	153.4	9.8	196.3	76.9	43.7	75.3

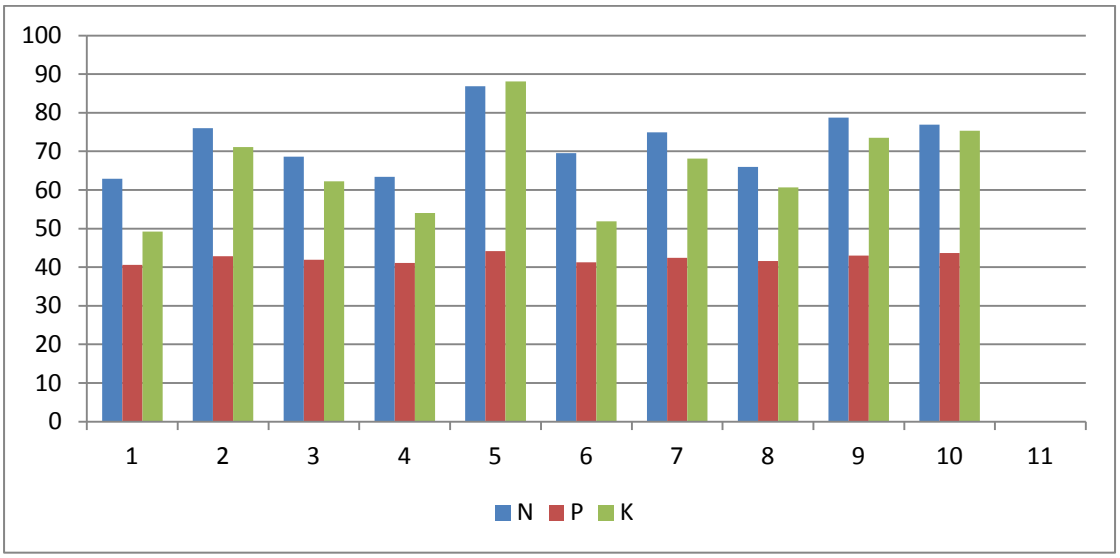


Figure 4.17:Uptake of nitrogen, phosphorus and potassium (kg/ha) as Influenced by different treatments

Maximum uptake of phosphorus (44.2 kg/ha) was found under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_{10}) Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.

The uptake of potassium (95.15 kg/ha) was also found maximum under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_{10}) Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.

4.6 Economics of the various treatments

4.6.1 Cost of cultivation (₹/ha)

Cost of cultivation (₹19905/ha) was common for all the treatments (Table 4.15). But the cost of treatment varied from treatment to treatment (Appendix XIII). The highest total cost of cultivation (₹22705/ha) was incurred under treatment T_5 (NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray) while the minimum was recorded in the control treatment (T_1) (Table 4.15 and Figure 4.18).

4.6.2 Gross return (₹/ha)

The total gross return (₹/ha) treatment wise were presented in Table 4.16 and depicted in Fig. 4.18. The maximum gross return (₹99672/ha) was recorded under treatment T_{10} (Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray) followed by T_5 (NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray) (₹93757/ha) and T_6 (Zinc Sulphate 0.25% spray at flower initiation and 10 days after 1st spray) (₹93094), while the minimum gross return (₹ 65787/ha) was recorded under the control treatment (T_1).

Table 4.15: Common cost of cultivation (₹/ha) excluding treatment cost

S.No.	Particular of expenditure	Cost of cultivation (₹/ha)
1	Field preparation	2250
2	Fertilizer	2125
3	Seed cost	2000
4	Seed treatment	50
5	Sowing	1250
6	Intercultural operations	3750
7	Plant protection	980
8	Harvesting	3750
9	Threshing	3250
10	Miscellaneous	500
	Total cost	**19905**

4.6.3 Net return (₹/ha)

The net return (₹/ha) treatment wise were presented in Table 4.16 and depicted in Fig. 4.18. The maximum net return ₹78570/ha was recorded under treatment T_{10} (Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray) followed by treatment T_6 (Zinc Sulphate 0.25% spray at flower initiation and 10 days after 1st spray)(₹72039/ha) and minimum was recorded in the control treatment (T_1) (₹44882/ha).

4.6.4 Benefit cost Ratio

The B:C ratio were presented in Table 4.16 and depicted in Fig. 4.19. The maximum B:C ratio 4.72 was recorded under treatment T_{10} (Neem coated Urea1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray) followed by treatment T_6 (Zinc Sulphate 0.25% spray at flower initiation and 10 days after 1st spray) (4.42), while the minimum B:C ratio (3.14) was recorded in control treatment (T_1).

Table 4.16: Economics of the various treatments

Seed sale price : 6000/q, Stover sale price : 100/qs

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net income (₹/ha)	B:C Ratio
T_1: Control (water spray).	1055	2487	20905	65787	44882	3.14
T_2: PSB soil applied+ NAA 20 ppm spray at flower initiation stage.	1405	2869	21819	87169	65350	3.99
T_3 : DAP 0.5 % spray at flower Initiation and 10 days after 1st spray.	1269	2862	21031	79002	57971	3.75
T_4: MOP 0.5 % spray at flower initiation and 10 days after 1st spray.	1183	2841	20995	73821	52826	3.51
T_5: NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray.	1513	2977	22705	93757	71052	4.12
T_6: Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray.	1502	2974	21055	93094	72039	4.42
T_7: KMB soil applied + NAA 20 ppm spray at initiation stage.	1413	2869	20959	87649	66690	4.18
T_8: Thiourea @ 500 ppm spray at vegetative and flowering stage.	1303	2824	22037	81004	58967	3.67
T_9: PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage.	1471	2885	22359	91145	68786	4.07
T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.	1608	3192	21102	99672	78570	4.72

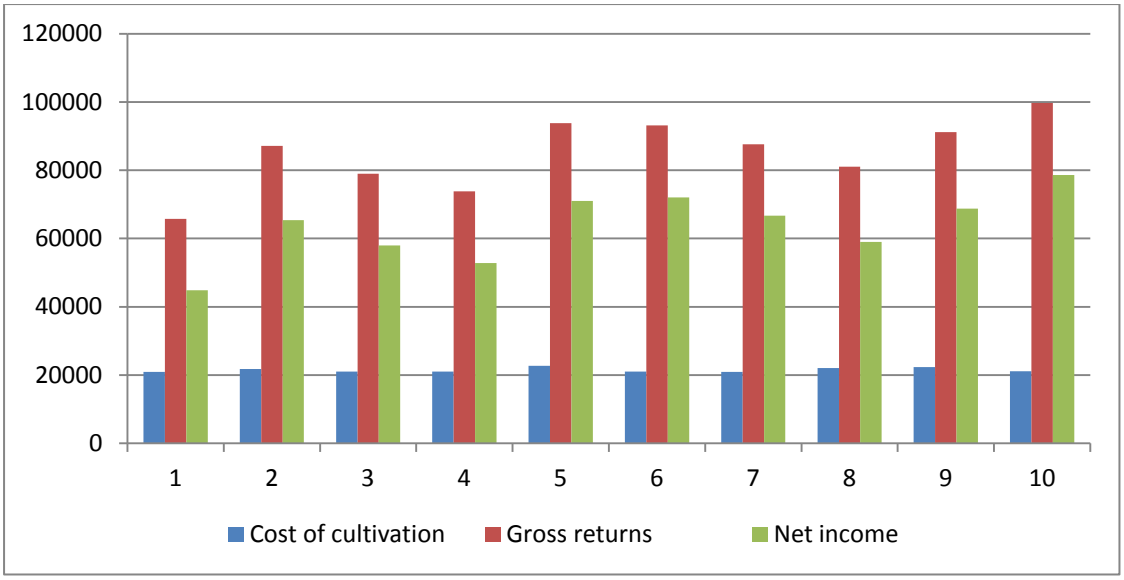


Figure 4.18: Cost of cultivation (₹/ha), Gross returns (₹/ha) and Net return (₹/ha) as influenced by different treatments

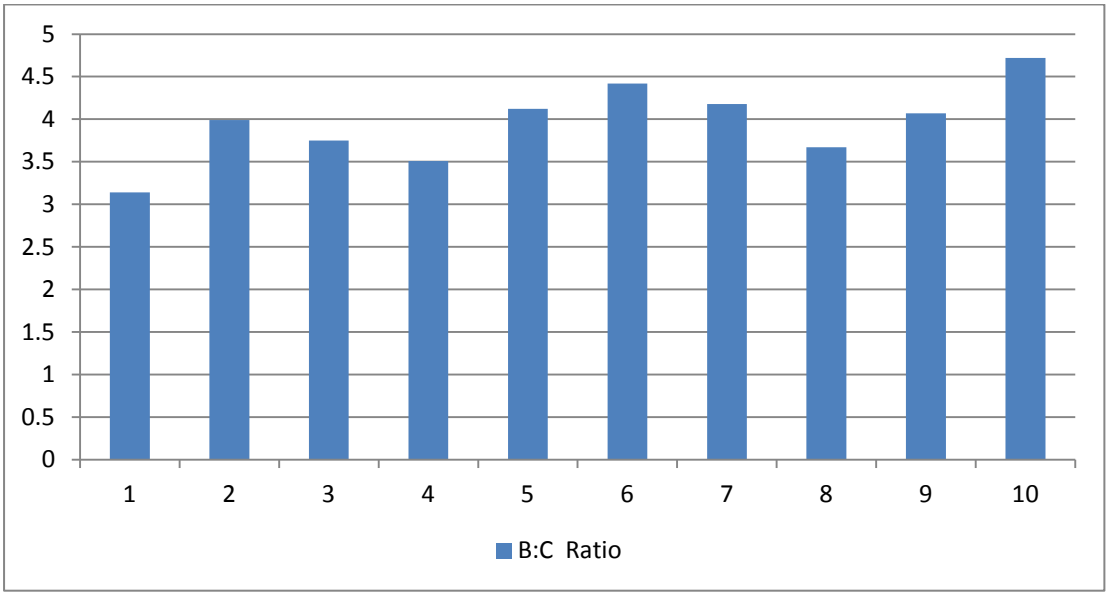


Figure 4.19 : B:C Ratio as influenced by different treatments

Chapter - V
DISCUSSION

The investigation entitled "**Effect of Soil and Foliar Application of Nutrients on Cowpea [*Vigna unguiculata* (L.) Walp]**" was carried out during *Kharif season* of 2018 at the Research Farm of the Department of Agronomy, College of Agriculture, Gwalior (M.P.). Results obtained from investigation stated in chapter IV have been examined critically and discussed here with appropriate interpretations. Efforts have also been made to compare the findings with those of the other investigators in order to provide suitable explanations.

In general, the weather conditions, which prevailed during *Kharif* 2018 was favorable for growth and development of the cowpea crop. The topography of experimental field was uniform. Fertility status of experimental site was homogenous. Variation in the growth and yield of crop was mainly due to effect of the treatments tested. However, the results on all aspects given in the preceding are being discussed as under.

Soil and Foliar spray is a well-established tool to complete and to enrich plant nutrition. Soil and foliar feeding can provide the nutrients needed for normal developments of crops. Foliar sprays are also the method of choice when prompt correction of nutrient deficiencies is required.

Effect on growth parameters

Soil and foliar application of nutrients caused a marked variation in growth parameters of cowpea at all of the crop growth stages except at 20 DAS. The growth parameters *viz*., plant height, number of branches per plant, number of leaves per plant, dry weight per plant, CGR, RGR, AGR and LAI had a direct relationship with soil and foliar application of nutrients. All soil and foliar nutrient treatments significantly increased all growth parameters over control treatment (T_1). The maximum values of all these growth parameters were recorded with the application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1^{st} spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1^{st} spray (T_5) and Zinc sulphate 0.25% spray at flower initiation and 10 days after 1^{st} spray (T_6) and these treatments were found significantly superior over other treatments. The order of significance were followed by application of PSB + KMB soil applied + NAA 20 ppm

spray at flower initiation stage (T_9) and KMB soil applied + NAA 20 ppm spray at flower initiation stage (T_7).

Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray(T_{10}), NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and Zinc sulphate 0.25% spray at flower initiation and 10 days after 1st spray (T_6) also gave significantly higher plant height, number of branches per plant, number of leaves per plant, dry weight per plant, CGR, RGR and LAI compared to control treatment (T_1).

Similar results had also been reported by Sujatha (2001) reported that foliar application of salicylic acid (100 ppm) on green gram at 75 DAS increased plant height (50.4 cm), root length (16.9 cm), number of leaves (18.4) and Leaf area index (LAI) (1.30).

Dey *et al.* (2017) conducted a field experiment to find out the influence of Urea, KCl, Zn placement and spray on growth of Cowpea crop. Application of various levels of Urea ,KCl and Zinc which significantly increased dry matter production/plant, plant height, number of branches/plant, number of trifoliate/plant, total nodule/plant. Foliar nutrient sprays *viz.,* 2% urea, 2% KCL, 1.5% ZnSO4. Foliar spray treatment with the aqueous solution of nutrients was done to the 15 and 30 DAS of cowpea crop. Significant increase was recorded in plant height, dry matter production, Maximum growth was recorded when spread with 2% urea spray followed by 2% KCl at flowering and 15 days later is the viable nutrient management package to the Cowpea for getting higher income through higher productivity.

Mona and Azab (2016) reported that the effects of foliar application of NPK compound with Fe, Zn and Mn at different doses on cowpea plants. In addition, soluble fertilizers NPK (19:19:19) and 500 ppm Fe, 300 ppm Zn and 300ppm Mn were applied. Four treatments of fertilization were tested: control (no fertilization), (50%), (100%), and (125%). The NPK fertilizers were sprayed every 15 days. The results are as follows: Foliar fertilization NPK with Fe, Zn and Mn reflect increasement in vegetative growth, yield and its components and nutrient concentration of cowpea plant compared with control.

The results obtained are also in close conformity with the findings of Haq and Mallarino (2000), Reddy *et al*. (2005), Deshmukh *et al.*(2008) and Afshari *et al*. (2013).

Effect on yield attributing characters

The factors which are directly responsible for ultimate seed production *viz.*, number of pods/plant,length of pod, seeds/pod and 100 seeds weight were augmented almost significantly due to all treatments over control treatment (T_1). The yield attributing characters like number of pods/plant, pod length, number of seeds/pod, and 100 seeds weight were increased significantly with Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and Zinc sulphate 0.25% spray at flower initiation and 10 days after 1st spray (T_6) and these treatments were found significantly higher over rest of the treatments.

These results are in close agreement with Gupta and Saxena (2014). They studied the effect of resource management in cowpea for yield maximization under rainfed conditions. Results of three years pooled data revealed that foliar application of urea either @ 1% or @ 2% and mulching @ 3 t/ha at 25-30 DAS of crop significantly increased yield attributes (pods/plant, seeds/pod and seed index) and seed yield of cowpea. Foliar application of 2% urea recorded maximum values of yield attributes, seed yield, net returns and B:C ratio. The significant increase in pods/plant, seeds/pod and seed index due to foliar application of 2% urea were 7.64 and 16.34, 4.38 and 9.30 and 5.23 and 6.23 per cent respectively over normal planting and control. Further, the maximum value of pooled grain yield (9.26 q/ha), net returns (₹21892/ha) and B:C ratio (1.77) were recorded under foliar application of 2% urea while the least were observed under control (5.47 q/ha, Rs 9299/ha and 0.85).

Ali and Mahmoud (2013) conducted an experiment the results showed that foliar application of salicylic acid 500 ppm enhanced significantly plant height, number of branches per plant, number of pods per plant, number of seeds per pod, 1000 seed weight, seed weight per plant and seed yield per hectare as compared with control in mung bean.

Five concentrations of water soluble fertilizer NPK (19:19:19) *i.e*. no foliar spray (control), 0.25%, 0.5%, 0.75% and 1.0% applied at three critical crop growth stages (peak flowering, pod development and at pod filling stage). The results reveals that grain yield (1661 kg/ha) was significantly higher with foliar application of 1.0% NPK (19:19:19) followed by 0.75% and 0.50% (1518 and 1454 kg/ha respectively). But there was no significant difference observed due to the stages of spray application. The higher yield with 1.0% WSF was due to higher number of pods per plant (121.8), pod weight per plant (105.5 g), grain yield per plant (19.9

g), plant height, higher number of branches, leaf area and higher total dry matter production at harvest in pigeon pea (Malesha *et al*. 2014).

The higher yield attributes from these soil and foliar application of nutrients over control may be due to increased growth and physiological (growth analysis) parameters as well as biomass/plant as a result of increased absorption of foliar nutrients. All these favourable situations might have resulted in greater accumulation of carbohydrates, proteins and their translocation from source to the sink (reproductive organs) which, in turn, increased the higher number of pods as well as other yield attributing parameters. Similar results had also been reported by Ghildiyal (1992), Ebrahim *et al.* (2011), Mahla *et al*. (2013).

Effect on productivity parameters

Each plant passes through the vegetative as well as reproductive phases of growth to complete its life cycle. Yield can be considered to be the final expression of the physiological and metabolic activities of plants and is governed by various factors. These yield-attributing factors have direct bearing on plant productivity and for increasing the yield that means the number of pods/plant, pod length, number of seeds/pod and 100 seeds weight and seed yield as well as stover yield/plant, etc play an important role.

The application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and Zinc sulphate 0.25% spray at flower initiation and 10 days after 1st spray (T_6) brought significantly higher but statistically equal seed and stover yields (1608, 1513, 1502, and 3003, 2990, 2965kg/ha, respectively) and proved to be significantly superior to the remaining treatments. The trend of increases in seed and straw yields obtained due to these treatments was exactly in accordance with the similar increases in the yield-attributing characters *viz.*, pods/plant, pod length, seeds/pod,100 seeds weight and grain yield/plant as well as increased vegetative growth.

The increases in yield-attributing characters and consequently the seed yield of cowpea and other pulses as a result of soil and foliar application of nutrients have also been reported by many research workers, Shinde and Jadhav (1995), Velayutham *et al.*(2003), Sritharan *et al.* (2005), Dixit and Elamathi (2007), Mondal and Mondal (2012).

Since yield is the resultant of additive and complementary effect of plant growth and yield attributing parameters and these yield attributing characters had better expression at higher availability of nutrients due to adequate quantity and balanced proportion of plant nutrient supplied during the crop growth period which ultimately led towards an increase in seed and straw yields.

Effect on quality parameter

Maximum protein content (%) in seed was recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5), and Zinc sulphate 0.25% spray at flower initiation and 10 days after 1st spray (T_6). Maximum protein yield (kg/ha) was also recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}). Similar results were also found by Singh (2007), Hemn Othman Salih (2013) and Senthikumar (2015).

Effect on nutrients uptake

The data on the uptake of nitrogen (N), phosphorus (P) and potassium (K) after experiment affected by different treatments.

After experiment maximum uptake of nitrogen by cowpea crop was found under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_9) PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage. Maximum uptake of phosphorus was found under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_{10}) Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.The uptake of potassium was also found maximum under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_{10}) Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.

The results obtained are also in close conformity with the findings of Ravanhar *et al*. (2003) and Singh (2007).

Economics

The maximum net income per hectare after deduction of cost of cultivation is the ultimate goal of any farm owner or grain producer. Amongst the soil and foliar nutrients treatments, application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10

days after 1st spray (T_{10}) resulted in maximum net income upto ₹78570/ha with B:C ratio 4.72. This was closely followed by application of Zinc sulphate 0.25% spray at flower initiation and 10 days after 1st spray (T_6) (₹72039/ha with B:C ratio 4.42), and NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) (₹71052 with B:C ratio 4.12).

These findings are in close agreement with previous findings of Chandrasekhar and Bangarusamy (2003), Gupta and Saxena (2014), Marimuthu and Surendran (2015), Singhals *et al.* (2015), Banasode and Math (2018).

Chapter - VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

An experiment was conducted to study the **"Effect of Soil and Foliar Application of Nutrients on Cowpea [*Vigna unguiculata* (L.) Walp]"**during *Kharif season* of 2018 at the Research Farm of the Department of Agronomy, College of Agriculture, Gwalior (M.P.). The experiment was laid out in Randomized Block Design with three replications having ten treatments: T_1 : Control (water spray), T_2 : PSB soil applied+ NAA 20 ppm spray at flower initiation stage, T_3 : DAP 0.5 % spray at flower initiation and 10 days after 1st spray, T_4 : MOP 0.5 % spray at flower initiation and 10 days after 1st spray, T_5 : NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray, T_6 : Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray, T_7 : KMB soil applied + NAA 20 ppm spray at flower initiation stage, T_8 : Thiourea @ 500 ppm spray at vegetative and flowering stage, T_9 : PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage, T_{10}: Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray, with the following objectives:

1) To assess the effect of soil and foliar applied nutrients on growth and yield of cowpea.
2) To find out the best source and method of nutrients application in cowpea.
3) To work out the economics of the treatments.

The various parameters that had been considered in the present investigation for evaluation of different soil and foliar application of nutrients were growth and yield attributing characters to support grain and straw yield were studied. The salient findings of work and major conclusion drawn therefore are summarized below:

Summary

❖ The different soil and foliar nutrient treatments did not affect the plant population significantly at any crop growth stages.

❖ All the soil and foliar nutrient treatments increased the plant height significantly over control treatment. The maximum plant height was recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5), Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray

(T_6), PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage (T_9) and KMB soil applied + NAA 20 ppm spray at flower initiation stage (T_7) and significantly superior over other treatments.

❖ Maximum number of branches was recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5), Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray (T_6), PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage (T_9) and KMB soil applied + NAA 20 ppm spray at flower initiation stage (T_7).

❖ Application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher number of leaves per plant over all other treatments except NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray (T_6).

❖ Maximum dry weight per plant was recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and significantly superior over other treatments.

❖ Foliar application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray(T_{10}) gave significantly higher CGR followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and significantly superior over other treatments.

❖ Maximum RGR was recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and significantly superior than remaining treatments.

❖ Maximum AGR was recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) and significantly superior over other treatments.

❖ Maximum LAI was recorded under Neem coated urea 2% spray at flower initiation (T_2) and statistically at par with remaining treatments except control treatment.

❖ Neem coated urea 2% spray at flower initiation (T_2) gave maximum number of pods per plant, pod length and 100 seed weight followed by T_5, T_6,T_9,T_7,T_2,T_3, and T_5.

❖ Application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher number of seeds per pod.The minimum number of seeds per pod was recorded in control treatment (T_1).

❖ Significantly higher seed yield per plant and stover yield per plant was produced under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5) and significantly superior than remaining treatments.

❖ The data revealed that treatment Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher seed yield (kg/ha), stover yield (kg/ha) and biological yield (kg/ha).The minimum seed yield (kg/ha), stover yield (kg/ha) and biological yield (kg/ha) was recorded in control treatment (T_1).

❖ The different soil and foliar nutrient treatments did not affect the harvest index significantly.

❖ Maximum protein content (%) in seed was recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) followed by NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray (T_5), and Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray (T_6).

❖ Maximum protein yield (kg/ha) was also recorded under Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}). The minimum protein yield (kg/ha) was recorded in control treatment (T_1).

❖ maximum uptake of nitrogen by cowpea crop was found under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_9) PSB + KMB soil applied + NAA 20 ppm spray at flower initiation stage. Maximum uptake of phosphorus was found under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_{10}) Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray. The uptake of potassium was also found maximum under treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray followed by treatment (T_{10}) Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray.

❖ Amongst the soil and foliar nutrient treatments, application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) resulted in maximum gross return ₹99672/ha, net income ₹78570/ha with B:C ratio

4.72. This was closely followed by T_5 (NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray) (gross return ₹93757/ha, net income ₹71052/ha and B:C ratio 4.12),and T_6 (Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray) (gross return ₹93094, net income ₹72039 and B:C ratio 4.42). Minimum gross income (₹65787/ha), net income (₹44882/ha), benefit cost ratio (3.14) were recorded in control treatment (T_1).

Conclusion

From this study it is concluded that different treatments have positive effect on growth and yield of cowpea. Application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher seed yield (1608 kg/ha), net monetary return (₹78570/ha) and B:C ratio (4.72), which was at par with treatment (T_5) NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray, and (T_6) Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray, (1502 kg/ha).

Hence, it is concluded that application of Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1st spray (T_{10}) gave significantly higher seed yield, net monetary return and B:C ratio as well as more economic than other treatments in cowpea.

Suggestions for further work

Since the conclusions are drawn on the basis of results of one-year experimentation, hence, it is suggested that this experiment should be repeated for at least one more year to confirm the findings.

The experiment may also be repeated to confirm the results obtained from the present investigation under different Agro-climatic conditions.

During the course of investigation scorching was also found in some leaves of cowpea under the treatment T_{10} (Neem coated urea 1% + salicylic acid 75 ppm spray at flower initiation and 10 days after 1stspray), T_5 (NPK (18:18:18) 1 % spray at flower initiation and 10 days after 1st spray) and T_6 (Zinc sulphate 0.25 % spray at flower initiation and 10 days after 1st spray). So it is also suggested that concentration should be used very low quantity 1 % instead of 2 %.

REFERENCES

Afshari, M., Shekari, F., Azimkhani, R., Habibi, H. and Fotokin, M.H. (2013). Effect of foliar application of salicylic acid on growth and physiological attributes of cowpea under water stress conditions. *Iran Agricultural Research, Vol.* **32,**No.1.

Ali, E.A. and Mahmoud, Adel. M. (2013). Effect of foliar spray of salicylic acid on seed yield and yield components of Mungbean. *Asian Journal of Crop Science* **5**: 33-40.

Anitha, S.,Sreenivasan, E. and Purushothaman, S.M. (2004). Effect of thiourea application on cowpea [*Vigna unguiculata* (L.) Walp.] productivity under rainfed conditions.*Journal of Tropical Agriculture* **42** (1-2): 53-54.

Anitha, S. Sreenivasan, E. and Purushothaman, S. M. 2005, Response of cowpea (*Vigna unguiculata* (L.) Walp.) to foliar nutrition of zinc and iron in the oxisols of kerala. *Legume Res.,* **28** (40):294-296.

Azarpour, E., Danesh, R. K., Mohammadi, S., Bozorgi, H. R. and Moraditochaee. (2011). Effect of nitrogen fertilizer under foliar spraying of humic acid on yield and yield components of cowpea (*Vigna unguiculata*). *World Applied Science Journal* **13**:1445-1449.

Banasode, Chetana., and Math, K. K. (2018). Effect of foliar fertilization of water soluble fertilizers on growth and economics of soybean in a vertisol. *Journal of Pharmacognosy and Phytochemistry*; **7** (2): 2391-2393.

Chandrashekar, C.N. and Bangarusamy, U. (2003). Maximizing the yield of mung bean by foliar application of growth regulating chemicals and nutrients. *Madras Agric. J.* **90** (1-3): 142-145.

CSLR (2017). Commisonar sattalment land record .gwalior.

Choudhary, G.L. and Yadav, L.R. (2011). Effect of fertility level and foliar nutrition on cowpea productivity. *J. Food Legumes* **24** (1): 67-68.

Deshmukh, S. G., Kale, H. B. and Solunke, P. S. (2008). Influence of graded fertility levels and urea spray on growth, yield and economics of rajmah. *Annals. of Plant Physiol*., **22** (2): 189-191.

Deshmukh, R. P., Nagre, P. K., Wagh, A. P. and Dod, V. M. (2014). Effect of different

biofertilizers on growth, yield and quality of cluster bean. *Indian Journal on Advances in Plant Research* (IJAPR), **1** (2): 39-42.

Dey, Sonu., Prasad, Sant., Tiwari, Prabhat., and Sharma,Prashant. (2017).Effect of urea, KCl, Zinc placement & spray on growth of cowpea. *Journal of Pharmacognosy and Phytochemistry*; *SP* 1: 971-973.

Dixit, P. M., and Elamathi, S. (2007). Effect of foliar application of DAP, urea, and KCL on yield of cowpea. *Legume. Res*. **30** (4): 305-307.

Ebrahim, A., Reza, K. D., Shirin, M., Hamid, R. B. and Maral M, (2011). Effect of urea under foliar spraying on yield and yield components of cowpea.*World applied Sci. J.***13** (6): 1445-1449.

Fisher, R.A. (1921). Some remarks on the method formed in a article on the quantitative analysis of plant growth. *A. Appl. Bio.***7**: 367-372.

Fisher, R.A. (1958). Skeleton Analysis of variance book “Design of Experiment”.

Ganiger*et al.*(1999) stated that the treatments NAA (250 and 500 ppm) and TIBA (25 and 50 ppm) recorded significantly more seed yield (1730, 1751, 1801 and 1722 kg/ha, respectively) as compared to control (1346 kg/ha) and other treatments in cowpea.

Ganiger, T.S., Kareckatti, S.R. and Patil, P.C. (2003). Economics of use of plant growth regulators and urea in cowpea. *Karnataka Journal of Agricultural Science*, **16** (1): 35-38.

Ghildiyal,M.C., (1992). Effect of urea on photosynthesis yield in mungbean. *J.Agron. Crop. Sci*. **168 (**2): 91-94.

GOI (2016-17). Published by Ministry of Agriculture, Govt. of India, the area, production and productivity of cowpea.

Gowthami, P. and Rama, Rao, (2014). Influence of foliar application potassium, boron and zinc on growth and yield of soybean. *Intern. J.food Agri. and Veterinari Sci*., **4** (3): 81-86.

Gupta, K.C., and Saxena, R. (2014). Effect of resource management incowpea for yield

maximization under rainfed conditions. *Journal Crop and Weed,* **11** (1): 146-148.

Haq, M.U. and Mallarino, A.P. (2000). Soybean yield and nutrient composition as affected by early season foliar fertilization. *Agron J.* **92** (1): 16-24.

Hemn Othman Salih., (2013). Effect of foliar fertilization of Fe, B and Zn on nutrient concentration andseed protein of Cowpea *(Vigna unguiculata).IOSR J. Agric. and Veterinary Sci.,* **6** (3): 42-46.

Kandagal, S.S., Panchal . Y.C., and Manjunath .S.,(1990). Effect of growth regulators and nutrients and yield components of mung bean genotype . *J. Maharashtra Agric . Univ.* **15** (2): 199-200.

Khalilzadeh, R.,Tajbakhsh, M. and Jalilian, J. (2012) Growth characteristics of mung bean *(Vigna radiata L.)* affected by foliar application of urea andbio-organic fertilizers. *Intl J Agri Crop Sci*.**4** (10): 637-642.

Krishanaveni, S. A., Palchamy, A. and Mahendran, S., 2004, Effect of foliar spray of nutrients ongrowth and yield of green gram. *Leg. Res*., **27** (2):149-150.

Kumaran, S., and Subramanian, M. (2001). Effect of plant population and methods of nutrient application on yield and economics of blackgram. *Res. on Crops*, **2** (1): 320–322.

Kumar, V. and Kaushik, V.K. (2014). Growth substances reponse to cluster bean [*Cyamposis tetragonoloba* (L.)] growth parameters.*Agriculture for Sustainable Development*, **2** (1): 11-13.

Mahla, Dayanand,H.R.,Rathore,V.S. and Singh ,J.P.(2013). Effect of soil and foliar application of nitrogen on yield attributes and yield of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] under extreme Thardesert conditions. *Res. on crops* **14** (1):130-134.

Muhur, R.N., Datta, N.P., Subramoney Sankar, H., Leley, V.K. and Donaline, L. Vay (1965). Soil testing in India. U.S. Agency for International Development Mission to India pp 39, 40, 45.

Maity,V.,and Bera, A.K. (2009). Effect of exogenous application of brassinolide and salicylic acid on certain physiological and biochemical aspects of green gram. *Indian J. Agric. Res*. **43** :194-19.

Malesha, Patil. K., Murali Basavaraj., Madhu, G.K. and Shruti, M.K.(2014). Effect of foliar spray of water soluble fertilizer on growth and yield of pigeon pea. *Quartely Journal of Life Sciences* **11** : 229-32.

Marimuthu,S. and Surendran,U. (2015) .Effect of nutrients and plant growth regulators on growth and yield of black gram in sandy loam soils of Cauvery new delta zone, India. *Cogent Food and Agriculture* : 2-9.

Mona, E.,Azab,E.,l. (2016). Effects of Foliar NPK Spraying with Micro nutrients on Yield and Quality of Cowpea Plants. *Asian Journal of Applied Sciences*, *ISSN*: 2321-089.

Mondal, M.M.A., and Mondal M.M.A., (2012). Effect of foliar application of urea on physiological characters and yield of soybean. *Legume Res*.,**35** (3) : 202-206.

Mostafavi, K. (2012). Grain yield and yield components of soybean upon application of different Micro nutrient foliar fertilizers at different growth stages. *International J. Agric. Res and Review.**2** (4):389-394.*

Nayak, B. (2001) Uptake of potash by different plants with the use of potash mobilizing bacteria (Frateuria aurantia). *Thesis*, QUAT, Bhubaneswar.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extractions with sodium bicarbonate. *U.S. Dept. of Agric. Circular* 939.

Parasuraman, P., (2001). Effect of seed pelleting with diammonium phosphate and potassium dihydrogen phosphate and foliar spray with diammonium phosphate on growth and yield of rainfed cowpea (*Vigna unguiculata*). *Indian J. Agron*., **46** (1): 131-134.

Patel, M. M., Patel, I. C., Patel, A. G., Acharya, S. and Tikka, S. B. S., 2009, Impact of foliar nutritionof zinc and iron on the productivity of cowpea (*Vigna unguiculata* (L.) Walp.) under rainfed conditions. *J. Arid Legum.,*6(1): 49-51.

Piper, C. (1950) Soil and Plant Analysis. International Public Inc., New York.

Prajapati, K. and Modi, H. A. (2016). Growth promoting effect of potassium solubilizing *Enterobactor Hormaechei (*KSB-8) on Cucumber (*Cucumis sativas*) under

hydroponic condition. *Int. J. Adv. Res. Biol. Sci.*, **3** (5): 168-173.

Rajavel, M., Vincent, S.(2009). Influence of nutrients and hormones on yield maximization of blackgram. *Journal of Ecobiology;* **24** (4):387-394.

Ravanhar, H.N., Borale, V.M., Hodole, S.C., Raut P.D., and Nikesar, R.J.,(2003). Effect of nitrogen level on dry matter, yield and protein content and nitrogen use efficiency of legumes, *New-Agriculturist*, **14** (1/2): 65-69.

Richard, L.A.E. (1954). Diagnosis and Improvement of Saline and Alkaline Soil. *USDA, Washington,* Hand book No.50.

Reddy, M., Padamaja, B., Rao, L.J. and Radha krishana, K.V. (2005). Effect of foliar spray of urea on nitrogen uptake and yield of urd bean under rainfed condition*. Indian J. Dryland Agric. Res.Develop.,***20** (2): 151-154.

Senithkumar., R. (2015). Effect of foliar spray of nutrient and plant growth regulator and morphological traits biochemical parameter and yield of black gram. *Legume Research An International J.***38** (1): 91-95.

Shinde, A. K. and Jadhav, B. B. (1995). Influence of NAA, ethral and KNO_3on leaf physiology and yield of cowpea. *Annals of Plant Physiology*, **9** (1): 43-46.

Singh, B.R. (2007). Effect of thiourea and molybdenum on productivity of Mothbean [*Vigna aconitifolia* (Jacq.) Marechal]. *M.Sc. (Ag.) Thesis, Rajasthan Agricultural University, Bikaner.*

Singh, D. B. and Sharma, T. V. R. S. (1996). Effect of GA_3 and NAA on growth and yield of cowpea (*Vigna unguiculata* (L.) Walp.) variety Arka Garima. *Flora and Founa, Jhansi*, **2** (1): 5-6.

Singh, R. P.; Gupta, S. C and Yadav, A. S (2008) Effect of levels and sources of phosphorus and PSB on growth and yield of black gram (Vigna mungo L. Hepper) Legume Res. ***31*** *(2) :139-141*

Singhal, V. K., Patel, G. G., Deepak, H., Patel, U. K., and Saini, L. K., (2015).Effect of foliar application of water soluble fertilizers on growth, yield and economics of vegetable cowpea. *An International Quarterly Journal of Environmental Sciences Special issue, Vol. VII*: 79-83.

Snedecor, G.W. and Cochran, W.G. (1967) Statistical methods. 6 th Edition, Ames, Lowa, the Lowa state University.

Srinivasan, K. and Ramasamy, M. (1992). Effect of foliar application of urea and DAP on rainfed Cowpea (*Vigna unguiculata*). *Indian J. Agron.* **37** (2): 265-267.

Sritharan, N., Anitha Aravazhi and Mallika Vanangamudi., (2005). Effect of foliar spray of nutrients andplant growth regulators for yield maximization in blackgram. *Madras Agric. J.***92** (4-6): 301-307.

Subbiah and Asija, A.S.(1956). A rapid procedure for the estimation of available nitrogen in soil. *Current Sci.* 259-261.

Sujatha, K.B., (2001). Effect of foliar spray of chemicals and bioregulators on growth and yield of green gram (*Vigna radiata* L.). *M.Sc. Thesis, Tamil Nadu Agric. Univ., Coimbatore.*

Toth, S.J. and Prince,A.L.(1949). Estimation of CEC and exchangeable calcium, potassium and sodium content of soil by flame photometer techniques. *Soil Science.* **67** : 439-445.

Veerabhadrappa, B. H. and Yeledhalli, N. A., 2005, Effect of soil and foliar nutrition on partitioning ofnutrients at different growth stages of groundnut. *Karnataka-J. Agril. Sci.,* **18** (4): 940-945.

Velayutham.V, Kalpna. R, and Muthiah. A.R.(2003).studies on micronutrients fertilization in Urdbeen*. Indian institute of Pulse Research.***5** (1): 177.

Vinoth Kumar C.,Vaiyapuri, K.,Mohmed Amanullah, M. and Gopalaswamy, G.(2013).Influence of foliar spray of nutrients on yields and economics of Soybean. *J.of Bio. Sci.* **13** (6): 563-565.

Walkley, A.J. and Black, I.A. (1934). An estimation of different method for determining soil organic matters and proposed modification of chromic acid titration method. *Soil Sci.* 37-39.

Watson, D.J. (1952). The physiological basis of variation in yield. *Adv. Agron.***4** :101-145.

Yadav, B.D., Joon, R.K. and Rana, D.S. (2003). Effect of thiourea on Cowpea (*Vigna*

unguiculata) productivity under rainfed conditions. *Advances in Arid Legumes Research. In: Indian AridLegume Society, Scientific Publishers (India), Jodhpur. pp.* 239-241.

APPENDICES

APPENDIX – I

Value of mean sum of squares for plant population per meter row length

Source of variation	d.f.	Plant population / m row length at	
		Initial	Final
Replication	2	0.03	0.05
Treatment	9	0.25	0.22
Error	**18**	0.54	0.20

NS – Non Significant

APPENDIX – II

Value of mean sum of squares for plant height

Source of variation	d.f.	Plant height (cm) at			
		20 DAS	40 DAS	60 DAS	Harvest
Replication	2	0.25	0.60	0.58	5.70
Treatment	9	1.17	21.56*****	53.64*****	50.75*****
Error	**18**	0.87	1.90	3.82	3.64

*** Significant at 5% level**

APPENDIX – III

Value of mean sum of squares for number of branches per plant

Source of variation	d.f.	Number of branches per plant at			
		20 DAS	40 DAS	60 DAS	Harvest
Replication	2	0.02	0.00	0.54	0.51
Treatment	9	0.85*****	2.93*****	3.14*****	3.32*****
Error	**18**	0.14	0.29	0.29	0.33

*** Significant at 5% level**

APPENDIX – IV

Value of mean sum of squares for number of leaves per plant

Source of variation	d.f.	Number of leaves per plant at			
		20 DAS	40 DAS	60 DAS	Harvest
Replication	2	0.96	0.09	1.28	0.41
Treatment	9	0.41	13.80*****	17.32*****	18.90*****
Error	**18**	0.49	3.21	0.61	0.85

*** Significant at 5% level**

APPENDIX – V

Value of mean sum of squares for dry weight per plant

Source of variation	d.f.	Dry weight per plant (g) at			
		20 DAS	40 DAS	60 DAS	Harvest
Replication	2	0.11	4.84	0.32	10.43
Treatment	9	0.17	36.45*****	158.78*****	254.75*****
Error	**18**	0.36	2.15	3.58	6.38

*** Significant at 5% level**

APPENDIX – VI

Value of mean sum of squares for CGR

Source of variation	d.f.	CGR (g/m^2/day) at			
		0-20 DAS	20-40 DAS	40-60 DAS	60-Harvest
Replication	2	0.32	4.76	2.60	2.96
Treatment	9	0.26	40.91*****	56.95*****	28.91*****
Error	**18**	0.39	3.47	1.91	2.04

*** Significant at 5% level**

APPENDIX – VII

Value of mean sum of squares for RGR

Source of variation	d.f.	RGR (mg/g/day) at			
		0-20 DAS	20-40 DAS	40-60 DAS	60-Harvest
Replication	2	29.38	39.41	12.81	3.07
Treatment	9	67.06	205.79*****	62.18*****	10.83*****
Error	**18**	74.30	26.14	8.44	2.26

*** Significant at 5% level**

APPENDIX – VIII

Value of mean sum of squares for AGR

Source of variation	d.f.	RGR (mg/g/day) at			
		0-20 DAS	20-40 DAS	40-60 DAS	60-Harvest
Replication	2	0.00	0.01	0.01	0.01
Treatment	9	0.00	0.08*****	0.12*****	0.06*****
Error	**18**	0.00	0.00	0.00	0.00

*** Significant at 5% level**

APPENDIX – IX

Value of mean sum of squares for LAI

Source of variation	d.f.	LAI at			
		20 DAS	40 DAS	60 DAS	Harvest
Replication	2	0.06	0.29	0.12	0.05
Treatment	9	0.00	0.80*****	0.85*****	0.05*****
Error	**18**	0.03	0.05	0.03	0.01

*** Significant at 5% level**

APPENDIX – X

Value of mean sum of squares for yield attributing characters

Source of variation	d.f.	Number of pods /plant	Pod length (cm)	Number of seeds /pod	100 seeds weight (g)
Replication	2	1.81	0.51	0.01	0.00
Treatment	9	34.49*****	5.05*****	4.35*****	1.08*****
Error	**18**	2.00	0.74	0.05	0.15

*** Significant at 5% level**

APPENDIX – XI

Value of mean sum of squares for seed and stover yield per plant

Source of variation	d.f.	Seed yield (g/plant)	Stover yield (g/plant)
Replication	2	48.27	26.91
Treatment	9	34.91*****	79.54*****
Error	**18**	1.07	3.69

*** Significant at 5% level**

APPENDIX – XII

Value of mean sum of squares for seed yield, stover yield, biological yield (kg/ha) and harvest index

Source of variation	d.f.	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Replication	2	8705.98	19686.81	40313.69	13.01
Treatment	9	85517.83*****	91717.59*****	84638.02	23.57*****
Error	**18**	3669.21	15246.48	40039.50	2.27

*** Significant at 5% level**

Appendix – XIII: **Inputs, their market price, rate of use, quantity used and their total cost**

S.No.	Name of input	Market price (₹)	Rate of use	Quantity used	Cost (₹)
1	Seed	100/kg	25 kg/ha	25 kg	2500
2	Carbendazim	100/50g	2.5 g/kg seed	50g	100
3	Neem coated urea	295/50kg	20 kg/ha	43.4 kg	255
4	SSP	297/50kg	40 kg/ha	250 kg	1470
5	MOP	750/50kg	20 kg/ha	33.4 kg	400
6	PSB	300/litre	500 ml/ha	500 ml	150
7	NAA	300/250g	20 mg/l	12 g	514
8	DAP	23/kg	5 g/l	6 kg	626
9	MOP	15/kg	5 g/l	6 kg	590
10	NPK (18:18:18)	150/kg	1 %	12.00 kg	2800
11	Zinc Sulphate	50/kg	2.5 g/l	3 kg	1150
12	KMB	180/litre	500 ml/ha	500 ml	90
13	Thiourea	944/500g	500 ppm	694.44 g	1311
14	Neem coated urea	5.9/kg	1 %	16.94 kg	100
15	Salicylic acid	700/500g	75 ppm	45 g	563
16	Valor 32 (Imazethapyr 30%+Pendimethalin 2%)	750/litre	800 g ai/ha	800 g	1100
17	Rogor (Dimethoate 30% EC)	480/litre	750 g ai/ha	2.5 litre	1000

1. Rent of tractor @ ₹750/h, 2. Labour charge @ ₹250/day, 3.Rate of grain @ ₹ 6000/q, 4.Rate of stover @ ₹100/-

VITA

The author of this Thesis Mr. Amit Chouhan S/o Shri Pappu Chouhan was born on 24 april 1994 at Village and Post-Bhawaniya Buzurg, Tehsil-Dharampuri, Dist-Dhar (M.P.), He completed his H.S.C. (10th) with 47.16 per cent marks from Bal Vikas High School , Chandawad , dhar and H.S.S.C. (12th) with 67 per cent marks from Govt. Boys Higher Secondary School , dhamnod ,dhar (M.P.)

He joined College of Agriculture, Tikamgarh (M.P.), affiliated to Jawaharlal Nehru Krishi Vishwa Vidyalaya, (JNKVV), Jabalpur (M.P.) in 2013 and completed B.Sc. (Ag.) degree in 2017, with 65.90 per cent marks.

He further joined Department of Agronomy, College of Agriculture, RVSKVV, Gwalior, (M.P.) for the post graduation degree programme. He is submitting his Thesis for M.Sc. (Ag) Agronomy Degree in partial fulfilment of the requirements for the degree of Master of Science, he was allotted the research problem entitled "Effect of Soil and Foliar Application of Nutrients on Cowpea [Vigna unguiculata (L.) Walp]" which is duly completed by him and is presented in the form of Thesis and successfully completed the post graduate degree M.Sc. (Ag.) Agronomy in 2019 with 75.30 per cent marks.

Place: *Gwalior*

Date: ***(Amit Chouhan)***