Vol.11 No. 2, Page No. 87–92 (2022)
Received: August, 2022; Accepted: October, 2022

Growth Patterns of Black Gram (*Vigna mungo* L.) as Affected by Various Phosphorus and Sulphur levels

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Abstract

To study the effect of various levels of phosphorus and sulphur on differentgrowth patterns of black gram var. Vikral plus, a field experiment was carried out at Crop Research Centre, ITM University, Gwalior, (26.140° N, 78.196° E; MSL 197 m). The soil belonged to the sandy loam textural class (pH 7.35; EC 0.40 dSm^{-1}). An experiment was carried out in a randomized block design with absolute control and three dosages of phosphorus (45, 60, and 75 kg ha^{-1}) and three dosages of sulphur (16, 20, and 24 kg ha^{-1}) each, having ten treatments. Nitrogen and potassium were applied as basal application @ 25 kg ha^{-1}. Different growth patterns and economics were periodically recorded and statistically analysed using standard methods. It can be illustrated that the dosages of phosphorus 75 and 60 kg ha^{-1} and, sulphur 24 and 20 kg ha^{-1} being at par each, influenced significantly and superior over their respective lower dosages of phosphorus and sulphur to dry matter accumulation, number of leaves, number of nodules, and economics, respectively. The dosages of phosphorus at 60 and sulphur at 20 kg ha^{-1} application in black gram on behalf of growth patterns and economics may be recommended.

Keywords: *Black gram, dry matter accumulation, economics, leaves, nodules.*

Introduction

Pulse crops are one of the most environmentally friendly crops, a farmer can grow. Pulses are also referred as grain legumes. They contain a lot of protein, fibre, and various vitamins, amino acids. Although they are most popular in developing countries but are increasingly becoming recognized as an excellent part of a healthy diet globally. Legumes are unique in that majority of them have symbiotic bacteria that fix nitrogen in structures known as root nodules. They play a key role in crop rotation. Legume crops are referred to as green manure crops. The protein level of pulses is 20 to 25 percent by weight, which is twice that of wheat and three times that of rice. Pulse crops can remain a great option for farmers in the poor countries with the introduction of improved varieties and promotion of better management techniques. Up to 25% of pulses are used as feedstuff, particularly for livestock and poultry (International Year of Pulses.org).

Black gram (*Vigna Mungo* L.), is one of the important pulse crops that is grown throughout the country. It has been reported that the crop produces yield equivalent to 22.10 kg of Nha^{-1}which has been estimated to be supplement of 59 thousand tonnes of urea annually (Jat *et al*.,2017).Major black gram growing states in terms of area wise are Madhya Pradesh, Uttar Pradesh, and Andhra Pradesh. It produces about 24.5 lakh tonnes of Urdbean annually from about 4.6 million hectares of area, with a productivity of 533 kgha^{-1}in 2020-21 (Govt of India, 2022). During Kharif, it is cultivated throughout the country. It is best suited to rice fallows during Rabi in southern and south-eastern parts of India.

Phosphorus promotes in the production and stability of DNA and RNA

and is necessary for the transport and storage of energy in biological systems through ATP (Adenosine triphosphate).It has been discovered that phosphorus is a crucial mineral component for the efficient biological N_2 fixing in leguminous plants. Nodulation and nodule function are comprised in low P environments, and the amount of N fixed is decreased. Nodules behave as a major sink for P.

Similarly, Sulphur (S) is an essential element which helps in the formation of proteins, enzymes, vitamins, and chlorophyll in plants. In addition to legumes, they can effectively fix nitrogen, that is essential for nodule growth. Since sulphur is a component of various vitamins and amino acids found in both plants and animals, it is essential for protein synthesis, especially in the formation of oils inside the seeds (ICL fertilizers). Thus, sulphur is a crucial element in influencing the nutritional value of foods. Sulphur is also important in photosynthesis and improves the winter hardiness of crops.

Materials and Methods

A Research study was carried out during the Kharif season of 2021 at Crop Research Centre, ITM University, Gwalior, Madhya Pradesh, India (26.140° N latitude, 78.196° E longitude, and an altitude of 197 meters above mean sea level). The climate of Gwalior is semi-arid, with extremes of temperature in both summers and the winters. The southwest monsoon season starts from mid forth of June to mid forth of September. The average annual precipitation ranges from 650-700mm. The soil in the experimental field had the respective physico-chemical properties with sand 54.24 (%), silt 23.56 (%), clay 22.11 (%), textural class sandy loam, soil reaction (pH) 7.35, EC 0.40 dSm^{-1}, with low organic carbon 0.11%, available nitrogen 67 kg ha^{-1}, low in available phosphorus 14.5 kg ha^{-1} and potassium 238.4 kg ha^{-1}. The black gram variety was (Vikral plus) with average duration of 75-85 days was used as an experimental crop. The experimental study was conducted in a randomized block design with absolute control and three levels of each phosphorus (45, 60, and 75 kg ha^{-1}) and sulphur (16, 20, and 24 kg ha^{-1}), for a total of ten treatments. Nitrogen and potassium were applied as per recommended dose and method (25 kg ha^{-1} nitrogen and potassium each as basal application). Nitrogen and potassium were applied through urea, and muriate of potash whereas, phosphorus and sulphur were applied through DAP, and elemental sulphur respectively. Treated seed of black gram at the rate of 15 kg ha^{-1} was sown in every treatment using the standard technique. Recommended spacing (30cm×10cm) was maintained by thinning technique. Appropriate plant protection measures were followed during the experiment. The observations on number of leaves, dry matter accumulation[5], and the number of nodules at 20, 40, 60 days after sowing (DAS) and at harvest stage and economics were recorded to analyse the effect of various treatments on growth attributes of the crop using standard methods. For comparing different treatment means, a two-way Analysis of the variance Table with the replication's technique was implemented. The data were statistically analysed.

Results and Discussion

The study demonstrates that the different levels of phosphorus and Sulphur application in the black gram crop had a significant effect on the dry matter

accumulation (Table 1). However, at all the crop growth phases, phosphorus of 75 kgha^{-1} produced significantly higher dry matter accumulation over all the other phosphorus levels but at par with 60 kgha^{-1}.This might be due of the fact that plants with larger phosphorus dosages utilized more nutrients and phosphorus for their better growth and development, resulting in an increase in dry matter accumulation, but after a certain point, there may be saturation[2].

At all the stages of crop growth, the Sulphur application @ 24kgha^{-1}produced significantly higher plant height than the other Sulphur levels[3]. This may be because plants may utilize additional nutrients like space, light, and moisture to grow and develop properly[3].

Table 1 Effect of phosphorus and sulphur levels on dry matter accumulation (g/m^2)

Treatments	20DAS	40DAS	60DAS	Harvest stage
S_0P_0 (control)	32±2.2^{f}	100±2.3^{f}	190±5.9^{f}	260±2.3^{f}
P_{45}	41±2^{b}	123±4^{b}	228±7^{b}	291±10^{b}
P_{60}	55±3^{a}	146±5^{a}	252±8^{a}	320±10^{a}
P_{75}	60±2^{a}	157±5^{a}	264±7^{a}	332±8^{a}
S_{16}	44±3^{b}	131±6^{b}	231±7^{b}	294±10^{b}
S_{20}	54±4^{a}	144±7^{a}	251±8^{ab}	319±9^{ab}
S_{24}	58±3^{a}	150±6^{a}	262±9^{a}	330±10^{a}
$S_{16}P_{45}$	36±0.4^{e}	113±3.2^{e}	210±5.2^{d}	273±16.5^{d}
$S_{20}P_{45}$	40±4de	122±0.7^{de}	226±3.6^{cd}	288±4.4^{cd}
$S_{24}P_{45}$	46±1.5^{cd}	135±7.3^{bcd}	248±13.7^{abc}	312±21^{abcd}
$S_{16}P_{60}$	45±4.5^{cde}	131±7.3^{cde}	233±6.7^{bcd}	297±16.1^{bcd}
$S_{20}P_{60}$	59±3.2^{ab}	153±8.7^{abc}	259±7.5^{abc}	330±12.4^{abc}
$S_{24}P_{60}$	62±4^{a}	154±5.6^{ab}	264±21.3^{ab}	333±19.1^{abc}
$S_{16}P_{75}$	52±1.1^{bc}	150±0.5^{abc}	249±12.8^{abc}	311±15.7^{abcd}
$S_{20}P_{75}$	63±2.1^{a}	158±8.3^{a}	268±13^{ab}	339±3.4^{ab}
$S_{24}P_{75}$	65±2.1^{a}	161±12.9^{a}	275±8.1^{a}	345±12.3^{a}

DAS-Days after sowing

^{a,b,c,d,e,f}*- values bearing different superscripts within the column differed significant (P<0.05).*

In the black gram crop, various doses of phosphorus and Sulphur had a significant impact on the number of leaves per plant (Table 2). At all the stages of crop growth, a phosphorus level of 75 kgha^{-1}being on par with 60 kgha^{-1}recorded significantly higher number of leaves per plant than the control plot. At all the stages of crop growth, the level 75 kgha^{-1}was recorded to have more number of leaves per plant as compared to that at lower levels.Phosphorus most likely increased the availability of other essential nutrients, allowing for maximum growth and, as a result, the greatest number of leaves per plant. Application of phosphorus increased nutrient availability, leading to greater removal. This may have boosted photosynthesis and distributed the synthase to different regions to encourage the meristematic development of potential apical buds and intercalary meristems, leading to an increase in the number of

leaves.Similar findings were recorded earlier[1].

In comparison to sulphur, level of 16 kgha^{-1} resulted in a significantly less number of leaves in comparison to other levels, but more when compared to that in control. Sulphur 24 kgha^{-1}treatment resulted in significantly a higher number of leaves per plant than other sulphur dosages of crop growth. Sulphur at the dose of 24 kgha^{-1}which was at par with that at 20 kgha^{-1}of sulphur recorded a significantly greater number of leaves than the lowest level with sulphur. The more number of leaves per plant might be due to the higher nutrition levels and usage in well-fertilized plots, as compared to control or lower levels, which couldn't provide with the necessary crop's nutritional needs[4].

Table 2 Effect of phosphorus and sulphur levels on the number of leaves per plant

Treatments	20DAS	40DAS	60DAS	Harvest stage
S_0P_0 (control)	5 ± 0^{f}	14.1 ± 0^{f}	16.07 ± 1^{f}	22.11 ± 0^{f}
P_{45}	6 ± 0^{b}	16 ± 1^{b}	18 ± 1^{b}	24 ± 1^{b}
P_{60}	7 ± 0^{a}	20 ± 1^{a}	22 ± 1^{a}	27 ± 1^{a}
P_{75}	8 ± 0^{a}	22 ± 1^{a}	24 ± 1^{a}	28 ± 1^{a}
S_{16}	6 ± 0^{b}	18 ± 1^{b}	19 ± 1^{b}	25 ± 1^{b}
S_{20}	7 ± 1^{a}	20 ± 1^{a}	22 ± 1^{a}	27 ± 1^{ab}
S_{24}	8 ± 0^{a}	21 ± 1^{a}	23 ± 1^{a}	28 ± 1^{a}
$S_{16}P_{45}$	5.3 ± 0^{d}	15.07 ± 1^{d}	16.33 ± 1^{e}	23.1 ± 2^{d}
$S_{20}P_{45}$	6 ± 1^{cd}	16.77 ± 2^{cd}	18.1 ± 1^{de}	24.15 ± 1^{cd}
$S_{24}P_{45}$	6.3 ± 1^{bcd}	17.57 ± 2^{bcd}	19.63 ± 1^{cde}	25.71 ± 1^{bcd}
$S_{16}P_{60}$	6.3 ± 0^{bcd}	17.67 ± 1^{bcd}	19.73 ± 1^{cde}	25.05 ± 1^{bcd}
$S_{20}P_{60}$	7.7 ± 1^{ab}	21.27 ± 2^{ab}	22.83 ± 1^{abc}	27.24 ± 1^{abc}
$S_{24}P_{60}$	8 ± 0^{a}	21.87 ± 0^{a}	24.17 ± 1^{abc}	27.64 ± 0^{abc}
$S_{16}P_{75}$	7.3 ± 1^{abc}	20.47 ± 2^{abc}	21.63 ± 2^{bcd}	26.34 ± 2^{abcd}
$S_{20}P_{75}$	8.3 ± 1^{a}	22.93 ± 2^{a}	24.27 ± 1^{ab}	28.15 ± 1^{ab}
$S_{24}P_{75}$	8.3 ± 0^{a}	22.87 ± 1^{a}	25.6 ± 1^{a}	29.45 ± 1^{a}

DAS-Days after sowing

^{a,b,c,d,e,f}- values bearing different superscripts within the column differed significant ($P<0.05$).

The dosages of phosphorus and sulphur had a significant influence in the number of nodules per plant. Phosphorus at 60 kgha^{-1}level being at par with that at 75kgha^{-1} resulted significantly superior in the number of nodules of a crop when compared to those at lower levels (Table 3). It has been observed that when there is an adequate quantity of phosphorus, the bacteria become motile and flagellate, which is necessary for bacterial migration, however, in the absence of phosphorus or insufficient quantity, the infection remained latent, resulting in poor root nodules formation. The number and size of nodules, as well as the sulphur-fixing potentiality of micro-organisms increased, as phosphorus fertilizer was applied to legumes.

At all the stages of crop growth, the sulphur level of 16kgha^{-1} resulted in a significantly lesser number of root nodules per plant than the other sulphur doses. Sulphur 24 kgha^{-1} and 20 kgha^{-1} being at

par significantly recorded a more number of root nodules per plant over the lower level of sulphur 16 kgha^{-1}. It might be due to that sulphur provides a favourable micro-experiment for profuse root development and bacterial colonies, which ultimately led to increased nodulation in the black gram crop.

Table 3 Effect of phosphorus and sulphur levels on the number of nodules per plant

Treatments	20DAS	40DAS	60DAS
$S_0 P_0$ (control)	8.58 ± 0^{e}	17.46 ± 0^{e}	20.9 ± 2^{e}
P_{45}	10 ± 1^{b}	24 ± 1^{b}	27 ± 1^{c}
P_{60}	12 ± 1^{a}	27 ± 1^{a}	30 ± 1^{b}
P_{75}	14 ± 1^{a}	30 ± 1^{a}	33 ± 1^{a}
S_{16}	10 ± 0^{b}	24 ± 1^{b}	27 ± 1^{b}
S_{20}	12 ± 1^{a}	28 ± 1^{a}	31 ± 2^{a}
S_{24}	13 ± 1^{a}	29 ± 2^{a}	32 ± 1^{a}
$S_{16}P_{45}$	9.68 ± 0^{d}	21.28 ± 2^{d}	24.35 ± 0^{d}
$S_{20}P_{45}$	8.75 ± 1^{d}	23.82 ± 2^{cd}	27.4 ± 3^{cd}
$S_{24}P_{45}$	10.76 ± 1^{cd}	25.97 ± 3^{bcd}	28.39 ± 1^{cd}
$S_{16}P_{60}$	10.43 ± 1^{d}	24.92 ± 1^{cd}	27.72 ± 2^{cd}
$S_{20}P_{60}$	13.21 ± 1^{abc}	27.84 ± 1^{abc}	30.46 ± 3^{abc}
$S_{24}P_{60}$	13.57 ± 1^{ab}	28.62 ± 1^{abc}	31.69 ± 2^{abc}
$S_{16}P_{75}$	11.26 ± 1^{bcd}	26.31 ± 1^{bcd}	29.7 ± 1^{bc}
$S_{20}P_{75}$	14.56 ± 0^{a}	31.46 ± 2^{ab}	34.07 ± 1^{ab}
$S_{24}P_{75}$	15.4 ± 0^{a}	32.71 ± 3^{a}	35.05 ± 2^{a}

DAS-Days after sowing.
^{a,b,c,d,e}- values bearing different superscripts within the column differed significant ($P<0.05$).

Economic evaluation of the treatments was conducted on the basis of gross return, net return and benefit cost ratio (Table 4).It was shown that the treatment combination obtaining phosphorus at 60 kg ha^{-1} and sulphur at 20 kg ha^{-1}had highest gross return (Rs 110067.05), net return (Rs 73361.54) and benefit cost ratio (Rs 2.00).It might be due to the cost involved was proportionately higher net return, which increased the Benefit Cost ratio[4].

Table 4 Effect of phosphorus and sulphur levels on the economics of blackgram

Treatment Combination	Cost of Cultivation (Rs ha^{-1})	Gross Return (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B:C ratio
$S_0 P_0$(Control)	31200	61615.4	30415.4	0.97
$S_{16}P_{45}$	35515.53	87472.7	51957.17	1.46
$S_{20}P_{45}$	35915.53	97614.5	61698.97	1.72
$S_{24}P_{45}$	36315.53	100648.8	64333.27	1.77
$S_{16}P_{60}$	36305.51	99061.3	62755.79	1.73
$S_{20}P_{60}$	36705.51	110067.05	73361.54	2.00
$S_{24}P_{60}$	37105.51	110167.65	73062.14	1.97
$S_{16}P_{75}$	37093.51	100553.3	63459.79	1.71
$S_{20}P_{75}$	37493.51	110303.1	72809.59	1.94
$S_{24}P_{75}$	37893.51	110760.25	72866.74	1.92

It may be concluded that the dosages of 60 and 75 kg ha^{-1} phosphorus and 20 and 24 kg ha^{-1} sulphur in the dry matter accumulation, number of leaves, number of nodules, and economics were highest to the other levels and similar within the levels. Thus, the levels of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1}sulphur application in black gram on behalf of growth patterns may be recommended.

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