"INFLUENCE OF FOLIAR NUTRITION ON GROWTH AND PRODUCTIVITY OF BLACKGRAM [*Vigna mungo* (L.) HEPPER]"

by

Mr. Landge Parasaram Bhimrav
(Reg. No. 018/007)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

DEPARTMENT OF AGRONOMY

POST GRADUATE INSTITUTE
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2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
Diploma

Place : MPKV, Rahuri

Date : / /2021 **(P.B. Landge)**

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CERTIFICATE

This is to certify that the thesis entitled, **"INFLUENCE OF FOLIAR NUTRITION ON GROWTH AND PRODUCTIVITY OF BLACKGRAM [*Vigna mungo* (L.) HEPPER]"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY,** embodies the results of a piece of *bona fide* research work carried out by **Mr. LANDGE PARASARAM BHIMRAV** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Date : / /2021 (A.V. Solanke)

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Date : / /2021

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Place : M.P.K.V., Rahuri

Date : / /2021 (P.B. Landge)

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LIST OF ABBREVIATIONS

%	:	Per cent
@	:	At the rate
^0C	:	Degree delsius
^0C	:	Degree celsius
$^{-1}$	:	per
B:C ratio	:	Benefit cost ratio
CD	:	Critical difference
Cm	:	Centimeter
d.f.	:	Degree of freedom
DAS	:	Day after sowing
Dm^2	:	Deci meter square
dS m^{-1}	:	Deci siemens per meter
e.g.	:	For example
EC	:	Electrical conductivity
et al.	:	*et alia* (and others)
Fig.	:	Figure
G	:	Gram
GM.	:	General mean
GMR	:	Gross monetary return
ha^{-1}	:	Per hectare
i.e.	:	Edest (that is)
K	:	Potassium
K_2O	:	Potassium oxide
Kg	:	Kilograms
kg ha^{-1}	:	Kilograms per hectare
L.ha	:	Lakh hactares
m^2	:	Square meters
Max	:	Maximum
mg kg^{-1}	:	Miligram per kilogram
Min	:	Minimum
mm	:	Milimeter
Mn	:	Manganese
MOP	:	Muriate of potash
MSL	:	Mean sea level

MT	:	Metric tones
MW	:	Meteorological week
MW	:	Meteorological week
N	:	Nitrogen
N	:	Nitrogen
NMR	:	Net monetary return
No	:	Number
NS	:	Non significant
$P(P_2O_5)$	:	Phosphorus
Ppm	:	Parts per million
PSB	:	Phosphate solubilising bacteria
q ha^{-1}	:	Quintal per hectare
RDF	:	Recommended dose of fertiliser
SA	:	Salicylic acid
SE(m) ±	:	Standard error of mean
T	:	Tonne (s)
viz.,	:	namely
WS	:	Wind speed
yr^{-1}	:	Per Year

ABSTRACT

INFLUENCE OF FOLIAR NUTRITION ON GROWTH AND PRODUCTIVITY OF BLACKGRAM [*Vigna mungo* (L.) HEPPER]

By

Mr. Landge Parasaram Bhimrav

A candidate for the degree
of
MASTER OF SCIENCE (AGRICULTURE)
in
AGRONOMY
2021

Research Guide	:	**Dr. S.K. Kamble**
Department	:	**Agronomy**

The present investigation entitled, "Influence of foliar nutrition on growth and productivity of blackgram" was conducted at Post Graduate Institute Farm, Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri. Dist. Ahmednagar (MS) during *kharif*, 2019.

The field experiment was laid out in randomized block design with seven treatments and three replications. The soil of experimental field was low in available nitrogen (187.32 kg ha^{-1}), medium in phosphorus (14.12 kg ha^{-1}) and medium in potassium (395.10 kg ha^{-1}). The treatments consisted of different fertilizer to blackgram, *viz.,* T_1 - Control (GRDF + water spray), T_2-GRDF+ Urea 2% at pre-flowering, T_3-GRDF + DAP 2% at pre-flowering, T_4 - GRDF+ 19:19:19 (N P K) 1% spray at pre – flowering, T_5 – GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development, T_6 – GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development, T_7 - GRDF+ 19:19:19 (NPK) 1% spray at pre -flowering + KNO_3 @ 1% at pod development. The general recommended dose of fertilizer i.e. FYM 5 t ha^{-1} + 20:40:00 $N:P_2O_5:K_2O$ kg ha^{-1} was applied to all treatment.

Abstract contd….. **Mr. P.B. Landge**

The growth parameters of blackgram *viz.,* plant height, number of branches $plant^{-1}$, leaf area $plant^{-1}$, dry matter $plant^{-1}$, chlorophyll content and root nodulation were significantly higher due to treatment GRDF with foliar applications of DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6).

The yield contributing characters *viz.,* number of pods $plant^{-1}$, pod length, number of seeds $plant^{-1}$, seed weight $plant^{-1}$ (g), test weight (g), seed yield ha^{-1} (kg) and straw yield ha^{-1} (kg) were significantly higher under GRDF with foliar applications of DAP 1 % at pre-flowering + KNO_3 @ 1% at pod development (T_6).

The quality parameters *viz.,* protein content (%) and protein yield (kg ha^{-1}) were significantly higher under treatment GRDF with foliar applications of DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6).

The highest amount of available N (223.89 kg ha^{-1}), available P (15.66 kg ha^{-1}) and available K (447.01 kg ha^{-1}) was recorded under treatment GRDF + Urea 2% at pre-flowering, GRDF + DAP 2 % at pre-flowering and GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development respectively. However, the highest total nitrogen uptake (65.41 kg ha^{-1}), total phosphorus uptake (10.44 kg ha^{-1}) and total potassium uptake (28.68 kg ha^{-1}) was recorded in treatment GRDF with foliar applications of DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6).

The highest net returns(₹ 38158 ha^{-1}) was recorded in treatment GRDF with foliar application of DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6) followed by GRDF with foliar application of Urea 1% at pre-flowering + KNO_3 @ 1% at pod development (T_5) (₹ 34643 ha^{-1}) and minimum net returns (₹ 19834 ha^{-1}) was recorded in treatment(T_1) GRDF with water spray (Control).

It was concluded that GRDF (FYM 5 t ha^{-1} + 20:40:00 $N:P_2O_5:K_2O$ kg ha^{-1}) with foliar application of DAP 1% at pre-flowering + KNO_3 @ 1% at pod development was found best option for the productivity and profitability of blackgram.

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1. INTRODUCTION

Pulses are commonly known as food legumes which are secondary to cereals in production and consumption in India. Pulses play an important source of dietary protein, energy, minerals and vitamins for the mankind. The productivity of pulse crop is declining over years due to various reasons. Among all the yield limiting factors, fertility management is imperative to ensure better crop production on exhausted soils. Farmers generally take up sowing with basal application of nutrients as recommended and there is no regional recommendation of foliar nutrition during crop growth period. Further, soil application of nutrients is often not enough to meet the growing crop demand particularly in short duration crop like blackgram, as it is basically indeterminate in habit of flowering and fruiting, there is a continuous competition for available assimilates between vegetative and reproductive sinks throughout the growth period. Since, the source is highly limited with lowering translocation of assimilates to the growing reproductive parts. Hence, leaf area is a important parameter to obtain higher source in terms of higher assimilation production, it also determines light interception and is an important parameter in deciding plant productivity.

Apart from this, major physiological constraints are flower drop and fruit drop. As it is majorly cultivated under rainfed condition even application of fertilizer at right time and right quantity may not be efficient due to soil moisture. When availability of moisture becomes scarce, application of fertilizers through foliar spray resulted in efficient absorption. Though foliar spray is not a substitute to soil application but it certainly be considered as a supplement to soil application and availability of soluble fertilizers make the task easy. Among the methods of fertilizer application, foliar nutrition is recognized as an important method of fertilization, since foliar nutrients usually penetrate the leaf cuticle or stomata and enters into the cells facilitating easy and rapid utilization of nutrients.

Due to this reason, potential productivity is not achieved and hence there is a need to ensure balanced nutrition at right time to the crop through foliar nutrition. Consequently, applications of nutrient elements through foliar spray at appropriate stages of growth become important for their efficient utilization and better performance of the crop as a balanced fertilization with nutrients in plant nutrition is very important in the production of high yield with high quality seeds. It has been well established that the fertilizer elements, which are absorbed through roots can also be absorbed with equal efficiency through foliage. The United Nations declared 2016 as International year of pulses (IYP) to heighten public awareness of the nutritional benefits of pulses as a part of sustainable food production aimed at food security and nutrition. India accounts for 33 % of world production of pulses.

Due to stagnant production, the net availability of pulses has come down from 60 gm in 1951 to 41.7 g/day/capita in 2016, as against Indian council of medical research (ICMR) which recommends 65 g/day/capita. The total area under pulses in India is around 25.23 million hectares with a production of 19.27 million tonne and productivity of 764 kg ha^{-1} (Instat, 2014). Pulses play an important role in indian agriculture as they restore soil fertility by fixing atmospheric nitrogen through their nodules. Pulses are drought resistant and prevent soil erosion due to their deep root system and good ground coverage, because of these good characters; pulses are called as "Marvel of Nature". Pulses can also be referred to as mini fertilizer factory, as they fix atmospheric nitrogen through symbiosis. Pulses are the most important component of the balanced diet in vegetarian country like India. The steady increase in Indian population together with stagnant production of pulses over the past four decades compared to cereals has naturally resulted in decreased per cent availability of pulses. Therefore, much attention has been given to boost up pulse production in India.

Among pulses, Blackgram (*Vigna mungo* L.) is an important crop in India. It is cultivated since ancient time. It is believe that blackgram is native of India. Blackgram contains 60 per cent carbohydrate, 24-25 per cent protein, 1.3 per cent fat. Blackgram is a small herbaceous annual erect or 30 to 100 cm tall plant. The stem is slightly ridged, covered with brown hairs and much branched from base. The leaves are large, trifoliate, green to dark green in colour. Blackgram have chromosome number 2n=24. It belongs to family Leguminoceae and sub family Papalionaceae. Blackgram require hot and humid growing season. It is a short duration crop suitable for multiple cropping systems and intercropping. It is generally grown as summer and rainy season crop. It can be grown successfully from sea level upto an elevation of 1800 metres. The crop is extensively grown in Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu and Uttar Pradesh. The yield potential of blackgram is very low because of the fact that, the crop is mainly grown in rainfed conditions with poor management practices and also due to various physiological, biochemical as well as inherent factors associated with crop. Apart from the genetic makeup, the physiological factor *viz*., insufficient portioning of assimilates, poor pod setting due to the flower abscission and lack of nutrient during critical stages of crop growth play a major role in declined blackgram production was coupled with a number of diseases and pests (Mahala *et al.,* 2001).

Area, production and productivity of blackgram during 2019-20.

Area (ha)	**Production (tonnes)**	**Productivity (kg ha^{-1})**
340.5	151.2	444

(Source : Agriculture dept govt. of Maharashtra).

The productivity of pulse crop in our country including blackgram is not sufficient enough to meet the domestic demand of the population. Hence, there is an ample scope for enhancement of the productivity of blackgram by proper agronomic practices.

Foliar feeding is one of the most efficient methods of supplying nutrient during critical growth stage. Foliar fertilizers provide available NPK, micro nutrient to induce good crop. It can supply deficient stress crop proper nutrient for a quick recovery. Foliar It can supply proper nutrient for a quick recovery to deficient stress crop nutrient on plant foliage allow for immediate absorption into plant in very short period of time. These immediate uptakes promote better plant health and increase yield potential. Foliar nutrient maintain nutrient balance within plant, which may occur strictly with soil uptake. Absorption of essential nutrient through plant roots may at time is limited by root distribution, soil temperature and soil moisture or soil nutrient imbalance etc factor. Most of nutrient that are foliar feed are mobile and will be transported throughout the plant, potassium is readily absorbed and highly mobile, phosphorus is absorb slow rate but it's also transported a rapid rate.

Foliar application is regarded as preferred solution when quick supply of nutrient is hindered or the soil condition is not conductive for the absorption of nutrient (Salisbury and Ross, 1985). Foliar spray technique helps the nutrient to reach the site of food synthesis directly leading to no wastage and quick supply of food and therefore reduce the requirement of fertilizer. Foliar nutrient can hasten the growth of crop suddenly.

Foliar spray is not substitute to soil application but it certainly be considered as supplement to soil application (Upadhyay *et al*., 1992). Among the method of fertilization application, foliar nutrient is recognized as an important method of fertilization. Since foliar nutrition usually penetrate the leaf cuticle or stomata and enter the cell facilitating easy and rapid utilization of nutrient (Latha and Nadanassababady, 2003).

Urea is diamide of carbonic acid $\{CO\ (NH2)_2\}$, it contains 46 % nitrogen. Urea is white crystalline water soluble compound. Foliar spray of urea improves the photosynthetic rate. Under irrigated condition urea spray @ 2 % recorded highest leaf area $plant^{-1}$. Foliar spray of urea @ 2 % recorded highest plant height in black gram (Sritharan, 2005).

DAP is phosphetic fertilizer, it contains 18 % N and 46% P_2O_5. Foliar application of nutrients using water soluble fertilizer is one of the possible ways to enhance the productivity of blackgram. The foliar application of super phosphate and di-ammonium phosphate was found beneficial for growth and development of plant than soil application. Phosphate helps in increasing pod weight, seed yield of blackgram (Kumar, 2008).

Foliar application of water soluble fertilizer (19:19:19) may be a good option, which enhance yield of pulse crop and reduce the cost of cultivation. Positive effect of supplying legume plants with supplementary nitrogen or balance dose of nutrients particularly at flowering stage was found to have beneficial effect on increasing seed yield (Jadhav and Kulkarni, 2016).

Foliar nitrogen nutrition may induce drought tolerance in crop. Increase in plant height was due to availability of nitrogen and potassium to plants through foliar spray. Potassium regulates the osmotic turgor of cells and water balance, which is driving force for cell division and elongation. Potassium nitrate (KNO_3) be consider the best option because it also provides potassium, which influence water economy and crop growth, through its effect on water uptake, root growth, maintenance of turgor pressure, transpiration and stomata behaviour. Foliar application of KNO_3 contributes in dry matter production (up to some extent) as indicated by delayed flowering. KNO_3 @ 1% spray recorded maximum photosynthetic rate. The reason for the enhanced need for K by plants suffering from environmental stress like drought appears to be related to the fact that K is required for maintenance of photosynthetic and CO_2 fixation.

Upon those consideration, the present investigation is undertaken to study the "Influence of Foliar Nutrition on Growth and Productivity of Blackgram (*vigna mungo* (L.) Hepper)" with following objectives :

1. To study the effect of foliar nutrition on growth, yield and quality of blackgram
2. To study the total uptake of nutrients by blackgram.
3. To work out the economics of blackgram as influenced by different treatments.

2. REVIEW OF LITERATURE

A brief review related to research work conducted in the past on "Influence of Foliar Nutrition on Growth and Productivity of Blackgram (*Vigna mungo* (L.) Hepper)'' is presented in this chapter under various heads.

2.1 Effect of foliar nutrition on growth attributes

Govindan and Thirumurugan (2000) reported that the growth parameters *viz*. LAI in greengram were significantly higher with the foliar spray of 1 % KNO_3 or 1 % KCl and their combination over control.

Hugar and Kurdikeri (2000) observed that combined application method of seed treatment and foliar spray was found better on all growth parameters such as, plant height (37.3 cm), number of leaves per plant (46.2) and plant dry matter (2.4 g per plant) followed by either seed treatment or foliar spray in soybean.

Parasuraman (2001) reported significantly higher plant height and number of branches plant^{-1} of cowpea obtained in the treatment with recommended inorganic fertilizer + 2 % DAP spray twice (first at flowering and second at 15 days after first spray) followed by recommended inorganic fertilizer alone.

Pandian *et al.* (2001) reported that application of basal dose of fertilizer along with 2 per cent DAP spray twice registered higher plant height (73.5 cm) in greengram.

Ramesh and Thirumurugan (2001) stated that foliar applications of 2 per cent DAP and 1 per cent KCl along with benzyl adenine 25 ppm had significantly increased the plant height in soybean.

Manivannan *et al.* (2002) revealed that combined application of Rhizobium seed treatment + foliar application of N, P, K + chelated micronutrients (microsol) at 15, 30 and 45 DAS recorded markedly higher leaf area index ,dry matter production and crop growth rate in blackgram when compared to control (no application).

Chandrasekhar and Bangarusamy (2003) revealed that foliar application DAP 2 % + SA 100 ppm + KCl 1 % + NAA 40 ppm recorded higher total dry matter production of (19.81 g plant^{-1}) over the control in green gram.

Shinde and Bhilare (2003) revealed that application of 2 per cent DAP at 65 DAS through foliar spray recorded higher plant height (55.72 cm), number of branches (29.15 $plant^{-1}$) and dry matter $plant^{-1}$ of (33.15 g) compared to control in chick pea.

Sritharan *et al*.(2005) indicated that, in blackgram foliar application of 2 % urea at the time of vegetative to pod filling stage, the crop shows significant increase in the growth characters like plant height (24.50, 62.30, 66.00, respectively) and leaf area (573, 69, 924.70 and 966.50, respectively) at three stages of crop growth like vegetative, flowering and pod filling stage.

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

Mahobia *et al*. (2006) revealed that the maximum plant height and dry matter production of pigeon pea were recorded At harvest with 2 % DAP spray at 50 % flowering compared with 1 % DAP during *kharif* season at the Indira Gandhi Agriculture University, Raipur.

Dixit and Elamathi (2007) showed that foliar application of DAP, micronutrient and NAA recorded an increase in plant height (3.4 %) and dry matter production (20.1 %) when compared to control (no foliar application). Foliar application of nutrient and growth regulator at pre flowering and flowering stages resulted in reduced percentage of flower drop in green gram.

Malay and Bhowmick (2008) conducted two-year field trail during *rabi* season of 2003-04 and 2004-05 at pulses and oilseed research sub-station, Beldanga, Murshidbad (West Bengal) to assess the effect of basal as well as foliar application of nutrients on growth and yield of lentil and observed that foliar spray of either urea or di ammonium phosphate (DAP) at 2 % solution twice at pre-flowering and 10 days thereafter in lentil remarkably increased the crop height 33.79 cm and 32.60 cm over control (30.86 cm).

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 rajma over two spray at 25 % pod initiation + pod development.

Kumar *et al.* (2008) observed significant increase in growth characters like plant height (47.5 cm), dry matter production (2576 kg ha^{-1}) and leaf area index (3.74) of blackgram by foliar application of DAP @ 2 per cent at flowering and pod development stage as compared to no foliar spray.

Gupta *et al.*(2010)reported that foliar application of DAP and urea at the rate of 2 % in greengram has significantly increased plant height (64.5 cm) steadily up to 60 DAS and leaf area index (5.0) than basal application of fertilizers and sprayed with distilled water.

Mondal *et al.* (2011) conducted field experiment Bangladesh Agri University revealed that foliar application of N or N plus micronutrients increased leaf area, chlorophyll content, total dry mass, reproductive efficiency; yield attributes and yield over the control.

Venkatesh and Basu (2011) studied the effect of foliar application of urea on growth, yield and quality of chickpea under rainfed conditions and concluded that foliar application of urea apart from the basal application of RDF increased branching in chickpea by 8-23 per cent over no spray or water spray.

Beg and Ahmad (2012) reported that application of potassium at 1 kg ha^{-1} as foliar spray at the time of flowering in addition to half basal fertilizer dose showed maximum enhancement of growth characters like height of the plant, length of petiole, length and breadth of lamina, number of stomata per unit area, length and breadth of guard cell, length and breadth of stomatal aperture and length of pod in mungbean.

Khalilzadeh *et al.* (2012) reported that foliar application of urea at 1 % recorded higher growth parameters like plant height (10.25 cm), leaf area (9.84 cm^2) and dry weight of shoot of 1.24 g $plant^{-1}$ in mungbean.

Shashikumar *et al.*(2013) reported that application of RDF as a basal dose and foliar spray of 40ppm NAA + 0.5 % chelated micronutrient + 2 % DAP given at 35 and 50 DAS recorded significantly higher growth components like plant height (37.11 cm), number of branches (8.27 $plant^{-1}$), leaf area index (4.18), and total dry matter production (15.98 g $plant^{-1}$) in blackgram.

Vekaria *et al.* (2013) reported that foliar application of potassium nitrate significantly affected the stem growth rate, leaf growth rate and root growth rate of green gram plant.

Amin *et al.*(2014) result show that exogenous application of thiourea either separately at 2,50,500 and 1000 mg l^{-1} and Asp A at 50,100 and 150 mg l^{-1} or any of their combinations, promoted almost all growth criteria compared to corresponding untreated control plants (i.e. neither treated with TU or Asp A) and also significantly increased the Chlorophyll- a, b, and carotenoids more than controls at 75 and 90 DAS in faba bean.

Gowthami and Rao (2014) revealed that foliar application of potassium nitrate @ 2 % + boric acid @ 50 ppm + zinc sulfate @ 1 % (T_7) at 30 and 60 DAS was found to be superior in increasing the CGR, RGR, NAR, LAI, SLW, LAR and seed yield, followed by potassium nitrate @ 2 % + boric acid @ 50 ppm at 30 and 60 DAS (T_4), boric acid @ 50 ppm + zinc sulfate @ 1 % at 30 and 60 DAS (T_6) and potassium nitrate @ 2 % + zinc sulfate @ 1 % at 30 and 60 DAS (T_5) whereas lower values were recorded in control.

Bansal and Ahmad (2015) revealed that Growth attributes were significantly found higher under application of 100 % RDF, 50% RDF + 2 % urea spray at 40 DAS in green gram over control.

Sritharan *et al.*(2015) found that foliar spray of 2% urea had the profound effect in improving the growth attributes, chlorophyll content, soluble protein and nitrate reductase activity in blackgram.

Mudalagiriyappa *et al.*(2016) results indicated that spray of water soluble fertilizer (19:19:19) at 1.5 % concentration at flowering and pod development stage along with basal application of fertilizers (13.5: 25: 25 kg N, P_2O_5, K_2O) significantly increased growth attributes in green gram.

Rao *et al*. (2016) reported that spraying of 2 % urea increase plant height, leaf area, and shoot dry weight by increasing total chlorophyll content, photosynthetic rate of green gram.

2.2 Effect of foliar nutrition on yield attributes and yield

Parasuraman (2001) reported significantly higher pods plant^{-1}, seeds pod^{-1}, and seed yield of cowpea obtained in the treatment with recommended inorganic fertilizer + 2% DAP spray twice (first at flowering and second at 15 days after first spray) followed by recommended inorganic fertilizer alone. The yield increase was due to 2 % DAP spray over recommended inorganic fertilizer application was 18.9 per cent.

Pandian *et al.*(2001) reported that application of basal dose of N and P along with 2 % DAP spray registered significantly higher number of pods plant^{-1} and 100 seed weight as compared to control in greengram.

Sarkar and Malik (2001) revealed that foliar application of potassium nitrate effects on yield attributing characters of grasspea. Foliar spray of KNO_3 at 0.50 % during 50 % flowering stage showed maximum values of pods plant^{-1}, length of pod, seeds pod^{-1} and 1000 seed weight; it was significantly superior to water spray and unsprayed control.

Yadkari and Thatikakunta (2002) reported that application of lower dose of potash and spraying of DAP at pre flowering and pod initiation in blackgram gave a seed yield of 13.8 qt ha^{-1} and which gave 66 per cent more yield compared to control.

Chandrasekhar and Bangarusamy (2003**)** observed that, foliar application of DAP (2%) + salicylic acid (100 ppm) + KCl (1%) + NAA (40 ppm) significantly increased the number of pods per plant (19.45) and seed yield (1443.38 kg ha^{-1}). However, these treatments were on par with DAP two per cent (13.2, 1162.41 kg ha^{-1}, respectively) in greengram.

Radhamani *et al.*(2003) revealed that spraying of DAP (2%) in combination with NAA (40 ppm) at 50 per cent flowering stage of greengram recorded the highest (874 kg ha^{-1}) seed yield due to increased number of pods per plant, seeds per pod and pod yield. Individual application of either DAP or NAA recorded lesser seed yield than their combinations. Control recorded the lowest (552 kg ha^{-1}) seed yield.

Thalooth *et al.* (2006) conducted field experiment to study the effect of foliar application of zinc and potassium on mungbean and observed that application of K_2O @ 24 kg ha^{-1} had a significant effect on number of pods plant^{-1} (22.25), number of leaves plant^{-1} (14.50), pod dry weight (11.83 g), while zinc application was superior with respect to straw yield (2034.82 kg fed^{-1}) and biological yield (2690.61 kg fed^{-1}).

Thakare *et al*. (2006) observed that application of 50 % RDF along with 2 % DAP and 50 ppm IAA at 20 and 35 at DAS recorded the highest number of pods per plant (41.1), 100 seed weight (5.00 gm) and seed yield per plant (15 gm) in soybean over recommended dose of fertilizer.

Dixit and Elemathi (2007) observed that, foliar application with DAP (2 %) + NAA (40 ppm) + B (0.2 %) + Mo (0.05 %) at 30 DAS on greengram increased the seeds per pod (25.86), 1000 seed weight (30.33), grain yield (10.16 q ha^{-1}) and haulm yield (30.33 q ha^{-1}) over no spray.

Ganapathay *et al.* (2008) conducted field experiment during *rabi* season of 2000 and 2001 and revealed that Foliar application of DAP 2 percent + NAA 40 ppm + $ZnSO_4$ 0.5 % + $FeSO_4$ 1 % twice (Pre flowering + Flowering) + soil inoculation of phosphobacteria recorded significantly highest reproductive efficiency and grain yield of rice fallow pulses during both the years.

Manonmani and Srimathi (2009) concluded that, spraying with 2 % DAP followed by urea one per cent recorded higher 100 seed weight (5.6 and 5.5 g), seed yield (1240 and 1040 kg ha^{-1}). Further, the seed germination per cent (92 and 88 %, respectively) in blackgram.

Rajavel and Vincent (2009) investigate that foliar spray of 2 % urea recorded the highest yield of 955 kg/ha followed by foliar spray of KCl 1 % along with soil application of humic acid @ 20 kg ha^{-1} (926 kg ha^{-1}). 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 blackgram.

Kuttimani and Velayutham (2011) conducted experiment on foliar application of nutrients and growth regulators on yield and economics of greengram and revealed that foliar application of 2 % DAP +100 ppm salicylic acid + 0.05 % sodium molybdate twice at vegetative and flowering stages of crop growth recorded better yield parameters (number of seeds per pod and 100 seed weight) and economics.

Verma *et al*. (2011) revealed that application of foliar spray at 45 day after sowing increased growth, yield attributing characters and grain yield (22 %) as well as nutrient content and uptake by greengram over control.

Rajesh (2011) reported that foliar application of 1 % polyfeed (19:19:19) and 1 % multi K enhanced higher plant height, number of pods per plant, pod weight and grain yield. Among the different foliar nutrition spray treatments, foliar spray of 1% polyfeed and 1 % multi K recorded highest grain yield of 1062 and 940 kg ha^{-1} during *kharif* (2010) and *summer* (2011) respectively. It increased grain yield of 50.8 and 25.6 percentage during *kharif* (2010) and *summer* (2011) seasons respectively.

Beg and Ahmad (2012) reported that potassium application at 1 kg ha^{-1} as foliar spray at the time of flowering in addition to half basal fertilizer dose showed the yield attributes like number of pods per plant, number of seeds per pod and 1000 grain weight showed maximum increase with application of 0.8 kg ha^{-1} applied as foliar spray at the time of flowering with half basal fertilizer dose.

Ezzat *et al*. (2012) conducted an experiment on soil and foliar fertilization of mungbean and reported that P fertilization significantly increased mungbean pod weight $plant^{-1}$, 100 seed weight, yield per plant and hectare compared with control. Mungbean seed yield per hectare was showed more responsible for foliar applied N than that with K. The higher seed yield per hectare reported from combined effect of 70 kg P_2O_5 and foliar spray of N. Foliar spray show significant effects on carbohydrate percentage and carbohydrate yield per hectare of mungbean seed. Foliar spray of urea combine with Fe or Zn increased seed yield and improved quality of seed.

Mondal *et al*. (2012) studied the effect of foliar application of urea on physiological characters and yield of soybean and revealed that foliar application of urea at 1.5 % three times at reproductive stages may be used for getting increased seed yield in soybean (3.19 t ha^{-1}).

Basavarappa *et al.* (2013) reported that application of RDF as basal dose and foliar spray of 40 ppm NAA + 0.5 % chelated micronutrient+ 2 % DAP at 35 and 50

DAS recorded significantly higher growth components like plant height (37.11),number of branches (8.27 plant^{-1}) leaf area index (4.18) and also higher grain yield (1298 kg ha^{-1}).

Shashikumar *et al.* (2013) revealed that that application of RDF as a basal dose and foliar spray of 40 ppm NAA + 0.5 % chelated micronutrient + 2 % DAP given at 35 and 50 DAS recorded significantly higher grain yield (1298 kg ha^{-1}), net returns and B:C ratio (52,900 ha^{-1} and 3.03, respectively), over rest of the treatments but it was at par with RDF + foliar spray of 2 % DAP + 0.5 % chelated micronutrient.

Kumar *et al.* (2013) revealed that foliar spray of 2 % DAP twice at flower initiation and pod formation stages of crop growth resulted in significantly higher number of pods plant^{-1} (62.50) , no. of seeds pods, seed index and higher grain yield (1460 kg ha^{-1}). It was on par with foliar spray of 2 % urea phosphate and TNAU pulse wonder spray on soybean.

Rao *et al*. (2013) conducted an experiment to study the effect of foliar nutrition on antioxidant enzymes, photosynthetic rate, dry matter production and yield of mungbean under receding soil moisture condition and reported that under receding moisture condition (moisture stress) KNO_3 @ 1 % prove superior over other foliar spray by recording more plan height, leaf area, shoot dry weight and photosynthesis rate by mitigating high leaf purloin content, peroxide activity sod activity. Under irrigated condition spray of urea 2 % gave higher yield. KNO_3 @ 1 % produced higher yield under receding moisture condition compared to other. Among all treatment control recorded low yield.

Bansal and Ahmad (2015) conducted field experiment during summer season of 2012 at Muzafferpur. Results revealed that the growth and yield attributes were significantly higher found under application of 100 % RDF, 50 % RDF + 2 % urea spray at 45 days.

Das and Jana (2015) conducted experiment to study the effect of water soluble fertilizer on growth and yield of greengram and reported that higher seed yield of pulses (greengram, black gram, lentil) were recorded with application of 2 % urea spray over basal dose of fertilizer application. Under basal dose of fertilizer application, results showed that a gradual increase in yield with increase in concentration of NPK (19:19:19) fertilizer up to 2 %. Among the fertilizer spray, treatments irrespective of basal dose of fertilizer, urea spray was significantly better than all other treatment.

Deotale *et al*. (2015) study the effect of two foliar sprays of $Ca(NO_3)_2$ (0.25, 0.50, 0.75 and 1 %) and KNO_3 (0.25, 0.50, 0.75 and 1%) on morpho-physiological traits and yield of green gram. Data revealed that foliar application of 0.50 % KNO_3 followed by 0.50 % $Ca(NO_3)_2$ significantly increased plant height, leaf area, number of branches, dry matter, RGR , NAR, number of pods plant^{-1}, 100 seed weight, yield plant^{-1}. Among the foliar spray treatments, spray of 0.5 % KNO_3 and 0.5 % $Ca(NO_3)_2$ increased grain yield by 23 and 19 per cent, respectively over control.

Sengupta and Tamang (2015) reported that foliar application of nutrients (urea and DAP) had significantly influenced the growth and yield of green gram.

Marimuthu and Surendran (2015) reported that application of 100 % RDF + 2% DAP was recorded higher plant growth (27.2 cm), number of pods plant^{-1} (37.15), yield of black gram (1162 kg ha^{-1}) and benefit cost ratio (2.98) over the other treatments. The lowest black gram yield (730 kg ha^{-1}) recorded under control.

Sritharan *et al.* (2015) studied that 2 % urea had the profound effect in improving the total chlorophyll content, soluble protein content and nitrate reductase activity. Foliar sprays of 2 % urea recorded the highest grain yield of 950 kg ha^{-1}. The yield enhancement may be due to the improved morphological, physiological, biochemical and yield parameters, *viz*., plant height, number of pods per plant, grain yield, harvest index, chlorophyll content, soluble protein content and nitrate reductase activity.

Jadhav and Kulkarni (2016) reported that among different sources of nutrients, foliar spray of 19:19:19 (1 %) followed by panchagavya (5 %) at flower initiation stage recorded significantly higher grain yield (1121 and 1105 kg ha^{-1}, respectively) of Greengram compared to other treatments. Control treatment recorded the lowest yield (734 kg ha^{-1}) among all.

Swati Koneni (2016) revealed that the growth attributes *viz*., plant height, number of functional leaves plant^{-1}, leaf area plant^{-1} , number of branches plant^{-1}, number of nodules plant^{-1} and total dry matter accumulation plant^{-1} were significantly influenced and recorded higher values by the treatment with 50 kg P_2O_5 ha^{-1} along with foliar application of BOOST-52 at 30 and 45 DAS.

Rao *et al.* (2016) conducted field experiment during Rabi season of 2012-13 at Regional Agricultural Research Station, Lam, Guntur, with an aim to find out effect of foliar nutrition on physiological and biochemical parameters of mungbean (*Vigna radiata* (L.) Hepper) under irrigated conditions. Among foliar nutrients, Urea @ 2 % recorded higher yield and proved superior over other foliar sprays.

Sadia *et al.* (2016) conducted an experiment to investigate the mitigation of drought stress by foliar application of salicylic acid and potassium in mungbean and result showed that number of pods, number of seeds pod^{-1} , test weight and seed yield significantly increased over control (water spray). Significant increase the number pod $plant^{-1}$, number of seed $plant^{-1}$, test weight, yield and grain yield with foliar application of nutrients.

Pavithra *et al.* (2017) reported that Among the foliar application of nutrients, significantly higher grain yield (612.35 kg ha^{-1}), number of seeds pod^{-1} (6.17), highest pod length (4.24 cm), higher number of cluster $plant^{-1}$ (5.57), higher number of pods $plant^{-1}$ (27.37), higher endosperm content.

Mahashwari and Karthiki (2017) foliar nutrient sprays *viz*., 2 % DAP, 1 % KCL, 1 % boron, 1 % $MgSO_4$, 1 % $ZnSO_4$ reported that (35.74 %), viscosity (257.12 cps^{-1}), test weight (3.60 g), net returns (13230 ha^{-1}) and B:C ratio (2.00) was associated with foliar spray consisting of 2 % DAP at 25 and 45 DAS as compared to other treatments.

Patel *et al*. (2019) revealed that an application of 40 kg $P_2O_5ha^{-1}$ was recorded significantly higher seed yield (1168 kg ha^{-1}), haulm yield (2475 kg ha^{-1}), protein content (19.34 %), N (3.09 and 0.59 %) and P (0.71 and 0.58 %) content in seed and haulm over control, respectively.

2.3 Effect of foliar nutrients on quality parameters of blackgram

Sathiyamoorthy and Vivekanandan (1988) observed that foliar spray of KNO_3, thiourea and DAP increased the protein yield without affecting the oil content in soybean in moderate saline or alkaline soil.

Amany (2007) studied the effect of foliar application of urea on yield and yield components of chickpea with four urea foliar application treatments such as one per cent urea sprayed at flowering, at pod set, pod filling and (control) unsprayed. Treatment of one per cent urea foliar application at pod filling resulted in highest protein content in seed (25 %).

Venkatesh and Basu (2011) studied the effect of foliar application of urea on growth, yield and quality of chickpea and recorded an increase in grain protein content of 17.88 to 19.31 percent which was due to increased nitrogen availability for seed filling.

Amin *et al.* (2014) reported that foliar application of thiourea @ 500 ppm in greengram increased the crude protein (24.1 %) over control (22 %) and also improve N, P and K status of seed.

Kurhade *et al.* (2014) revealed that, application of RDF + 40 kg K_2O ha^{-1} and RDF + foliar spray of KCl 1.5 percent (at flowering and 10-15 days after flowering) recorded significantly higher protein content (22.16 %) and (20.47), respectively over the RDF alone control treatment.

Sritharan *et al.* (2015) studied that 2 % urea had the profound effect in improving the total chlorophyll content, soluble protein content and nitrogen reductes activity.

2.4 Effect of foliar nutrition on nutrient uptake

Tisdale *et al.* (1995) foliar nutrition is recognized as an important method of fertilizer application since foliar nutrient usually penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients.

Muthuvel *et al.*(1985) reported that, foliar spray of DAP @ 2 % and urea 1 % at flowering stage, soil nutrient status was increased with the available N, P and K status of soil (131, 6.3 and 134 kg ha^{-1}, respectively) of rainfed black gram compared to no foliar spray.

Manjula Devi and Pillai (1997) observed that foliar application of urea @ 2 per cent at three growth stages on four promising genotypes of blackgram LBG-20 in combination with two per cent urea spray at pre-flowering + flowering + pod development stages recorded higher nutrient uptake of NPK (80.6, 9.5, 13.4 kg ha^{-1}) as compared to other treatment combination. Mazhar and Mallarino (2000) showed that foliar fertilization increased tissue N–P–K composition, nutrient uptake, photosynthesis, or plant weight measured at the growth stage in soybean.

Elayaraja and Angayarkanni (2005) concluded that, foliar application of DAP 2 % at 20, 30 and 45 DAS resulted in higher NPK uptake in both seed (43.03, 46.22 and 6.85 kg ha^{-1}, respectively) and haulm (5.39, 8.18 and 15.01 kg ha^{-1}, respectively).

Reddy *et al*. (2005) reported that nitrogen uptake by seeds of urdbean increased significantly with 2 % urea spray at 30, 40 and 60 DAS over absolute control on clay loam soil of Warangal blackgram.

Raman and Venkataramana (2006) studied the effect of foliar nutrients on NPK uptake, yield attributes and yield of green gram on inceptisol at Kanpur. The results revealed that foliar spray of DAP @ 2 % with NAA 30 ppm and penshipao @ 0.01 % at 20 and 45 DAS recorded higher NPK (69.01, 18.19 and 65.71 kg ha^{-1}, respectively) uptake over control (58.66, 12.97 and 53.68 kg ha^{-1}, respectively).

Thakare *et al*. (2006) reported that nitrogen content in leaves of soybean increased with foliar fertilization of 2 % urea + 50 ppm IAA at 20 and 35 DAS over recommended dose of fertilizer during *kharif* season at Collage of Agriculture, Nagpur.

Dixit and Elamathi (2007) observed that, foliar spray of DAP two per cent + NAA 40 ppm + Bo 0.2 % + Mo 0.05 % at 30 DAS resulted in significantly increased the NPK uptake and protein content over control.

Ingale *et al.*(2007) from College of Agriculture, Nagpur, during *Kharif* 2005-06, studied the influence of two foliar sprays of 2-3 % cow urine and 50 ppm NAA on nutrient uptake. Data revealed that treatment 6 % cow urine + 50 ppm NAA significantly increases the leaf nitrogen (5.15 %), phosphorus (1.08) and potassium (1.54 %) over control (3.64, 0.85 and 0.68 % of NPK).

Kuttimani and Velayutham (2011**)** observed that nutrient uptake by green gram was higher at 45 DAS and reduced At harvest stage in which N, P and K uptake was 17.8 kg, 3.65 kg and 20.5 kg ha^{-1}, respectively when the plants are supplied with 0.05 g sodium molybdate + 2 % DAP +100 ppm Salicylic acid.

Venkatesh and Basu (2011) found that higher leaf nitrogen content (3.46 %) was recorded with three foliar application of urea sprayed at 60, 75 and 90 DAS than the control (3.16 %) under rainfed condition in chick pea.

Verma *et al*. (2011) found that foliar application of 2 % urea significantly increased the nutrient (N, P and K) and protein content (%) in grain and uptake and protein yield kg ha^{-1} over control of greengram.

Goud *et al*. (2014) found that foliar application of KNO_3 twice at flowering and 15 days thereafter recorded higher uptake of nutrients over their single spray at flowering stage followed by RDF alone and absolute control.

Kurhade *et al.* (2014) revealed that application of RDF + foliar spray of KCL 1.2 % (at flowering) significantly increased the uptake of N, P and K over the RDF alone.

Bansal and Ahamad (2015) conducted field experiment during *summer* season of 2012 at muzaffarpur and found that 50 % RDF + 2 % urea spray at 40 DAS influenced significantly available nitrogen (197.78 kg ha^{-1}), phosphorus (17.49 kg ha^{-1}) and potassium (126.87 kg ha^{-1}) over control.

Mudalagiriyappa *et al*. (2016**)** found that foliar application of water soluble fertilizer significantly increased the uptake of NPK in Chick pea. Nitrogen and potassium uptake recorded 98.5 and 81.8 kg ha^{-1} respectively at 1.5 per cent percent WSF at flowering as well as pod development.

2.5 Effect of foliar nutrients on economic parameters of blackgram

Yakadri and Thatikunta (2002) reported higher B: C ratio (3.78) due to application of potash alone or in combination of foliar spray of DAP two per cent at flowering and pod development stage for blackgram.

Shinde and Bhilare (2003) observed that foliar spray of DAP @ two per cent at two different growth stages, recorded the higher gross monetary returns (Rs. 49726 ha^{-1}), net monetary returns (₹. 32466 ha^{-1}) and benefit cost ratio (2.87) in chickpea.

Chandrasekhar and Bangarusamy (2003) revealed that the highest cost benefit ratio (3.47) was registered with foliar spray of DAP @ 2 % which signifies that foliar spray with DAP is the cheapest agronomic practice in achieving good grain yield with minimum production cost in greengram.

Behera *et al.* (2007) conducted a experiment on sandy loam soil of Allahabad to study the effect of foliar spray of DAP and growth regulators on yield attributes indicated that, 2 % foliar spray of DAP and NAA 40 ppm twice at 25 and 35 days after sowing resulted in higher benefit cost ratio (2.58) in greengram.

Dixit and Elamathi (2007) studied the effect of DAP (2 %), NAA (40 ppm), boron (0.2 %) and molybdenum (0.05 %) as foliar spray on K-851 greengram (*Vigna radiata* L.) and it was recorded maximum B : C ratio of 1.97 with significant increase in growth and yield of crop.

Deshmukh *et al.*(2008) observed the higher net monetary return (₹ 6491 ha^{-1}) and benefit cost ratio (1.53) with 1% urea spray at pre-flowering + 25 % pod initiation + pod development in rajma during *rabi* season.

Gupta *et al.* (2011) reported that foliar application of 2 per cent urea in chickpea at flowering and 10 days after along with biofertilizers resulted in maximum net return (₹ 5608 ha^{-1}) over the control which was attributed to increased grain yield.

Kuttimani and Velayutham (2011) stated that foliar application of nutrient solution of DAP (2 %) + sodium molybdate (0.05 %) at 30 and 45 DAS in greengram resulted in higher B : C ratio mainly due to less cost of inputs and higher net returns.

Yadav and Choudhary (2012) studied the effect of fertility levels and foliar nutrition on profitability, nutrient content and uptake of cowpea (*Vigna ungiculata* L.) and concluded that foliar spray of 2 % DAP recorded higher net returns (₹ 24039 ha^{-1}) compared to 2 per cent urea and 2 per cent KCl.

3. MATERIAL AND METHODS

A field experiment entitled "Influence of foliar nutrition on growth and productivity of blackgram (*Vigna mungo* (L.) Hepper.) '' was conducted during *kharif* season of 2019.

The details of material used and methods adopted during the course of investigation are described in this chapter under following sub heads.

3.1 Details of Experimental Materials

3.1.1 Experimental site

The field experiment was conducted at Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during *kharif* season of 2019.

3.1.2 Soil

The topography of experimental field was uniform and levelled. The soil of experimental field was medium deep and textural class was clay loamy with more than 30 cm depth. The physical and chemical properties of the experimental field was assessed by randomly selecting soil samples from 0-30 cm depth and from five different locations before layout of the experimental field. These samples were thoroughly mixed and prepared the composite sample was drawn and analyzed in Post Graduate Student Laboratory, Department of Agronomy, M.P.K.V Rahuri by using standard analytical methods presented in Table 3.1.

Data presented in table.3.1 showed that the soil physical properties *viz*., field capacity (37.30 %), permanent wilting point (18.10 %), bulk density (1.24 Mg m^{-3}), soil porosity (53.21 %) indicate that soil was moisture retentive. The soil chemical properties *viz*., pH, EC and organic carbon content were 8.25, 0.26 dSm^{-1} and 0.40 per cent, respectively with low in available nitrogen (187.32 kg ha^{-1}), moderate in available phosphorous (14.12 kg ha^{-1}) and very high in available potassium (395.10 kg ha^{-1}).

Table 1. Physical and Chemical properties of experimental soil

Sr. No	Characteristics	Composition	Method used	Reference(s)
A.	**Physical composition**			
1.	Particle size distribution			
1.	Particle size distribution			
	Sand (%)	22.3	International pipette method	Piper (1966)
	Silt (%)	26.4		
	Clay (%)	51.3		
	Textural class	Clay loam		
2.	Bulk density (g cm^{-3})	1.24	Core sampler	Dastane (1972)
3.	Moisture at - 1/3rd bar	37.30	Pressure plate apparatus	Black (1965)
4.	Moisture at -15 bar	18.10		
5.	Available soil moisture (%)	19.20	Gravimetric	Dastane (1972)
B.	**Chemical composition**			
1.	Soil pH (1:2.5)	8.25	Potentiometry	Piper (1966)
2.	EC (dSm^{-1})	0.26	Conductometry	Piper (1966)
3.	Organic carbon (%)	0.40	Wet oxidation	Nelson and Sommer (1982)
4.	Available N (kg ha^{-1})	187.32	Alkaline potassium permanganate	Subbiah and Asija (1965)
5.	Available P (kg ha^{-1})	14.12	0.5M $NaHCO_3$ (pH 8.5)	Olsen *et al.* (1954)
6.	Available K (kg ha^{-1})	395.10	Flame Photometer	Knudsen *et al.* (1982)
c.	**Plant analysis**			
a.	Nitrogen	--	Micro-Kjeldhal"s	Jackson (1973)
b.	Phosphorus	--	Vandomolybdate phosphoric yellow colour method in nitric acid system	Jackson (1973)
c.	Potassium	--	Flame photometric	Champman and Patil (1961)

3.1.3 Cropping history of experimental plot

Cropping history of experimental plot for preceding two years of commencement of the investigation is given in Table 2.

Table 2. Cropping history of the experimental plot

Year	*Kharif*	*Rabi*	Summer
2017-18	Soybean	Gram	Fallow
2018-19	Greengram	Wheat	Fallow
2019	Blackgram (present investigation)	-	-

3.1.4 Climate and weather conditions

Geographically, the Central Campus Farm of Mahatma Phule Krishi Vidyapeeth, Rahuri is situated between 19^0 18'N and 19^0 57'N latitude and 74^0 35'E and 74^0 19' E longitude. The altitude varies from 495 to 556 m above mean sea level. This area falls in the semi-arid tropics with an annual rainfall ranging from 307 mm to 619 mm, the average rainfall is 520 mm. The rainfall is erratic and distributed unevenly in 15 to 45 rainy days. Out of the total annual rainfall, about 80 per cent receives from South-West monsoon during June to September and rest of the rainfall receives from North-East monsoon during October and November and practically negligible rain received during summer.

The climatic conditions prevailed during experimental period expressed through data on weekly means meteorological weather parameter *viz.*, maximum and minimum temperature, relative humidity, sunshine hours, wind velocity, rainfall and pan evaporation were obtained from Meteorological Observatory located at AICRP on Irrigation Water Management Project, Mahatma Phule Krishi Vidyapeeth, Rahuri and are presented in Table 3.2.

The Blackgram crop was sown on July 11^{th} 2019 and harvesting was undertaken on September 20^{th} 2019. The rainfall received during the crop growth period was 266.6 mm in 18^{th} rainy days, in July, August and September month. The rainfall received in the month of June (77 mm) was useful for land preparation and rainfall received in July and august month was 137.4 mm and 91 mm respectively, which was found helpful for vegetative and reproductive growth of crop.

During the crop growing season the maximum temperature ranges between 27^0C during 31^{th} MW to 33.8^0C during 29^{th} MW. The minimum temperature varied from 23.6^0C during 30^{th} MW to 21.3^0C during 34^{th} MW.

The mean relative humidity ranged from 38 to 88 per cent at morning and 14 to 77 per cent at evening. The maximum relative humidity (88 %) was observed during 31^{th} meteorological week at morning hours and minimum relative humidity (38 %) was noticed during 21^{th} meteorological week. The wind speed was in the range of 1.6 to 8.3 km hr^{-1} and bright sunshine hours were ranged from 0.2 to 10.9 hours. Bright sunshine hours were lower than normal helped to the crop to utilize the available soil moisture.

Table 3. Weekly meteorological data collected on different weather parameters during experimental period

MW No.	Date	Temp (^{0}C)		RH (%)		Sun-shine Hrs	Wind speed km/hrs	Rainfall (mm)	Number of rainy days	E.PAN
		Max	Mini	HR I	HR II					
May										
19	07-13	39.3	21.7	44	17	10.5	3.3	000.0	-	12.1
20	14-20	40.0	21.8	34	14	10.8	4.6	000.0	-	13.7
21	21-27	41.2	25.6	38	16	10.9	4.4	000.0	-	14.7
22	28-03	41.1	23.5	39	19	10.5	5.4	000.0	-	13.4
June										
23	04-10	39.1	26.1	51	30	6.1	5.4	007.0	1	11.9
24	11-17	37.0	24.9	59	35	9.5	8.3	000.4	-	10.9
25	18-24	36.1	24.3	70	40	7.8	6.2	018.2	-	10.9
26	25-01	31.4	23.8	81	60	2.8	2.0	051.4	-	04.6
July										
27	02-08	30.6	23.5	79	63	1.3	4.9	037.0	2	4.3
28	09-15	32.1	23.6	76	56	4.7	7.2	003.8	1	5.3
29	16-22	33.8	23.2	71	51	7.8	6.4	032.0	2	5.9
30	23-29	30.5	23.6	78	68	2.3	4.1	018.4	2	3.3
31	30-05	27.0	22.8	88	77	0.2	4.8	047.8	5	1.9
August										
32	06-12	28.0	23.2	80	68	2.0	8.2	003.6	-	3.6
33	13-19	31.0	22.5	75	59	4.3	6.9	001.4	-	5.4
34	20-26	32.5	21.3	72	47	7.9	4.1	000.0	-	6.2
35	27-02	32.0	23.0	75	56	5.9	4.1	087.2	4	4.8
September										
36	03-09	30.0	23.3	77	71	1.8	3.6	003.0	-	4.3
37	10-16	28.8	22.5	78	68	1.3	4.6	021.6	2	3.7
38	17-23	29.8	21.7	83	71	4.2	1.6	084.2	4	3.7
39	24-30	30.2	21.9	83	67	4.9	00.8	036.6	3	3.3

3.2 Experimental details

3.2.1 Experimental design and treatments

The experiment was laid out in randomized complete block design with seven treatments and each treatment was replicated three times. The treatments were allotted randomly in each replication. The gross plot size was 3.60 x 3.0 m. the net plot size was 3.0 x 2.60 m. Details of treatments along with symbol used in plan of layout given in Table 4 and experimental layout are presented in appendix 1.

Table 4. Details of treatments

Sr. No.	Symbol	Treatment
1	T_1	Control (No foliar spray)
2	T_2	GRDF + Urea 2% at pre-flowering
3	T_3	GRDF + DAP 2% at pre-flowering
4	T_4	GRDF + 19:19:19 (NPK) 1% spray at pre –flowering
5	T_5	GRDF + Urea 1 % at pre-flowering + KNO_3 @ 1 % at pod development
6	T_6	GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development
7	T_7	GRDF + 19:19:19 (NPK) 1% spray at pre -flowering + KNO_3 @ 1 % at pod development

Note :
1. 5 t ha^{-1} of FYM was applied 15 days before sowing in all the treatments
2. Tentative days for pre-flowering and pod development in Blackgram are 30 DAS and 51 DAS, respectively.

3.2.2 Other details

1.	Name of crop	:	Blackgram
2.	Variety	:	AKU-15
3.	Seed rate	:	12-15 kg ha^{-1}
4.	Spacing	:	30 × 10 cm^2
5.	Plot size	:	Gross plot: 3.60 x 3.0 m^2
			Net plot: 3.0 x 2.60 m^2
6.	RDF	:	20:40:00 NPK (kg ha^{-1})
7.	Experimental design	:	Randomized Block Design
8.	Number of replications	:	Three
9.	Number of treatments	:	07
10.	Number of plots	:	21
11.	Season	:	*Kharif*
12.	Year	:	2019

3.2.3 Variety

AKU-15 : This variety is developed by crossing between (BM-86) x (MH). It matures in 64-72 days. This variety is suitable for *kharif* cultivation in Vidharbha region. It is moderately resistant to powdery mildew, non-lodging and non-shattering. The average grain yield is 10-12 q ha^{1}.

3.3 Details of field operations:

The details of operation carried out in experimental plot during the year 2019 are given in a Table 5.

Table 5. Schedule of field operations carried out during the course of investigation

Sr. No.	Nature of operation performed	Frequency	Date
A.	**Preparatory tillages**		
1.	Ploughing	1	20.06.2019
2.	Harrowing	1	05.07.2019
3.	Preparation of layout	1	10.07.2019
4.	Soil sample collection	1	10.07.2019
B.	**Seeds and sowing**		
1.	Application of basal fertilizer	1	11.07.2019
2.	Seed treatment and rhizobium biofertilizer	1	11.07.2019
3.	Sowing	1	11.07.2019
4.	Thinning	1	18.07.2019
5.	Gap filling	1	18.07.2019
6.	Hand weeding	1	01.08.2019
7.	First foliar spray of water soluble fertilizer	1	13.08.2019
8.	Spraying of quinolphos	1	21.08.2019
9.	Irrigation	1	26.08.2019
10.	Second foliar spray	1	31.08.2019
C.	**Harvesting**		
1.	Harvesting of crop		20.09.2019
2.	Threshing of crop		25.09.2019

3.3.1 Preparation of field

The field was prepared by ploughing and passed rotavator. Stubbles and weeds were removed from experimental plot and then plots were laid out as per plan of layout.

3.3.2 Fertilizer application

The entire quantity of recommended dose of fertilizer for blackgram (20:40:00 NPK kg ha^{-1}) was applied as basal dose at the time of sowing in the form of DAP and urea.

3.3.3 Seed material

Blackgram variety AKU-15 was used for sowing which was released by Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The important character of the variety are non-lodging and resistant to powdery mildew.

3.3.4 Seed treatment

Seeds of blackgram were treated with Rhizobium culture and PSB (Phosphorus Solubilising Bacteria) culture @ 2.5 g/kg of seed just before sowing.

3.3.5 Time and method of sowing

The lines were marked at desired distance and shallow furrows were opened with the help of marker at 30 cm row distance for sowing of black gram. The seeds were drilled manually in the furrows using the recommended seed rate @ 12-15 kg ha^{-1}. The sowing was done on 11^{th} July 2019.

3.3.6 Gap filling

Gap filling was done on 18^{th} July 7^{th} day after sowing so as to maintain the plant population.

3.3.7 Hand weeding and hoeing

Hand weeding was done at 20^{th} day after sowing and hoeing was done at 30 day after sowing to keep the crop free from weeds in all treatments.

3.3.8 Plant protection

Timely plant protection measures were adopted whenever necessary. Attack of sucking pest in black gram was noticed in the 1^{st} week of August. The sucking pest was controlled by spraying of quinolphos @ 1.5 lit ha^{-1}.

3.3.9 Harvesting and Threshing

The black gram crop was harvested on 20^{th} September 2019, when the pods were fully ripened and turned black. The pod was picked from each plot as per treatment. Harvested produce was left in the Agronomy farm building for three days to allow in sun-drying. Harvested produce was 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 in kg and expressed in quintal ha^{-1}.

3.4 Biometric Observations

The biometric observations were recorded from labelled five plants, selected randomly to represent the population in each net plot.

3.4.1 Crop growth study

3.4.1.1 Emergence count m^{-2}

Number of plants m^{-2} area was counted and recorded at 10^{th} days after sowing in the observation unit of each plot to calculate mean plant stand.

3.4.1.2 Final plant population m^{-2}

Number of plants m^{-2} area was counted and recorded at the time of harvesting in the observation unit of each plot to calculate mean plant stand.

3.4.1.3 Plant height

Plant height was measured in order to estimate the effect and extent of plant growth due to various treatments. Height of the five randomly selected plants in each plot was measured at 14^{th} day's interval up to maturity. Height was measured from the soil surface to the main stem (apical). The average height of five plants was taken as plant height and expressed in centimetres.

3.4.1.4 Number of branches per plant

The number of branches (primary and secondary) was counted and the average of five plants was expressed as number of branches per plant.

3.4.1.5 Leaf area per plant

The green leaves per plant randomly collected from 5 plants were passed through biovis portable leaf area meter for reading leaf area. The leaf area per plant recorded at 28, 42, 56 DAS and At harvest and expressed as dm^{-2} per plant.

3.4.1.6 Dry matter production per plant

Plant samples for dry matter studies were collected at 28, 42, 56 DAS and At harvest. At each sampling, five plants were uprooted at random in each treatment. These samples were oven dried at 70^{0}C in hot air oven for 72 hours till a constant weight obtained. The dry weight of plant were recorded, the total dry matter production per plant was obtained by weight of all plant and was expressed on per plant basis (g $plant^{-1}$).

3.4.1.7 Chlorophyll content (mg gm^{-1})

Plant samples for chlorophyll content studies were collected at 28, 42 and 56 DAS respectively. Total chlorophyll were estimated in a fully expanded young leaf with the help of portable clorophyll meter. It expressed in mg g^{-1} fresh weight.

3.4.1.8 Root nodules per plant

Number of root nodules per plant were recorded at 28,42 and 56 DAS from uprooted plants in experimental plot.

3.4.2 Crop yield components and yield

3.4.2.1 Number of pod per plant

The number of pods per plant were recorded from randomly selected five plants of each plot just before the harvesting and the average was taken as the number of pods per plant.

3.4.2.2 Pod length (cm)

The lengths of the 10 pods were randomly selected from the total number of pods which were separated from the sampled plants. These were measured and the average was worked out to single pod.

3.4.2.3 Number of seed per pod

The pods were picked up from randomly selected five plants of each plot. The grains from 10 representative pods were separated, counted and the mean number of grains per pod was calculated by dividing the number of grains by the number of pods.

3.4.2.4 Grain weight per plant (g)

The grains from the pods of five plants were separated by threshing and their mean weight was taken as grain weight per plant.

3.4.2.5 Test weight (g)

The seed sample from the produce of each plot was taken and counted 1000 seeds and then its weight was recorded.

3.4.2.6 Seed yield per plot (kg)

The blackgram plants were harvested from each plot and then threshed separately. The seed yield of each plot were sun dried, cleaned and weight was recorded.

3.4.2.7 Seed yield (kg ha^{-1})

The blackgram plants were harvested from net plot and then threshed after the sun drying. The seed yield of net plot was recorded and then converted in to kg ha by multiplying with size of net plot.

$$\text{Seed yield (kg ha}^{-1}\text{)} = \frac{\text{Seed yield per plot x 10000}}{\text{Net plot size (m}^{-2}\text{)}}$$

3.4.2.8 Straw yield (kg ha^{-1})

The plant from net plot were cut close to ground, tied into bundles, dried in the sun and their weight was recorded as per treatments. From per plot yield per hectare was worked out.

3.4.3 Quality components

3.4.3.1 Protein content (%)

Nitrogen content in the seeds of green gram was estimated by Kjeldhal's method (Jackson, 1967). The protein per cent in the seed was calculated by multiplying the nitrogen content by a factor of 6.25.

3.5 Chemical properties of the soil of the experimental site

Pre experimental composite soil samples were collected at random in the experimental field before sowing and chemical analysis was done. Similarly, post-harvest soil samples were collected treatment wise, air dried under shade, ground and sieved through 2 mm sieve and used for analysis of macro elements

3.5.1 Chemical analysis of soil and plant samples

3.5.1.1 Soil nutrient analysis

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

Available soil nitrogen was estimated by alkaline potassium permanganate method as outlined by Subbaiah and Asija (1956), whereas the phosphorus estimation was done by Brays's extractant method as outlined by Jackson (1967) using spectrophotometer. Available potassium was extracted with neutral normal ammonium acetate and the content was estimated by flame photometer (Jackson, 1967).

3.5.1.2 Chemical analysis of plant samples

Plant samples collected for dry matter estimation At harvesting stage from the respective treatments were oven dried and ground into fine powder in a mill and used for estimating Nitrogen, Phosphorus and Potassium. The per cent concentration of the nutrients was multiplied with the respective dry matter content and NPK uptake values were worked out.

Total nitrogen content in composite plant samples (stem, leaves and pods) of blackgram At harvest was estimated by modified micro- Kjeldhal method (Jackson, 1967) and expressed in per cent and converted to kg ha^{-1} based on dry matter obtained.

For analysis of phosphorus and potassium, plant samples were pre-digested with tri acid mixture (HNO_3: $HClO_4$: H_2SO_4 at 10:4:1) which was used for complete digestion of plant samples.

Phosphorus content in plant samples was determined by vanado molybdophosphoric yellow colour method by using spectrophotometer at 470 nm (Jackson, 1967) and expressed in per cent and converted into to kg ha^{-1} based on dry matter.

Potassium content in plant sample was determined by flame photometric method and expressed in percentage and converted into kg ha^{-1} based on dry matter.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%) x Biomass (kg ha}^{-1}\text{)}}{100}$$

3.6 Economics of treatments

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.

3.6.1 Cost of cultivation (₹ ha^{-1})

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 investigation.

3.6.2 Gross monetary returns (₹ ha^{-1})

Gross monetary returns is the total earnings from crop produce (grain + straw) in terms of (₹ ha^{-1}). The gross monetary return was calculated by considering the prevailing price of the produce at time of harvesting.

3.6.3 Net monetary returns (₹ ha^{-1})

The net monetary returns (₹ ha^{-1}) was calculated after deducting all the expenditure (₹ ha^{-1}) from gross return. It was obtained by subtracting cost of cultivation from gross return. This represents the actual income of farmer.

The net monetary returns (₹ ha^{-1}) for different treatments were calculated with the following formula-

Net monetary returns (₹ ha^{-1}) = Gross returns (₹ ha^{-1}) –Cost of cultivation (₹ ha^{-1})

3.6.4 Benefit cost ratio

The Benefit cost ratio was worked out as follows.

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

3.7 Statistical analysis

The data collected during the course of present investigation were statistically analysed by adopting standard method known as analysis of variance (Panse and Sukhatme, 1967). Where ever results were significant, critical difference (CD) were worked out at 5 % level of probability for comparison of treatment mean. The treatment effects were presented by making tables of means with appropriate standard error (SE m ±) and CD values.

4. RESULTS AND DISCUSSION

An experiment entitled, "Influence of foliar nutrition on growth and productivity of blackgram" was conducted during *Kharif* season of 2019-2020.During the course of field experimentation, the observations recorded on different growth, yield, quality, nutrient uptake and economics aspect of the blackgram as influenced by various treatments of foliar nutrition have been studies in details and results with the discussion are presented in this chapter under appropriate heads.

4.1 Effect of foliar nutrition on growth parameters

4.1.1 Plant population

Data regarding the emergence count and final count stand At harvest as influenced by various treatments are shown in Table 1.

Table 1. Initial plant count and final plant stand At harvest as influenced by various treatments

Sr. No.	Treatments	Initial plant population plot^{-1}	Initial plant population ha^{-1}	Final plant population plot^{-1}	Final Plant population ha^{-1}
T_1 :	GRDF alone (water spray)	258.28	331128	258.20	331025
T_2 :	GRDF + Urea 2% at pre-flowering	258.74	331718	258.55	331474
T_3 :	G RDF + DAP 2% at pre-flowering	259.11	332192	258.57	331500
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	258.89	331910	257.83	330551
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	259.30	332436	258.94	331974
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	259.30	332436	258.74	331717
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	260.56	334051	259.54	332743
	S.Em ±	0.87	-	0.323	-
	C.D at 5%	NS	NS	NS	NS
	General mean	259.17	-	258.62	-

Mean emergence count and final stand At harvest were 259 and 258 plot^{-1} respectively. The mean emergence and final plant count At harvest did not differ significantly due to different foliar nutrition treatments.

4.1.2 Plant height (cm)

Plant height is an important character of the vegetative phase and indirectly influences the yield components. The data on mean plant height (cm) of blackgram as influenced by different treatments are presented in Table 2 and graphically illustrated in Fig. 2.

Table 2. Plant height (cm) of blackgram as influenced by different treatments

Sr. No.	Treatments	Plant height (cm)			
		28 DAS	**42DAS**	**56 DAS**	**At harvest**
T_1 :	GRDF alone (water spray)	258.28	331128	258.20	331025
T_2 :	GRDF + Urea 2% at pre-flowering	258.74	331718	258.55	331474
T_3 :	G RDF + DAP 2% at pre-flowering	259.11	332192	258.57	331500
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	258.89	331910	257.83	330551
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	259.30	332436	258.94	331974
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	259.30	332436	258.74	331717
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	260.56	334051	259.54	332743
	S.Em ±	0.87	-	0.323	-
	C.D at 5%	NS	NS	NS	NS
	General mean	259.17	-	258.62	-

There was no significant effect of foliar nutrition on plant height at 28 DAS as no foliar application was done up to 30 days of sowing, but treatment T_2 (GRDF+ Urea 2% at pre-flowering) to T_7 (GRDF+ 19:19:19 (N P K) 1% sprayed at pre - flowering + KNO_3 @ 1% at pod development) are numerically superior over absolute control. The mean of plant height at different growth stages ranges from 15.68 cm at 28 DAS to 53.22 cm At harvest.

At 42 DAS, treatment T_3 (GRDF + DAP 2% at pre-flowering) produced the highest plant height of 41.05 cm, which was significantly higher over the rest of treatments and it was at par with T_2, T_4 and T_7 treatments. However, lower plant height (45.45 cm) was recorded in absolute control (T_1).

At 56 DAS, treatment T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development) recorded highest plant height of 57.14 cm over the rest of treatments. However, lower plant height (45.45 cm) was recorded in absolute control (T_1). These results are in agreement with Pandien *et al.* (2001) and Vekaria *et al*. (2013).

At harvest, application of GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development (T_6) treatment recorded significantly higher plant height (57.37cm) and the next best higher plant height was recorded in T_5 GRDF+ Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development (56.98 cm). While, lower plant height (45.56 cm) was recorded in absolute control.

The increase in plant height might be due to additional supply of nutrients through foliar application which increased the nutrient uptake and better translocation of nutrients. In the present study, the increase in plant height by urea spray may be attributed to the increase in N status in plant system. Nitrogen and potassium influences water relations which regulate cell division and elongation and nitrogen content of leaves is rapidly converted to protein and increases these characters. Similar results of increase in plant height were also reported by Malay and Bhoumick *et al*. (2008) in lentil. Muthulakshmi and Lingakumar (2016) noticed that salicylic acid enhanced plant height of blackgram.

4.1.3 Number of branches plant^{-1}

The data on mean number of branches plant^{-1} of blackgram as influenced by different treatments are presented in Table 3 and graphically illustrated in Fig. 3.

There was no significant difference upto 28 DAS as no foliar application was done up to 30 days of sowing. There were significant differences observed among all the treatments when foliar nutrition was given. Branching is an important growth stage of crop, which is directly related with the number of pods formation per plant and ultimately the productivity of crop. It could be seen from the data presented in Table.3 that the mean number of branches plant^{-1} of blackgram increased from 2.34 at 28 DAS to 6.22 At harvest.

At 42 DAS, treatments T_3 (GRDF+ DAP 2% at pre-flowering) recorded highest number of branches plant^{-1} 5.55 over the rest of treatments and it was at par with

T_2 (GRDF+ Urea 2% at pre-flowering) 5.33 treatment. However, lower number of branches (3.52) was recorded in absolute control (T_1).

Table 3. Number of branches plant^{-1} as influenced by different treatments

Sr. No.	Treatments	Number of branches plant^{-1}			
		28 DAS	**42DAS**	**56 DAS**	**At harvest**
T_1 :	GRDF alone (water spray)	2.31	3.52	5.33	5.42
T_2 :	GRDF + Urea 2% at pre-flowering	2.32	5.33	6.13	6.22
T_3 :	G RDF + DAP 2% at pre-flowering	2.39	5.55	6.26	6.34
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	2.36	5.23	6.00	6.05
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	2.35	4.95	6.45	6.48
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	2.33	5.13	6.57	6.62
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	2.34	5.23	6.36	6.39
	S.Em ±	0.019	0.15	0.13	0.13
	C.D at 5%	NS	0.45	0.42	0.39
	General mean	2.34	4.99	6.16	6.22

At 56 DAS, T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) recorded significantly higher number of branches plant^{-1} (6.57) over rest of the treatments. The next best higher number of branches plant^{-1}(6.45) was recorded in T_5 (GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1% at pod development), which was at par with T_3, T_5, T_7, (6.26, 6.45 and 6.36 respectively). While, T_1 (absolute control) recorded lower number of branches plant^{-1} (5.33). Similar trend of increased number of branches plant^{-1} of blackgram was observed At harvest. Similar results were also obtained Shashikumar *et al.* (2013).

At harvest, application of (GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development) T_6 recorded significantly higher number of branches plant^{-1} (6.62) over rest of the treatments and it was at par with treatment T_5, T_7 and T_3 (6.48, 6.39 and 6.34 respectively). However, T_1 (absolute control) recorded lower number of branches plant^{-1} (5.42).

Increased in number of branches influenced due to the fact that foliar application of nutrient would be easily available and translocated in the plants without any loss. In addition to this, spraying of 18:46:00 and KNO_3 increased the growth components due to the supply of foliage applied nitrogen, phosphorus and potassium at critical stages of the crop, leading to better photosynthetic activity resulting in better development of growth components. Potassium is known to augment cell division and cell expansion. Application of K increased the availability of nitrogen and phosphorus which resulted in better plant growth and more number of branches plant^{-1}. The present result are finding in accordance with Beg and Ahmad (2012).

4.1.4 Leaf area plant^{-1} (dm^2)

The leaf area plant^{-1} as influenced by various treatments are presented in Table 4. There were no significant differences of foliar nutrition on Leaf area plant^{-1} at 28 DAS as no foliar application was done up to 30 DAS, but treatment T_2 (GRDF + Urea 2 % at pre-flowering) to T_7 (GRDF + 19:19:19 (N P K) 1 % spray at pre-flowering + KNO_3 @ 1% at pod development) are numerically superior over absolute control. It could be seen from the data presented in table 4.4 that the mean leaf area plant^{-1} of blackgram increased from 26.28 dm^2 at 28 DAS to 34.40 dm^2 plant^{-1} at 56 DAS.

At 42 DAS, T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) recorded significantly higher leaf area (36.23 dm^2 plant^{-1}) over rest of the treatments. The next best higher leaf area (35.20 dm^2 plant^{-1}) was recorded in T_5 (GRDF + Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development), which was at par with T_6. However, T_1 (absolute control) and T_4 (GRDF+ 19:19:19 (N P K) 1% spray at pre–flowering recorded lower leaf area (30.15 and 33.21 dm^2 plant^{-1}, respectively).

At 56 DAS, T_6 (GRDF+ DAP 1% at pre-flowering+ KNO_3 @ 1% at pod development) recorded significantly higher leaf area (36.62 dm^2 plant^{-1}) over rest of the treatments. The next best higher leaf area (35.35 dm^2 plant^{-1}) was recorded in T_5 (GRDF+ Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development), which was at par with T_6. However, T_1 (absolute control) and T_4 (GRDF+ 19:19:19 (N P K) 1% spray at pre-flowering recorded lower leaf area (31.93 and 33.26 dm^2 plant^{-1}, respectively). These results are in agreement with the findings Hugar and Kurdikeri (2000) in soybean.

Table 4. Leaf area plant^{-1} (dm^2) of blackgram as influenced by different treatment

Sr. No.	Treatments	Leaf area plant^{-1} (dm^2)			
		28 DAS	**42DAS**	**56 DAS**	**At harvest**
T_1 :	GRDF alone (water spray)	24.90	30.15	31.93	30.55
T_2 :	GRDF + Urea 2% at pre-flowering	25.87	34.25	34.35	34.07
T_3 :	G RDF + DAP 2% at pre-flowering	26.24	34.33	34.45	34.14
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	26.63	33.21	33.26	32.47
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	26.48	35.20	35.35	34.96
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	26.80	36.23	36.62	36.25
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	27.02	34.82	34.85	34.78
	S.Em ±	0.48	0.38	0.80	0.46
	C.D at 5%	NS	1.16	2.47	1.44
	General mean	26.28	34.03	34.40	33.89

At harvest significantly higher leaf area plant^{-1} (36.25 dm^2 plant^{-1}) were observed in T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) over rest of the treatments followed by treatment T_5 (GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1% at pod development) recorded leaf area (34.96 dm^2 plant^{-1}). However, T_1 (absolute control) and T_4 (GRDF+ 19:19:19 (N P K) 1% spray at pre –flowering) recorded lower leaf area (30.55 and 32.47 dm^2 plant^{-1} respectively). Similar results obtained by Govindan and Thirumurugan (2000).

4.1.5 Dry matter accumulation plant^{-1} (g)

The data pertaining to dry matter accumulation plant^{-1} as influenced by various treatments are presented in Table 5. The rate of increased in dry matter was slow at initial stages, while fast between 45 DAS to 60 DAS.

It could be seen from the data presented in table 5 that the mean dry matter accumulation of blackgram increased from 4.51 (g) at 28 DAS to 11.94 (g) At harvest, respectively. There were no significant differences of foliar nutrition on dry matter accumulation plant^{-1} at 28 DAS as no foliar application was done up to 30 days after sowing. However the treatments T_2 (GRDF+ Urea 2% at pre-flowering) to T_7 (GRDF+ 19:19:19 (N P K) 1% sprayed at pre -flowering + KNO_3 @ 1% at pod development) are numerically superior over absolute control (T_1).

Table 5. Dry matter plant^{-1} (g) as influenced by different treatments

Sr. No.	Treatments	Dry matter plant^{-1} (g)			
		28 DAS	**42 DAS**	**56 DAS**	**At harvest**
T_1 :	GRDF alone (water spray)	4.34	5.50	8.57	9.20
T_2 :	GRDF + Urea 2% at pre-flowering	4.61	6.65	12.07	12.05
T_3 :	G RDF + DAP 2% at pre-flowering	4.43	6.80	12.13	12.18
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	4.58	6.33	10.99	11.71
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	4.48	5.77	12.42	12.51
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	4.58	6.20	12.90	13.10
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	4.57	6.43	12.34	12.83
	S.Em ±	0.22	0.23	0.47	0.30
	C.D at 5%	NS	0.70	1.44	0.93
	General mean	4.51	6.24	11.63	11.94

At 42 DAS significantly higher dry matter accumulation plant^{-1} of black gram (6.80 gm) were recorded with application of (GRDF+ DAP 2 % at pre-flowering) T_3 over rest of the treatments. The next best higher total dry matter production (6.65 g) was recorded in T_2 (GRDF+ Urea 2 % at pre-flowering), which was at par on T_7, T_4 and T_6 (6.43, 6.23 and 6.20 gm), respectively. However, lower total dry matter production was recorded in T_1 (absolute control) of 5.50 g.

At 56 DAS, significantly higher dry matter accumulation plant^{-1}of blackgram (12.90 g) were recorded with application of GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6) over rest of the treatments. The next best higher total dry matter production (12.42 g) was recorded in T_5 (GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1% at pod development), which was at par T_3,T_5,T_7. However, lower total dry matter production was recorded in T_1 (absolute control) of 8.57 g.

At harvest, significantly higher dry matter accumulation plant^{-1}was noticed with T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) (13.10 g) and being at par with T_3, T_5, T_7. Similar findings were also reported by Chandrashekar and Bangarusamy (2003).

The photosynthetic activities of the plants are well reflected in their dry matter accumulation. An increased production of dry matter indicates the better utilization of nutrients along with better harvest of solar energy. Increase in dry matter production might be due to foliar application of nutrient increased the rate of photosynthetic process which finally resulted in increased dry matter production by the plant at each stage of growth. Increased plant height, more number of trifoliate leaves and higher leaf area index due to application of foliar nutrients might resulted in increased in dry matter accumulation plant^{-1}. The present results are accordance with the finding of Chandrashekar and Bangarusamy (2003)and Shashikumar *et al.* (2013).

4.1.6 Chlorophyll content (mg^{-1})

The data on total chlorophyll content as influenced by various treatments recorded at 28, 42 and 56 DAS are presented in Table 6 and graphically depicted in Fig. 6.

There was no significant difference upto 30 DAS. Among the treatments except absolute control (T_1) realizing the importance of nutrition. There were significant differences observed among all the treatments when foliar nutrition was given. It could be seen from the data presented in Table 6 that the mean chlorophyll content of blackgram increased from 36.69 to 48.82.

At 42 DAS Maximum chlorophyll content of blackgram leaves were found in treatment T_3 (GRDF+ DAP 2 % at pre-flowering) which was significantly higher over rest of the treatments, but it was on par with T_2 (GRDF+ Urea 2 % at pre-flowering) . However, lower chlorophyll was recorded in T_1 (absolute control). Similar findings were also reported by Sritharan *et al*. (2015) in blackgram, Rao *et al*. (2016) in greengram.

At 56 DAS Maximum chlorophyll content of blackgram leaves were found in treatment T_6 (GRDF+ DAP 1% at pre-flowering+ KNO_3 @ 1% at pod development) which was statistically significant over rest of the treatments, but it was on par with T_5 and T_7. However, lower chlorophyll was recorded in T_1 (absolute control).

Table 6. Chlorophyll content index as influenced by different treatments

Sr. No.	Treatments	Chlorophyll content (mg^{-1})		
		28 DAS	**42 DAS**	**56 DAS**
T_1 :	GRDF alone (water spray)	36.2	41.9	43.3
T_2 :	GRDF + Urea 2% at pre-flowering	37.4	46.1	47.6
T_3 :	G RDF + DAP 2% at pre-flowering	37.2	46.7	49.1
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	36.4	43.5	46.5
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	37.4	44.5	51.5
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	36.9	44.2	52.3
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	35.1	43.3	51.2
	S.Em ±	0.79	0.43	0.60
	C.D at 5%	NS	1.32	1.86
	General mean	36.69	44.35	48.82

Increase in the total chlorophyll might be due to addition of foliar spray like DAP and potassium nitrate which increased the leaf nitrogen content. As ‘N’ is essential for chlorophyll synthesis, increase in leaf nitrogen content results in increase in chlorophyll content. The present results are accordance with similar findings of Gowthami and Rao (2014) and Rao *et al*. (2016).

4.1.7 Number of root nodules plant^{-1}

The number of root nodules plant^{-1} were recorded at three stages *viz*. 28, 42 and 56 DAS. The data pertaining to root nodule plant^{-1} as influenced by various treatments are presented in Table 7.

There is increase in number of root nodules plant^{-1} up to pod development stage after that it seems to be declined. Upto 28 DAS there was no significant effect of foliar application on number of root nodules seen.

Table 7. Number of root nodules plant^{-1} as influenced by different treatment

Sr. No.	Treatments	Number of root nodules plant^{-1}		
		28 DAS	42 DAS	56 DAS
T_1 :	GRDF alone (water spray)	11.32	14.93	11.90
T_2 :	GRDF + Urea 2% at pre-flowering	13.37	21.89	15.54
T_3 :	G RDF + DAP 2% at pre-flowering	13.64	23.24	16.00
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	13.62	20.34	15.90
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	13.26	27.49	15.23
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	12.87	31.16	16.18
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	12.06	26.76	15.97
	S.Em ±	0.52	0.59	0.32
	C.D at 5%	NS	1.81	1.01
	General mean	12.88	23.69	15.25

At 42 DAS highest number of root nodules (31.16) found in treatment T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development)which was statistically significant over rest of the treatment. However, lower number of root nodules (14.93) were recorded in T_1 (absolute control).

At 56 DAS highest number of root nodules (16.18) found in treatment T_6 (GRDF+ DAP 1 % at pre-flowering + KNO_3 @ 1% at pod development) which was significantly higher over rest of the treatments followed by T_3 treatment GRDF+ DAP 2 % at pre-flowering. However, lower number of root nodules (11.90) were recorded in T_1 (absolute control). Similar findings were also reported by Vekaria *et al*. (2013).

4.2 Effect of foliar nutrition on yield parameters.

The data in respect of number of pods plant^{-1}, number of seeds pod^{-1}, pod length, weight of grain plant^{-1} and 1000 seed weight (test weight) as affected by various treatments are shown in Table 8 and graphically depicted in Fig. 8. Mean value number of pods plant^{-1}, pod length (cm), number of seeds per pod, grain weight plant^{-1} (g) and test weight (g) were 29.68, 5.90, 5.72, 6.33 and 43.91 respectively.

4.2.1 Number of pod plant^{-1}

The number of pods plant^{-1} is an important parameter which has direct related to seed yield plant^{-1} and production per unit area. The data given in Table 8, revealed that the effect of foliar spray treatments on number of pods plant^{-1} was found significant over control.

It is evident from the table that, At harvest significantly higher number of pods (35.60) was observed in T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) over the rest of treatments which was at par with the next best higher treatment T_5 (GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1% at pod development which records with number of pods (34.37) plant^{-1}. However treatment T_1 (RDF alone) 23.52 recorded lower number of pods per plant. Similar type of findings were also reported by Das and Jana (2015) and Dixit and Elamathi (2007).

Increase in number of pod might be due to foliar application of growth regulator which reduce the shading of flower and resulted in more number of pod per plant. Further foliage application of nitrogen attributed to higher chlorophyll content with enhanced photosynthetic activity and higher uptake of nutrients and there by increased plant dry matter production in the pod setting phase, which might have improved the pod development and number of pods per plant. The present results in accordance with finding of Sarkar and Malik (2001) and Thalooth *et al.* (2006).

4.2.2 Number of seeds plant^{-1}

The data on number of seeds plant^{-1} blackgram as influenced by different treatments are presented in Table 8.

Significantly higher number of seeds plant^{-1} (6.80) was noticedin T_6 (GRDF+ DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development) over rest of the treatments, but it was on par with T_5, (GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1 % at pod development) 6.53. However, lower number of seeds pod^{-1} was recorded in T_1 (absolute control) (5.17) and T_2 (GRDF + Urea 2 % at pre-flowering) (5.37).

Increase in number of seeds pod^{-1} might be due to application of nutrients at critical stage has helped in more translocation of photosynthates to the developing pods which have also helped in better filling thus increase in number of seeds pod^{-1}. Potassium application not only enhanced the availability of other nutrient but also increase transportation of photosynthates and protein synthesis from source to sink. These results are in agreement with the finding of Rao *et al.* (2013) on mungbeen.

Table 8. Yield attributing characters of blackgram as influenced by different treatments

Sr. No.	Treatments	Pods plant^{1} (No)	Seeds pod^{-1} (No)	Pod length (cm)
T_1 :	GRDF alone (water spray)	23.52	5.17	4.93
T_2 :	GRDF + Urea 2% at pre-flowering	27.28	5.37	5.53
T_3 :	G RDF + DAP 2% at pre-flowering	28.63	5.73	5.83
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	25.41	5.63	5.37
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	34.37	6.53	6.07
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	35.60	6.80	6.37
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	32.97	6.03	5.93
	S.Em ±	0.56	0.15	0.10
	C.D at 5%	1.75	0.47	0.31
	General mean	29.68	5.90	5.72

4.2.3 Pod length(cm)

The data on pod length of blackgram as influenced by different treatments are presented in Table 8.

Application of GRDF+ DAP 1% at pre-flowering+ KNO_3 @ 1% at pod development (T_6) registered significantly highestpod length (6.37cm) over rest of the treatments followed by treatment T_5 (6.07 cm) in (GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development) which was at par with T_6. However, lower pod length was recorded in T_1 (absolute control) of 4.93 cm.

Increase in pod length might be due to foliar application of macro nutrient (N, P, K) at reproductive stages of the crop were effectively absorbed and more translocation of photosynthates to the developing pods which has also helped in better filling. Thus increases number of seeds pod^{-1} due to increase in number of seeds pod^{-1} there was increase in pod length. These results are in confirmation with the findings of Shashikumar *et al.* (2013).

4.2.4 Grain weight plant^{-1}

The data pertaining to grain weight plant^{-1} was given in Table 9. It was observed that, weight of grain plant^{-1} significantly influenced due to various treatments. The mean weight of grain plant^{-1} was 6.33.

Application of GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development (T_6) recorded highest weight of grain plant^{-1} (8.02 g) Which was at par with the treatment (T_5) GRDF + Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development) (7.50 g). The lowest grain weight plant^{-1} was observed in T_1 (absolute control) (4.50 g) and T_2 (GRDF + Urea 2 % at pre-flowering) (5.57g).

Increase in grain weight plant^{-1} might be due to the supply of foliage applied nitrogen, phosphorus and potassium at critical stages of the crop, resulted in better development of yield components i.e. increase in number of pod, number of grain pod^{-1} pod length due to these increased the grain weight plant^{-1}. The present results are in accordance with the findings of Parasuraman (2001) and Verma *et al.* (2011).

4.2.5 Test weight (g)

The data pertaining to1000 seeds weight (g) is given in Table.9. It was observed that, 1000 seeds weight significantly influenced due to various treatments. The mean of 1000 seeds weight was (43.91 g).

Application of GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6) registered significantly higher test weight (47.53g) over rest of the treatments which was at par with (T_5) the next best ttreatment. Test weight (46.57g) was noticed in GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1 % at pod development (T_5). However, lower test weight was recorded in T_1 (absolute control)of 37.85 g. The results obtained were in conformity with findings of Mahashwari and Karthiki (2017).

Due to foliar application of higher test weight (1000 seeds) may be the result of enhanced photosynthetic activity, followed by efficient transfer of metabolites and subsequent accumulation of these metabolites in the seed with the resultant increase in size and weight of the individual seeds. These results are in agreement with the finding of Ibrahim and Sarkar and Malik (2001).

Table 9. Grain weight plant^{-1}, test weight and number of seeds plant^{-1} as influenced by different treatments

Sr. No.	Treatments	Grain weight plant^{-1} (g)	Test weight (gm)	Number of seeds plant^{-1}
T_1 :	GRDF alone (water spray)	4.50	37.85	124.88
T_2 :	GRDF + Urea 2% at pre-flowering	5.57	42.47	145.63
T_3 :	G RDF + DAP 2% at pre-flowering	6.11	45.17	160.33
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	5.29	41.51	150.44
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	7.50	46.57	228.56
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	8.02	47.53	241.74
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	7.30	46.23	198.96
	S.Em ±	0.19	0.64	5.32
	C.D at 5%	0.59	1.97	16.4
	General mean	6.33	43.91	178.65

4.2.6 Number of seeds plant^{-1}

The data on number of seeds plant^{-1} of blackgram as influenced by different treatments are presented in Table 9.

Significantly higher number of seeds plant^{-1} (241.7) was noticedin T_6 (GRDF+ DAP 1 % at pre-flowering + KNO_3 @ 1% at pod development) over rest of the treatments, but was on par with T_5, (GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1% at pod development) 228.56. However, lower number of seeds plant^{-1} was recorded in T_1 (absolute control) (124.88) and T_2 (GRDF + Urea 2 % at pre-flowering) (145.63) respectively.

Increase in number of seeds plant^{-1} might be due to application of nutrients at critical stage has helped in more translocation of photosynthates to the developing pods which have also helped in better filling thus increasing number of seeds plant^{-1}. Potassium application not only enhanced the availability of other nutrient but also increase transportation of photosynthates and protein synthesis from source to sink. These results are in agreement with the finding of Rao *et al*. (2013) on mungbean.

4.3 Yield studies

The data on seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index as influenced by various treatments are presented in Table.10 and graphically illustrated in Fig.10

4.3.1 Seed yield (kg ha^{-1})

Seed yield of blackgram was significantly influenced by various treatments of foliar nutrition. Mean of grain yield was (1177 kg ha^{-1}). Significantly higher grain yield (1360 kg ha^{-1}) was noticed in T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development) over rest of the treatments followed by treatment (T_5) GRDF + Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development recorded seed yield (1274 kg ha^{-1}). However, lower grain yield was recorded in T_1 (absolute control) (922 kg ha^{-1}). Similar results were obtained by Deotale *et al.* (2015) and Patel *et al.* (2019).

Table 10. Seed yield and Straw yield of blackgram as influenced by various treatments

Sr. No.	Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Increase in yield over T_1 (%)
T_1 :	GRDF alone (water spray)	922.0	1136.3	2058.0	44.8	00.0
T_2 :	GRDF + Urea 2% at pre-flowering	1163.0	1547.6	2711.0	42.8	26.1
T_3 :	G RDF + DAP 2% at pre-flowering	1233.6	1839.6	3074.0	40.1	33.7
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	1043.3	1304.0	2346.0	44.4	13.1
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	1274.0	1863.0	3137.0	40.6	38.1
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	1360.0	1914.0	3274.0	41.5	47.5
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	1205.0	1798.3	3048.0	39.5	30.6
	S.Em ±	24.09	27.61	0.73	-	-
	C.D at 5%	74.25	85.08	2.25	-	-
	General mean	1177.48	1629.05	2806.89	-	-

The increase in seed yield is in accordance with foliar spray of growth regulator and urea might be attributed to hastened availability of N in the plant system, more chlorophyll synthesis, greater accumulation of protein in plants and efficient translocation of assimilates to reproductive parts. Seed yield of blackgram is resultant product of yield attributing characters. Beneficial effects of foliar nutrition on yield attributes have increased the seed yield. These results are in agreement with the finding of Sarkar and Malik (2001) and Yadkari and Thatikakunta (2002).

4.3.2 Straw yield (kg ha^{-1})

Straw yield of blackgram was significantly influenced by various treatments of foliar nutrition. Mean of straw yield was (1629 kg ha^{-1}).

The highest straw yield (1914 kg ha^{-1}) was observed in treatment T_6 (GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) over the rest of treatments followed by treatment T_5 GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1% at pod development (1863 kg ha^{-1}). However lower straw yield recorded in T_1 (absolute control) (1136 kg ha^{-1}).

4.3.3 Biological yield (kg ha^{-1})

Biological yieldof blackgram was significantly influenced by various treatments of foliar nutrition. Mean of Biological yield was (2806.89 kg ha^{-1}).

The highest biological yield (3274 kg ha^{-1}) was observed in treatment T_6 (GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development) over the rest of treatments followed by treatment T_5 GRDF + Urea 1 % at pre-flowering + KNO_3 @ 1 % at pod development (3137 kg ha^{-1}). However, lower straw yield recorded in T_1 (absolute control) (2058 kg ha^{-1}).

4.3.4 Harvest index (%)

Harvest index is ratio of economical yield to the biological yield and it was found highest for T_1 absolute control (44.8 %).

Lowest ratio of harvest index was found for T_7 treatment GRDF + 19:19:19 (NPK) 1 % spray at pre -flowering + KNO_3 @ 1 % at pod development (39.5 %).

4.3.5 Increase in yield over control treatment (%)

Significantly highest increase in yield over the control treatment T_1 occurred in treatment (T_6) GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development 47.5 per cent followed by treatment (T_5) GRDF+ Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development recorded higher yield 38.1 per cent.

4.4 Effect of foliar nutrition on seed quality parameters of blackgram

4.4.1 Protein content (%)

The data in Table 11 pertaining to protein content (%) was significantly influenced by various treatments. The mean protein content was 21.98 per cent.

Application of GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6) registered significantly higher grain protein content (22.87 %) over rest of the treatments, followed by treatment(T_5) GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1% at pod development(22.43 %). However, lower grain protein was recorded in T_1 (absolute control) (20.93%). Similar results were obtained by Sathiyamoorthy and Vivekanandan (1988).

Increase in protein content of grain might be due to that the presence of high leaf nitrogen content by foliar spray might have increased the protein synthesis and also improves protein content due to more nitrogen. Similar results to increase in total protein content due to foliar spray of nutrient through urea and K_2O was reported by Kurhade *et al.* (2014).

4.4.2 Protein yield (kg ha^{-1})

The data in Table 11 pertaining to protein yield was significantly influenced by various treatments. The mean of protein yield was 257.41 kg ha^{-1}.

Application of GRDF+ DAP 1% at pre-flowering+ KNO_3 @ 1% at pod development (T_6) registered significantly higher grain protein yield 311.51 kg ha^{-1} over rest of the treatment. However, lower protein yield was recorded in T_1 (absolute control) (192.75 kg ha^{-1}). Similar results were obtained by Meena and Sharma (2005); Singh (2007).

Increase in protein content of grain might be due to that the presence of high leaf nitrogen content by foliar spray might have increased the protein synthesis.

Similar results to increase in total protein content due to foliar spray of nutrient through foliar spraying of 2 % urea Sritharan *et al.* (2015).

Table 11. Protein content of blackgram as influenced by various treatments

Sr. No.	Treatments	Protein content (%)	Protein yield (kg ha^{-1})
T_1 :	GRDF alone (water spray)	20.93	192.75
T_2 :	GRDF + Urea 2% at pre-flowering	22.00	255.74
T_3 :	G RDF + DAP 2% at pre-flowering	21.56	265.80
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	21.87	224.81
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	22.43	285.65
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	22.87	311.51
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	22.06	265.59
	S.Em ±	0.21	0.19
	C.D at 5%	0.66	0.60
	General mean	21.98	257.41

4.5 Nutrient content and uptake by blackgram

4.5.1 Nitrogen content in seed and straw (%)

The data presented in Table 12 revealed that, there was significant effect of different treatments on nitrogen content of grain and straw 3.51 and 0.91, respectively.

Highest nitrogen content was recorded with treatments T_6 (GRDF + DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development (3.66 %) in grain and (0.94 %) in straw followed by the lowest N content in grain and straw was recorded in T_1 (absolute control) (3.35) and (0.86) respectively.

4.5.2 Nitrogen uptake (kg ha^{-1})

The data in Table 12 and graphically illustrated in Fig. 12 revealed that the mean uptake of nitrogen by grain, straw and total uptake was 41.64, 14.88 and 56.68 kg ha^{-1} respectively. Maximum uptake of nitrogen by seeds (49.77 kg ha^{-1}), straw (17.81 kg ha^{-1}) and total uptake (67.58 kg ha^{-1}) were found in treatment T_6 (DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development) which was significantly higher over the rest of the treatments. Lower nitrogen uptake was recorded in T_1 (absolute control). Similar findings were also reported by Verma *et al.* (2011).

Table 12. Nitrogen content and uptake of blackgram as influenced by various treatments

Sr. No.	Treatments	N content (%)		N uptake (kg ha^{-1})		Total N (kg ha^{-1})
		Seed	Straw	Seed	Straw	
T_1 :	GRDF alone (water spray)	3.35	0.86	30.73	9.76	40.37
T_2 :	GRDF + Urea 2% at pre-flowering	3.52	0.93	42.56	14.36	56.92
T_3 :	G RDF + DAP 2% at pre-flowering	3.45	0.90	42.60	16.49	59.12
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	3.50	0.89	36.47	11.64	48.16
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	3.59	0.93	45.73	17.53	63.27
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	3.66	0.94	49.77	17.81	67.58
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	3.53	0.92	43.83	17.56	61.40
	S.Em ±	0.01	0.009	0.06	0.07	0.06
	C.D at 5%	0.05	0.03	0.21	0.23	0.20
	General mean	3.51	0.91	41.64	14.88	56.68

The increasing N uptake might be due to increased availability of nitrogen twice to the crop and higher biomass production and retarded the loss of chlorophyll and leaf nitrogen with increased photosynthesis and increase nitrogen supply during flowering and pod filling stages. Present result confirmed by the findings of Manjula Devi and Pillai (1997).

4.6.3 Phosphorus content in straw and grain (%)

The data in respect of phosphorus content in grain and straw are presented in Table.13 revealed that, the values of phosphorus content significantly affected by different treatments with mean of 0.51 and 0.17 per cent in grain and straw respectively.

Highest phosphorus content was recorded in treatments T_6 (GRDF+ DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development) (0.56 %) and (0.21 %) in grain and straw respectively. However, lower phosphorous content was recorded in T_1 (absolute control).

4.6.4 Phosphorus uptake (kg ha^{-1})

Data in respect of phosphorus uptake by grain, straw and total uptake is presented in Table 13 and graphically illustrated in Fig. 12.

The mean uptake of phosphorus by grain, straw and total uptake was 6.12, 2.13 and 8.25 kg ha^{-1}, respectively.

Table 13. Phosphorus content and uptake of blackgram as influenced by various treatments

Sr. No.	Treatments	P content (%)		P uptake (kg ha^{-1})		Total P (kg ha^{-1})
		Seed	Straw	Seed	Straw	
T_1 :	GRDF alone (water spray)	0.41	0.15	3.78	1.38	5.16
T_2 :	GRDF + Urea 2% at pre-flowering	0.51	0.16	5.94	1.86	7.77
T_3 :	G RDF + DAP 2% at pre-flowering	0.54	0.18	6.67	2.23	8.88
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	0.53	0.16	5.53	1.66	7.19
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	0.52	0.20	6.63	2.54	9.17
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	0.56	0.21	7.62	2.87	10.44
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	0.54	0.19	6.70	2.36	9.11
	S.Em ±	0.005	0.007	0.01	0.01	0.01
	C.D at 5%	0.01	0.02	0.05	0.04	0.04
	General mean	0.51	0.17	6.12	2.13	8.25

Significantly highest uptake of phosphorous in grains, straw and total uptake (7.62, 2.87 and 10.44) in kg ha^{-1}respectively was noticed in T_6 (GRDF+ DAP 1% at pre-flowering+ KNO_3 @ 1% at pod development) over rest of the treatments. However, lower phosphorous uptake was recorded in T_1 (absolute control). These results are in agreement with similar finding of Mudalagiriyappa *et al.* (2016).

This increase in uptake of phosphorous has been attributed to the higher per cent of available phosphorus in diammonium phosphate (46 % P) compared to other treatments used in experiment.

The higher uptakes of nutrients were mainly due to its easy availability and absorption of nutrients under foliar spray without spending much energy for their transport and without any loss in transit. Foliar spray of macro nutrients and growth hormone increase the uptake of nutrients from soil and also increases metabolic activity in the plant cell. Similar results were also reported by Thakare *et al*. (2006), Elayaraja and Angayarkanni (2005).

4.6.5 Potassium content in seed and straw (%)

The data in respect of potassium content in grain and straw are presented in Table.14 revealed that, the values of potassium content significantly affected by different treatments with mean of 1.10 and 0.92 per cent in grain and straw respectively. Highest potassium content was recorded in treatments T_6 (GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) (1.17) and (0.94 %) in grain and straw respectively. However, lower potassium content was recorded in T_1 (absolute control).

4.6.6 Potassium uptake (kg ha^{-1})

The data in respect of potassium uptake by grain, straw and total uptake is presented in Table 18 and graphically illustrated in Fig. 13. The mean uptake of potassium by grain, straw and total uptake was 12.98, 10.81 and 23.78 kg ha^{-1}, respectively.

Higher potassium uptake in grain, straw and total (15.87, 12.78 and 28.68 kg ha^{-1}) was registered in T_6 (GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development) which was significantly higher over rest of the treatments. The next better uptake of potassium by seed, straw and total uptake (14.27, 11.86 and 26.12 kg ha^{-1} respectively) was recorded in (T_5) treatment and also increases metabolic activity in the plant cell. Similar results were also reported by Thakare *et al*. (2006), Elayaraja and Angayarkanni (2005) and Deotale *et al*. (2015).

Table 14. Potassium content and uptake of blackgram as influenced by various treatments

Sr. No.	Treatments	K content (%)		K uptake (kg ha^{-1})		Total K (kg ha^{-1})
		Seed	Straw	Seed	Straw	
T_1 :	GRDF alone (water spray)	1.05	0.86	9.65	7.91	17.62
T_2 :	GRDF + Urea 2% at pre-flowering	1.07	0.93	12.49	10.84	23.24
T_3 :	G RDF + DAP 2% at pre-flowering	1.06	0.92	13.08	11.34	24.39
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	1.10	0.91	11.52	9.47	20.96
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	1.12	0.93	14.27	11.86	26.12
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	1.17	0.94	15.87	12.78	28.68
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	1.13	0.92	14.06	11.46	25.45
	S.Em ±	0.011	0.01	0.03	0.01	0.06
	C.D at 5%	0.035	0.030	0.11	0.05	0.20
	General mean	1.10	0.92	12.98	10.81	23.78

4.7 Available nitrogen, phosphorus and potassium in the soil after harvest

The data respect of available nitrogen, phosphorus and potassium in the soil after harvest of the crop as influenced by various treatments are presented in Table 15.

4.7.1 Available nitrogen (kg ha^{-1})

Available nitrogen in the soil was significantly improved by the foliar application of different nutrient. The average available nitrogen status of soil was 219.0 kg ha^{-1}.

The highest value of available nitrogen was recorded with treatments GRDF + Urea 2 % at pre-flowering (T_2) (223.89 kg ha^{-1}) which was significantly superior over all other treatments. This treatment was at par with GRDF+ 19:19:19 (N P K) 1 % spray at pre –flowering (T_4) (221.72 kg ha^{-1}). However lowest available nitrogen noticed in T_1 (absolute control) of 212.83 kg ha^{-1}. These results are in agreement with finding of Venkatesh and Basu, (2011) and Bansal and Ahmad (2015).

4.7.2 Available phosphorus (kg ha^{-1})

Available phosphorus in the soil was significantly improved by the foliar application of different nutrient. The average available phosphorus status of soil was 15.00 kg ha^{-1}.

Highest available phosphorus (15.66 kg ha^{-1}) was observed in treatment GRDF+ DAP 2 % at pre-flowering (T_3), which was statistically significant over rest of the treatments followed by treatment T_6recorded (15.37 kg ha^{-1}) in GRDF+ DAP 1 % at pre-flowering + KNO_3 @ 1% at pod development, which was at par with remaining treatments except T_4, and T_1. However lowest available phosphorus observed in T_1 (absolute control) of 14.31 kg ha^{-1}. These results are in agreement with Kuttimani and Velayutham (2011).

Table 15. Available nitrogen, phosphorus and potassium in soil after harvest as influenced by various treatments

Sr. No.	Treatments	After harvest		
		Nitrogen	Phosphorus	Potassium
T_1 :	GRDF alone (water spray)	213.78	14.31	354.18
T_2 :	GRDF + Urea 2% at pre-flowering	223.89	15.34	381.82
T_3 :	G RDF + DAP 2% at pre-flowering	220.78	15.66	390.16
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	221.72	14.99	411.62
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	220.62	15.17	430.52
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	219.41	15.37	447.01
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	219.64	15.21	430.07
	S.Em ±	0.93	0.23	4.93
	C.D at 5%	2.86	0.70	15.19
	General mean	219	15	406
	Initial status	187.32	14.12	395.10

4.7.3 Available potassium (kg ha^{-1})

Available potassium in the soil was significantly improved by the foliar application of different nutrient. The average available potassium status of soil was 406 kg ha^{-1}.

Highest available potassium (447 kg ha^{-1}) was observed in treatment GRDF+ DAP 1% at pre-flowering+ KNO_3 @ 1% at pod development (T_6), which was significantly higher over rest of the treatments. However lowest available potassium observed in T_1 (absolute control) of 354.18 kg ha^{-1}. These results are in agreement with Goud *et al*. (2014).

4.8 Economics of treatments

Data regarding gross monetary returns, net monetary returns and B:C ratio as influenced by various treatments are presented Table. 16 and graphically depicted in Fig.8. The mean gross monetary returns,cost of cultivation, net monetary returns and B:C ratio were ₹ 52714, ₹ 22602, ₹ 30111 and ₹ 2.32 respectively.

4.8.1 Gross monetary returns (₹)

The gross monetary returns were significantly influenced due to various treatments. The maximum gross monetary returns were obtained in treatment GRDF + DAP 1 % at pre-flowering+ KNO_3 @ 1 % at pod development (T_6) (₹. 61200). The next higher gross monetary returns were obtained in treatment GRDF + Urea 1% at pre-flowering + KNO_3 @ 1 % at pod development (T_5) (₹. 57330). However, lowest gross monetary returns were obtained in T_1 (absolute control) (₹. 41490).

4.8.2 Net monetary returns (₹)

The net monetary returns were significantly influenced due to various treatments. The maximum gross monetary returns were obtained in treatment GRDF + DAP 1 % at pre-flowering+ KNO_3 @ 1 % at pod development (T_6) (₹. 38158). Lowest net monetary returns were obtained in T_1 (absolute control) (₹. 19834) and in T_4 (GRDF + 19:19:19 (NPK) 1 % spray at pre-flowering) (₹. 24382). These results are in conformity with the results of Shinde and Bhilare (2003).

4.8.3 B:C ratio

Highest B:C ratio of 2.65 was found with treatment GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1% at pod development (T_6). The next best B:C ratio (2.52) was recorded in treatment GRDF+ Urea 1% at pre-flowering + KNO_3 @ 1 % at pod development (T_5). However lower B:C ratios found in T_1 (absolute control) (1.91) and in T_4 (GRDF+ 19:19:19 (NPK) 1% spray at pre –flowering) (2.08). These results are in conformity with the results of Yakadri and Thatikunta (2002).

Table 16. Gross monetary returns, Net monetary returns and benefit cost ratio as influenced by various treatments

Sr. No.	Treatments	Gross monetary returns	Cost of cultivation	Net monetary returns	B:C ratio
T_1 :	GRDF alone (water spray)	41490	21656	19834	1.91
T_2 :	GRDF + Urea 2% at pre-flowering	52335	22456	29879	2.33
T_3 :	G RDF + DAP 2% at pre-flowering	55485	22734	32751	2.44
T_4 :	GRDF + 19:19:19 (N P K) 1 % spray at pre –flowering	46935	22553	24382	2.08
T_5 :	GRDF + Urea 1% at pre-flowering + KNO_3 @ 1% at pod development	57330	22687	34643	2.52
T_6 :	GRDF + DAP 1% at pre-flowering + KNO_3 @ 1% at pod development	61200	23042	38158	2.65
T_7 :	GRDF+ 19:19:19 (N P K) 1% spray at pre -flowering + KNO_3 @ 1% at pod development	54225	23092	31133	2.34
	S.Em ±	7.65	-	4.77	-
	C.D at 5%	23.57	-	14.72	-
	General mean	52714	-	30111	-

5. SUMMARY AND CONCLUSION

5.1 Summary

A field experiment entitled "Influence of foliar nutrition on growth and productivity of blackgram" was conducted at Post Graduate Instructional Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during *kharif* season of 2019. The experiment consists of seven treatments and three replications.

The experimental soil type was medium deep and textural class was clay loamy with more than 30 cm depth. The blackgram crop was sown on 11th July 2019 and harvested on 20th September 2019. Total rainfall of 266.6 mm in 18th rainy days was recorded during the crop growing season. Overall on the weather during crop growing season was quite satisfactory.

Experiment was laid out in Randomized Block Design (RBD) with seven treatments and three replications. The treatments consist of (T_1) Absolute control, (T_2 GRDF + Urea 2 % at pre-flowering, (T_3 GRDF+ DAP 2 % at pre-flowering, (T_4) GRDF + 19:19:19 (NPK) 1 % spray at pre-flowering, (T_5) GRDF + Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development, (T6) GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development, (T_7) GRDF+ 19:19:19 (N P K) 1% spray at pre-flowering + KNO_3 @ 1% at pod development foliar spray will be executed at pre-flowering stage and pod development stage.

The finding recorded during course of investigation is summarized as bellow.

5.1.1 Effect of different foliar nutrition treatments

5.1.2 Plant stand

The foliar nutrition treatments had no significant influence on emergence count and final plant stand.

5.1.3 Growth characters

There was no significant difference upto flowering stage among the foliar application treatments except absolute control (T_1) realizing the importance of nutrition. There were significant differences observed among all the treatments when foliar nutrition was given. Growth characters *viz*., plant height, number of branches plant^{-1}, leaf area plant^{-1}, dry matter accumulation plant^{-1} total chlorophyll content were significantly higher with the application of GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development. On the other hand, in all cases the lower response was found from the control treatments.

Yield attributes were significantly influenced by different treatments of foliar nutrition. Significantly higher number of pods plant^{-1} (35.60), pod length (6.37), number of seeds pod^{-1} (6.80), number of seeds plant^{-1} (241), grain weight plant^{-1} (8.02 g), test weight (47.53 g), were found significantly highest with the application of GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1% at pod development.

The seed yield plot^{-1}, seed yield ha^{-1}, straw yield ha^{-1} (1.06 kg plot^{-1}, 1360 and 1914 kg ha^{-1} respectively) were significantly higher with the application of GRDF + DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development. The lowest seed yield plot^{-1}, seed yield ha^{-1} and straw yield ha^{-1} (0.72 kg plot^{-1}, 922 kg ha^{-1}, 1136 kg ha^{-1}, respectively) were recorded in absolute control with GRDF and without foliar spray of nutrients were applied which signifies the importance of foliar nutrition.

5.1.4 Protein content

The protein content was significantly highest with the treatment of GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1% at pod development which was at par with GRDF + 19:19:19 (NPK) 1 % spray at pre -flowering + KNO_3 @ 1% at pod development.

5.1.5 Nutrient uptake by blackgram

Nitrogen content and uptake (kg ha^{-1}) of nitrogen in seed, straw and totals were observed maximum in treatment GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development. Phosphorus and potassium content and uptake (kg ha^{-1}) in seed, straw and total uptake were also observed maximum in treatment GRDF + DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development. The available nitrogen, phosphorus and potassium were recorded highest with the application of GRDF + Urea 2 % at pre-flowering, GRDF + DAP 2 % at pre-flowering, GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development respectively. It was significantly more than absolute control treatment.

5.1.6 Economics

Gross monetary returns, net monetary returns and B:C ratio were significantly highest in treatment (T_6) GRDF+ DAP 1% at pre-flowering + KNO_3 @ 1 % at pod development.

5.2 Conclusions

Base on the results of the present investigation conducted to evaluate the best foliar nutrition treatments and its influence on growth and yield of blackgram, the following brief findings were drawn

1. Application of GRDF along with foliar application of DAP 1 % @ pre flowering and KNO_3 1% @ pod development significantly enhanced the growth contributing characters *viz.*, plant height, number of branches plant^{-1}, leaf area plant^{-1}, number of root nodules plant^{-1}, dry matter accumulation plant^{-1} and total chlorophyll content.
2. The highest yield and yield attributing characters *viz.*, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, grain weight plant^{-1}, test weight, seed yield and straw yield were recorded with application of GRDF along with foliar application of DAP 1 % @ pre flowering and KNO_3 1 % @ pod development followed by GRDF + Urea 1 % at pre-flowering + KNO_3 @ 1% at pod development.
3. Protein content of blackgram was found higher with treatment GRDF+ DAP 1% at pre-flowering+ KNO_3 @ 1% at pod development.
4. Nutrient content and uptake of seeds, straw and total uptake of nitrogen, phosphorus and potassium were found highest with application of GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1% at pod development.
5. Available Nitrogen, Phosphorus and Potassium (kg ha^{-1}) was recorded highest in treatments *viz.,* GRDF + Urea 2 % at pre-flowering, GRDF + DAP 2 % at pre-flowering and GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development respectively.
6. Gross monetary returns, net monetary returns and B : C ratio were maximum with application of GRDF + DAP 1 % at pre-flowering + KNO_3 @ 1 % at pod development. These conclusions are based on the result of one year investigation and therefore further experimentation will be needed to give valid recommendation.

6. LITERATURE CITED

Amany, A.B. 2007. Effect of plant density and urea foliar application on yield and yield components of chickpea (*Cicer arietinum* L.). *Research Journal Agriculture and Biological Sciences.,* **3**(4) : 220-223.

Amin, A.A., Abouziena, H.F., Abdelhamid, M.T., Rashad El-Sh., M. and Fatma Gharib, A.E. 2014. Improving growth and productivity of faba bean plants by foliar application of thiourea and aspartic acid. *International Journal of Plant Science,* **3**(6) : 724-736.

Aziz, M.A. and Miah, M.A.M. 2009. Effect of flora on the growth and yield of wetland rice. *Journal of Agriculture and Rural Development,* **7** : 9-13.

Bansal, M. and Ahmad, A.,2015. Effect of Nutrient management on growth, Yield and Quality of summer mungbean (*Vigna radiata* L). *The bioscan.* **10**(1) : 641-645.

Basavarappa, S,R., Shashikumar, R. and Patil, H.Y. 2013. Influence of foliar nutrition on performance of blackgram (*Vigna mungo* L.) nutrient uptake and economics dryland ecosystem. *Legume Research an International Journal.* **36** : 422-428.

Beg, M.Z. and Ahmad, S. 2012. Effect of potassium on mungbean. *Indian Journal of Lifescience.* **1**(2) : 109-114.

Behera, Nigamanda and Elamathi, S. 2007. Studies on the time of nitrogen, application of foliar spray of DAP and growth regulators on yield attributes, yield and economics of greengram. *International Journal of Agriculture Science. pp.* 168-169.

Boote, K.J., Gallaher, R.N., Robertson, W.K., Hinson, K. and Hammond, L.C. 1977. Effect of foliar fertilization on photosynthesis, leaf nutrition and yield of soybeans. *Agronomy Journal*. **70**(5) : 787-791.

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

Das, S.K and Jana, K. 2015. Effect of foliar spray of water soluble fertilizers at pre flowering stage of pulses. *Agriculture Science Digest*, **35**(4) : 275-279.

Deotale, R.D., Mahale, S.A., Patil, S.R., Sahane, A.N. and Sawant, P.P. 2015. Effect of foliar sprays of nitrate salts on morpho-physiological traits and yield of green gram. *International Journal,* **3** : 63-67.

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 rajma. *Annals of Plant Physiolpgy*., **22**(2) : 189-191.

Dixit, P.M. and Elemathi, S. 2007. Effect of foliar application of DAP, micronutrients and NAA on growth and yield of green gram (*Vigna radiata* L.). *Legume Research*, **30**(4) : 305-307.

Elayaraja, D. and Angayarkanni, A. 2005.Effect of foliar nutrition on the nodulation and yield of rice fallow blackgram. *The Andhra Agriculture Journal.,* **52**(3 & 4) : 602-604.

Ezzat, M. Abd El Lateef, Tawfik, M.M., Hozyin, M. Bakry, B.A., Elewa, T.A, Farrag,A.A and Amany, A Bahr 2012. Soil and foliar fertilization of mungbean. (*Vignaradiate* (L.) wilczek) under Egyptian conditions. *Elix. Agriculture.,* **47** : 8622-8628

Ganapathy, M., Baradhan, G. and Ramesh, N. 2008. Effect of foliar nutrition on reproductive efficiency and grain yield of rice fallow pulses. *Legume Research*., **31**(2) : 142-144.

Goud, V.V., Konde, N.M., Mohod, P.V. and Kharche, V.K. 2014. Response of chickpea to potassium fertilization on yield, quality, soil fertility and economic in vertisols. *Legume Research***, 37**(3) : 311-315.

Govindan, K. and Thirumurugan, V. 2000. Response of green gram to foliarnutrition of potassium. *Journal of Maharashtra Agriculture University.,* **25** : 302-303.

Gowthami, P. and Rama Rao, G. 2014. Effect of foliar application of potassium, boron and zinc on growth analysis and seed yield in soybean. *International Journal.,* **4**(3) : 73-80.

Gupta, S.C., Kumar, S. and Khandwe, T. 2011. Effect of biofertilizer and foliar spray of urea on symbiotic traits, nitrogen uptake and productivity of chickpea. *Journal of Food Legume.,* **24**(2) : 155-157.

Hugar, A.B. and Kurdikeri, M.B. 2000. Effect of application methods and levels of zinc and molybdenum on field performance and seed yield in soybean. *KN. Journal Agriculture Science*. **13**(2) : 439-441.

Ingale, S.R., Dectale, R. Kalamkar, D.V., Suryapujary, S. Mand Cujata, B.P. 2007. Influence of cow urine and NAA on biochemical and yield and yield contributing parameters of blackgram. *Journal of Soil and Crop,* **17**(2) : 373-378.

Iqtidar, A. and Rahman, S.F. 1984. Effect of boron on the protein and amino acid composition of wheat grain. *Journal Agriculture. Science., UK,* **103**(1) : 75-80.

Jackson, M.L. 1967. Soil chemical analysis. *Prentice Hall of India Pvt. Ltd., New Delhi*, *pp*. 111-203.

Jadhav, R.L and Kulkarni, S. 2016**.** Effect of foliar spray of nutrients on productivity of Greengram (*Vigna radiata*) in North Eastern transitional zone of Karnataka. *Indian. Legume Research*., **39**(5) : 817-819.

Jayarani Reddy, P.K., Narsimha Rao, L., Narsimha Rao, C.L. and Mahalakshmi, B.K. 2004. Effect of different chemical on growth, yield and yield attributes of pigeonpea in vertisol. *Annual. Plant Physiology.,* **17**(2) : 120-124.

Kadam, J.R., Pawar, S.U. and Patil, S.R. 2008. Effect of water soluble phosphatic fertilizers on chemical properties of soil and yield of soybean . *Journal of Maharashtra Agricultural University.,* **339**(2) : 151-153.

Kalarani, M.K. and Sheriff, M. 1994. Increasing yield due to delaying leaf senescence by the foliar fertilization of N, P, K and B. *Madras Agriculture Journal.,* **81**(3) : 171-172

Kalarani, M.K. 1991. Senescence regulation in soybean [*Glycine max (L.)* Merrill]. M.Sc. (Agri.) Thesis, *Tamil Nadu Agriculture University., Coimbatore.*

Kaur, M.J and Jagetiya, B.L. 2005. Evaluation of yields by KNO_3 application in glycine max. *Bulletin. of Pure and Apllied Science.,* **24B**(1) : 51-56.

Khalilzadeh, R., Mehdi, T. and Jalal, J. 2012. Growth characteristics of mungbean (*Vigna radiata* L.) affected by foliar application of urea and bioorganic fertilizers. *International Journal Agriculture Crop Science.,* **4**(10) : 637-642.

Khan, N.A., Sayeed, S., Masood, A., Nazr, R. and Iqbal, T. 2010. Application of salicylic acid increase content of nutrient and antioxidant metabolism in mungbean and alleviates adverse effect of salinity stress. *International Journal of Plant Boilogy.* **1** : 15-18.

Kocon, A. 2010. Effect of foliar or soil top-dressing of urea on some physiological processes and seed yield of faba bean. *Polish Journal Agronomy.,* **3** : 15-19.

Kumar, G.S., Muthukrishnan, P., Ramasamy, S. and Chandragiri, K.K. 2008. Effect of organic and inorganic foliar spray on growth and yield of blackgram (*Vigna mungo* L.). *Madras Agriculture Journal.,* **95**(1-6) : 57-60.

Kumar, V.C., Vaiyapuri, K.A. Mohmed, M. and Gopalaswamy, G. 2013. Influence of foliar spray of nutrients on yields and economics of Soybean. *Journal of Biological Science.,* **13**(6) : 56-58.

Kurhade, P.P., Sethi, H.N. and Zadode, R.S. 2014. Effect of different levels of potassium on yield, quality, available nutrient and uptake of blackgram. *International Journal of Agriculture Science.* **11 :** 175-178.

Kuttimani, R. and Velayutham, A. 2011**.** Foliar application of nutrients and growth regulators on yield and economics of greengram. *Madras Agriculture Journal.,* **98**(4) : 141-143.

Kuttimani, R. and Velayutham, A. 2011. Foliar application of nutrients enhances the yield attributes and nutrient uptake of green gram. *Agriculture Science Digest.,* **31**(3) : 202-205.

Lateef, A.E.M., Ashour, N.I. And Forrag, A.A. 1998. Effect of foliar spray with urea and some micro-nutrients on mungbean (*Vigna radiata* L.) growth yield and seed chemical composition. Bull. *National Research Center Cairo*, **23**(2) : 219-232.

Latha, M.R. and Nadanassababady, T. 2003. Foliar nutrition in crops. *Agriculture Review.,* **24**(3) : 229-234.

Maheshwari, M and Karthik, A. 2017. Effect of Foliar Nutrition on Growth, Yield Attributes and Seed Yield of Pulse Crops. *Advanced Crop Science Techonogy.,* **5** : 3-5.

Mahmoud., M., Shaaban., Abdalla., El-Sayed., F., El-Nour., A., El-Zanaty., A. M., El-Saady and Mohamed., A. K., 2006. Boron/ nitrogen interaction effect on growth and yield of faba bean plants grown under sandy soil conditions. *International Journal Agriculture Research.,* **1**(4) : 322-330.

Malay, K. and Bhowmick, T. 2008. Effect of foliar nutrition and basal fertilization in lentil under rainfed conditions. *Journal Food Legume.,* **21**(2) : 115-116.

Manivannan, V., Thanunathan, K., Imavaramban, V. and Ramanathan, N. 2002. Effect of foliar application of NPK and chelated micronutrients on rice-fallow urdbean *Legume Research.,* **25**(4) : 270-272.

Manjula Devi, M. and Pillai, R.N. 1997. Foliar fertilization of urea on yield and nutrient uptake by urd bean. *Legume Research.,* **20**(3/4) : 221-223.

Manonmani, V. and Srimathi, P. 2009. Influence of mother crop nutrition on seed and quality of blackgram. *Madras Agricultue Journal.,* **96**(16) : 125-128.

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. *Indian Cojents. Food & Agriculture*. **1** : 10-10-415.

Mathur, N., Singh, S., Bhora, S., Bhora, A. and Vyas, A. 2006. Improved productivity of mungbean by foliar application of Thiourea under arid condition. *World Journal of Agriculture Science.* **2**(2) : 185-186.

Mazhar Haq, U. and Antonio, M.P. 2000. Soybean yield and nutrient composition as affected by early season foliar fertilization. *Agronomy Journal.,* **92**(1) : 16-24.

Mahobia, R.K., Malaiya, S. and Srivastava, G.K. 2006. Effect of foliar application of nutrients on growth and yield of pigeonpea under rainfed condition in *vertisols* of Chattisgarhplains. *Annual Plant Physiolology.,* **20**(2) : 215-219.

Meena, B.S. and Sharma, D.D. 2005. Effect of phosphorus sources, solublizers and bioregulators on growth, yield and phosphorus uptake by pigeonpea (*Cajanuscajan*). *Indian journal of Agronomy.* **50**(**2**):143-145.

Mondal, M.M.A., Puteh, A.B., Malek, M.A. and Roy, S. 2012. Effect of foliar application of urea on physiological characters and yield of soybean. *Legume Research.,* **35**(3) : 202-206.

Mondal, M.M.A., Rahmanakter, M.B. and Fakir. M.S.A. 2011. Effect of foliar application of nitrogen and micronutrients on growth and yield in mungbean. *Legume Research.,* **34**(3) : 166-171.

Mudalagiriyappa, Ali., Ramachandrappa, S.M., Nagaraju, B.K. and Shankaralingappa, B.C. 2016. Effect of foliar application of water soluble fertilizers on growth, yield and economics of chickpea (*Cicer arietinum* L.)*Legume Research..***39**(4): 610-613

Mudalagiriyappa, M., Sameer Ali, Ramachandrappa, B.K., Basavaraja, P.K. and Kiran, T. 2016. Effect of foliar application of water soluble fertilizers on nutrient uptake and reproductive efficiency of chickpea (*Cicer arietinum* L.). *The Bioscan.* **11**(3) : 1601-1604.

Muthulakshmi, S. and Lingakumar, K. 2016. Salicylic acid induced responses on growth and biochemical constituents in (*Vigna mungo* L.) Hepper. *European Journal Experimental Biology*. **6**(1): 9-14 (ISSN: 2248-9215).

Muthuvel, P., Sivasamy, R. and Subramanian, V. 1985. Mitigating the adverse effect of drought in rainfed blackgram. *Madras Agriculture Journal,* **72**(1) : 22-24.

Nabih, I., Ashour., and Alice, T.T. 1982. Effect of soil and foliar application of nitrogen during pod development on the yield of soybean plants. *Field Crop Research.,* **6** : 225-229.

Olsen, S.R., Cole, C.V., Watanable F.S. and Dean, T. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *U.S. Dept. of Agriculture Chemistry and Soil Science Agriculture.* pp. 125-131.

Pandian, B.J., Kumar, A., Veerabadran, V. and Ravichandran, R.V. 2001. Growth and yield of rice fallow greengram as influenced by methods of sowing, stubble management and nutrient application in Tambiraparani command area. *Madras Agriculture Journal.,* **88**(7-9) : 406-409.

Panse, V.G and Sukhatme, P.V. 1967. Statistical method for agriculture workers, *published by ICAR. New Delhi*.

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 Journal of Agronomy.,***45**(1) : 131-134

Palta, J.A., Nandwal, A.S., Kumari, S. and Turner, N.C. 2005. Foliar nitrogen applications increase the seed yield and protein content in chickpea (*Cicer arietinumL.)* subject to terminal drought. *Australian Journal Agricultural Research.,* **56** : 105-112.

Patel, J.R. and Patel, Z.G. 1994. Effect of foliar fertilization of nitrogen and phosphorus on growth and yield of summer greengram. *Indian Journal Agronomy.,* **39**(4) : 578-580.

Pavithra, A.H., Sridhara, T. and Pradeep Gopakkali. 2017. Enhancing the yield and yield parameters of Cluster bean through Foliar application *of Nutrients International Journal Current Microbiol. Applied Scienc.* **6**(4) : 1508-1512.

Pawar, S.E. and Bhatia, C.R. 1980. The basis for grain yield differences in Mungbean cultivars and identification of yield limiting factors. *Theoretical and applied Genetics.,* **57** : 171-175.

Patel, H.B., Shah, K.A. and Patel, K.H. 2019. Response of greengram to different Level of phosphorus and organic liquid fertilizer on yield, quality, nutrient content and Uptake. *International Journal Current Microbiology and Applied Sciences.* **8**(04) : 1234-1242.

Piper, C.S.1966. Soil and plant analysis. *Hons Publishers Bombay*.

Pujari, B. T. and Gaddankari, S.A. 1998, maximizing production of pigeonpea under dry tract of peninsular India. Proceedings of eighty fifth session of the Indian Science Congress, Hyderabad, pp. 17.

Radhamani, S., Balasubramanian, A. and Chinnusamy, C. 2003. Foliar nutrition with growth regulators on the productivity of rainfed greengram. *Agriculture Science Digest,* **23**(4) : 307-308.

Raj, S. 1985. An Introduction to physiology of field crops, Oxford and *IBH Publishing Co. New Delhi. pp.* 94-97.

Rajavel, T. and Vincent, V.R. 2009. Influence of nutrients and hormones on yield maximization of blackgram. *Journal of Ecobio.;* **24**(4) : 387-394.

Rajesh, N. 2011. Studies on the performance of transplanting and foliar nutrition in red gram M. Sc. (Agri.), Thesis, Tamil Nadu Agriculture University, Coimbatore.

Ramamurthy, Y.K., Ramasamy, M. and Jahangir, K.S. 1993**.** Response of rainfed blackgram (*Phaseolus mungo)* to foliar nutrition of potassium. *Indian Journal Agronomy.,* **40**(1) : 114-115

Raman, R. and Venkataramana, K. 2006**.** Effect of foliar nutrition on NPK uptake, yield attributes and yield of green gram (*Vigna radiata*). *Crop Research.,* **32**(1) : 21-23.

Ramesh, K. and Thirumurugan, V. 2001. Effect of seed pelleting and foliar nutrition on growth of soybean. *Madras Agriculture Journal.,* **88** : 465-468.

Rao, S.N., Naidu, T.C.M. and Rani, A.Y. 2013. Effect of foliar nutrition on antioxidant enzymes, photosynthetic rate, dry matter production and yield of mung bean under receding soil moisture condition. *International Journal of Pure and Applied Bioscience.* 3(1) : 115-12.

Rao, S.N., Naidu, T.C.M. and Rani, Y.A. 2016. Effect of foliar nutrition on physiological and biochemical parameters of mung bean (*Vigna mungo* (L.) Hepper) under irrigated conditions. *International Journal of Research in Applied, Natural and Social Sciences.* **4** : 2347-4580.

Reddy, M., Padmaja, B., Rao, L.J. and Radhakrishna, K.V. 2005. Effect of foliar spray of urea on nitrogen uptake and yield of urdbean (*Vigna mungo* (L.) under rainfed conditions. *Indian Journal Dryland Agriculture Research and Development.,* **20**(2) : 151-154.

Sadia Majeed, Muhammad Akram, Muhammad Latif, Muhammad Ijaz and Mubshar Hussain. 2016. Mitigation of drought stress by foliar application of salicyclic acid and potassium in mungbean (*Vigna radiata* L.).

Sahai, V.N. 2004. Miniral nutrients. In fundamental of soil. *3rd edition Kalyani Publishers. New Delhi, India. pp.* 151-155.

Salim, M. M., 1992. Effect of sowing methods and foliar nutrition with urea and some micronutrients on growth and yield of soybean. *Egyptian Journal of Agronomy.,***17** : 141-154.

Salisbury, F.B. and Ross, C.W. 1985. Plant Physiology. *3rd Edition Wadsworth, Belmont, CA.* pp. 540.

Sarkar, R.K. and Malik, G.C. 2001. Effect of foliar spray of potassium nitrate and calcium nitrate on grass pea (*Lathyrus sativus* L.) grown in rice fallows. *Lathyrus Lathyrism. Newsletter.* **2 :** 15-18.

Sarkar, R.K., Chandraborthy, A. and Saha, A. 1999. Effect of foliar application of potassium nitrate and calcium nitrate on groundnut (*Arachis hypogaea*. L.). *Indian. Journal of Agronomy.*, **44**(4) : 809-812.

Sathiyamoorthy, P. and Vivekanandan, M., 1988, Cumulative effects of pre-sowing seed treatment and foliar application of salts in improving biomass and grain yield of soybean in moderate saline/alkaline soil. *Journal of Agronomy and Crop Science.,* **161**(2) : 107-113.

Satyajit Pathak, Namdeo, K.N., Chakrawarti,V.K. and Tiwari, R.K. 2003. Effect of biofertilizers, diammonium phosphate and Zinc sulphate on growth and yield of chickpea (*Cicer arietinum* L.) *Legume Crop Research.* **26**(1) : 42-46.

Sengupta, K. and Tamang, D. 2015. Response of green gram to foliar application of nutrients and brassinolide. *Journal Crop and Weed*, **11**(1) : 43-45.

Shashikumar, R., Basavarajappa, S.R., Salakinkop, Manjunatha Hebbar, Basavarajappa, M.P. and Patil, H.Y. 2013. Influence of foliar nutrition on performance of blackgram (*Vigna mungo* l.), nutrient uptake and economics under dryland ecosystems. *Legume Research.,* **36**(5) : 422-428.

Shinde, S.H. and Bhilare, R.L. 2003. Response of chickpea to soil and foliar application of DAP. *Madras Agricultural Journal.* **90**(4-6) : 352-354.

Singh, G., Sekhon, N. and Manjit, K. 1980. Effect of phenolic compounds on the yield potential of gram (*Cicer arietinum* L.). *Indian Journal Plant Physiology,* **23** : 21-25.

Sritharan, Anitha, A. and Mallika, V. 2005. Effect of foliar sprays of nutrients and plant growth regulators (PGRs) for yield maximization in blackgram. *Madras Agricultural Journal,* **92**(4-6) : 301-307.

Solalappan, U. and Ramiah, S. 1990. Effect of seed treatments, soil and foliar fertilization on N and P on yield attributes of pigeon pea grown under rainfed condition. *Indian Journal of Agronomy.,* **35**(3) : 234-237.

Srinivasan, K. and Ramasamy, M. 1992. Effect of foliar nutrition of urea and diammonium phosphate on rainfed cowpea. *Indian Journal of Agronomy.* **37** : 265-267.

Sritharan, N., Anitha, A and Mallika, V. 2005. Effect of foliar spray of nutrients and plant growth regulators (PGRs) for yield maximization in black gram. *Madras Agricultural Journal.,* **92**(4-6) : 301-307.

Sritharan, N., Rajavel, M. and Senthilkumar, R. 2015. Physiological approaches : Yield improvement in blackgram. *Legume. Research*, **38**(1) : 91-95.

Srivastava, G.P. and Srivastava, V.C. 1994. Effect of irrigation and foliar spray of nutrients on growth and seed yield of gram (*Cicer arietinum*). *Indian Journal Agricultural Science.,* **64**(4) : 219-222.

Subbaiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*., **25** : 259- 260.

Swati Koneni 2016. Effect of Soil and Foliar Application of Phosphorus on Growth of Green Gram (*Vigna radiata* L.) *Trends in Biosciences.* **9**(1) : 14-16.

Thalooth, A.T., Tawfik, M.M. and Mohamed, H.M. 2006. A comparative study on the effect of application of zinc, potassium and magnesium on growth, yield and some chemical constituents of mungbean plants grown under water stress conditions. *World Journal Agricultural Science.,* **2**(1) : 37-46.

Thakare, G.K., Chore, C.N., Deotale, R.D., Kamble, P.S., Pawar, B.S. and Lende, R.S.

2006. Influence of nutrients and hormones on bio-chemical and yield and yield attributing parameters of soybean. *Journal of Soils and Crops*. **16**(1) : 210-216.

Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L 1995. Soil fertility and fertilizers. *Prentice Hall of India Pvt. Ltd., New Delhi*, pp. 506-507.

Thiyageswari, S. and Ranganathan, G. 1999. Micronutrients and cytozyme on grain yield and dry matter production of soybean. *Madras Agricultural Journal.,* **86**(7-9) : 496-498.

Upadhyay, V.B., Koshta, L.D., Bisen, C.R and Sachidanand, B. 1992. Studies on response of arhar (*Cajan uscajan* (L.) Millsp) to foliar spray of DAP and under rainfed condition. *Jawaharlal Nehru Krishi Vishwa Vidyalaya, Research Journal.*, **26**(**1**) : 60-61

Vekaria, G.B., Talpada.,G.S. and Akbari, K.N. 2013. Effect of foliar nutrient of potassium nitrate on the growth and yield of Greengram. *Leg. Res.; an International Journal.* 6(**2**) : 162-163.

Venkatesh, M.S. and Basu, P.S. 2011. Effect of foliar application of urea on growth, yield and quality of chickpea under rainfed conditions. *Journal Food Legume.,* **24**(2) : 110-112.

Verma, C.B., Yadav, R.S., Singh, I. J. and Singh, A.K. 2009. Physiological traits and productivity of rainfed chickpea in relation to urea spray and genotypes .*Legume Research*. **32** :103-107.

Verma, C.K., Yadav, D.D. and Singh, V. 2011. Effect on yield and quality of greengram (*Vigna radiate* L.) varieties by foliar spray of urea and seed rate. *Plant Arch.* **11** : 289-291..

Yadav, L.R. and Choudhary, G.L. 2012. Effect of fertility levels and foliar nutrition on profitability, nutrient content and uptake of cowpea (*Vigna unguiculata* L. Walp). *Legume Research.,* **35**(3) : 258-260.

Yakadri, M. and Ramesh, T. 2002. Effect of soil application of potassium and DAP spray in blackgram. *Madras Agriculture Journal.* **89**(1-3) : 147-149.

7. APPENDIX

Cost of cultivation of Blackgram depends upon fallowing prices

Sr. No.	Particular	Unit	Rate
1.	Tractor ploughing	ha^{-1}	2500
2.	Harrowing	ha^{-1}	1250
3.	Seed	ha^{-1}	1050
4.	Sowing	ha^{-1}	1500
5.	Gap filling 2 labour × Rs.220	ha^{-1}	440
6.	Thinning 2 labour × Rs. 220	ha^{-1}	440
7.	Weeding labour 12 × Rs.220	ha^{-1}	2640
8.	Fertilizer application 2 labour × Rs. 220	ha^{-1}	440
9.	Chemical fertilizer		
	1) Urea cost Rs. 5.94 kg^{-1} × 43 kg	ha^{-1}	255
	2) SSP cost Rs. 7.8 kg^{-1} × 250 kg	ha^{-1}	1950
	3) MOP cost Rs. 11.7 kg^{-1} × 66.8 kg	ha^{-1}	782
	4)FYM cost Rs. 800 $tonn^{-1}$ × 5 tonn	ha^{-1}	4000
10.	Water soluble fertilizers		
	Urea (2%) Rs. 5.94 kg^{-1} × 6 kg	ha^{-1}	35
	DAP (2%) Rs. 25 kg^{-1} × 6 kg	ha^{-1}	150
	19:19:19 (1%) cost Rs. 150 kg^{-1} × 3 kg	ha^{-1}	450
	Kno3 @ (1%) Cost Rs.120 kg^{-1} × 3 kg	ha^{-1}	360
11.	Quinolphos	ha^{-1}	750
12.	Irrigation charges	ha^{-1}	600
13.	Harvesting 15 labour × Rs. 220	ha^{-1}	3300
14.	Selling rate of blackgram	q^{-1}	4500

8. VITAE

MR. LANDGE PARASARAM BHIMRAV

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

2021

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