International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 2132-2140, 2023; Article no.IJECC.105228
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Phosphorous and Mulching on Growth and Yield of Zaid Green gram (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102874

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105228

Review Article

Received: 21/06/2023
Accepted: 25/08/2023
Published: 04/09/2023

ABSTRACT

A field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the topic "Effect of Phosphorous and Mulching on Growth and Yield of *Zaid* Green gram (*Vigna radiate* L.)", to study the response of green gram under various mulching techniques such as, Saw dust mulching, Paddy mulching and Without mulching along with combination of Phosphorus (20, 40 and 60 kg/ha). The results revealed that significant and higher plant height (43.24 cm), higher plant dry weight (5.32 g) and also, significantly higher number of pods/plant (30.8), maximum number of seeds/pod (11.73), higher test weight (31.2 g), higher seed yield (1.29 t/ha), higher stover yield (2.89 t/ha), Maximum gross return (90,300.00 INR/ha), maximum net return (58,915.00 INR/ha) and higher B:C ratio (1.88) were recorded in treatment 7 [Phosphorous (60kg/ha) + Sawdust mulching (22.5kg/ha)].

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Keywords: Mulching; phosphorus; growth; yield; economics.

1. INTRODUCTION

Green gram is an important conventional pulse crop of India. It is also called as “Golden Bean” or “Moongbean”, it belongs to the family “leguminaceae”. It can be cultivated on wide range of soils and gives best on well drained loamy to sandy-loam soils. Green gram is best suited to areas having an annual rainfall of 60 to 75 cm. Temperature should be between 25°C to 35°C. Green gram improves physical properties of soil and fixes atmospheric nitrogen [1]. It as high nutritive value, and due to this, has advantage over the other pulses. The seed contains protein (24.20%), fat (1.30%), and carbohydrates (60.4%), calcium is 118 mg and phosphorus is 340 mg/100gram of seed, respectively (Imran et al., 2016).

Globally, Pulses are grown by 171 countries over an area of 148.42 lakh hectares with production of 150.84 lakh tonnes and productivity of 1016 kg/ha [2]. “India ranks first in the world as producer, consumer and importer of pulses with an area of 29.03 million hectares, production of 23.40 million tons and and productivity was 806 kg/ha. The cultivation of green gram in the Uttar Pradesh is about 0.51 lakh hectares with the production of 0.22 lakh tonnes and 526 kg/ha average productivity” (GOI, 2019).

“Phosphorus (P) is one of the most important elements among the three macronutrients that plants must require for the better growth and development. Addition of P fertilizer enhances root development, which improves the supply of other nutrients and water to the growing parts of the plants, resulting in an increased photosynthetic area and thereby more dry matter accumulation. Phosphorus plays a vital role in photosynthesis, respiration, energy storage, energy transfer, cell division, cell elongation and several other processes within plant system” [3]. “It promotes early root formation, growth and improves harvest index of crops. Phosphorus, when applied to legumes, enhances the activity of *Rhizobia* by increasing nodulation and thereby helps in atmospheric nitrogen fixation. It helps in better nodulation and efficient functioning of nodule bacteria for fixation of N which will be utilized by plants during grain- development stage, and in turn lead to increased green yield” [4].

“Mulching is one of the most important agronomic approaches which aimed to protect moisture from soil and acts as barrier to check the fluxes of water and heat from soil surface, helps conserved soil moisture is one efficient water management in green gram cultivation under moisture stress conditions” (Yadov and Dashora, 2003). “Mulching reduces evaporation, soil erosion, increasing infiltration and population of micro-organisms, improve soil moisture status, nutrient utilization, soil temperature regulation and can suppress weeds, due to delayed emergence and smothering effect on weeds” [5]. “Agronomic intervention like mulching proves to be a practical solution for maintaining the optimum soil thermal and moisture regimes and ultimately higher crop yields” [6-10]. “After the harvest of the paddy straw, farmers have paddy straw in abundance and usually being burnt in the field which pollutes the environment. Thus, using paddy straw for mulch in various field crops as well as vegetables can unravel the menace. Further, it is best organic mulch which in addition to the paddy straw mulch adds organic matter to the soil after its decomposition. The mulch application helps in the blockage of the transportation of the vapours from the soil surface by acting as a barrier to the soil and altering the net radiation arriving at the soil surface” [11,12]. “It also helps in the suppression of the growth of the weeds, moderating the soil surface temperature, modifying the microclimatic conditions and helps in prevention of soil erosion” [13]. “Paddy straw mulching helps in the tying up of soil nitrogen and the promotion of nitrogen in leguminous crops like green gram. Hence, it is hypothesized that with the application of mulch, a lesser number of irrigations are required by the crop” [14]. With this in mind, the experiment was carried out to determine the “Effect of Phosphorous and Mulching on Growth and Yield of *Zaid* Green gram”.

2. MATERIALS AND METHODS

A field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the topic “Effect of Phosphorous and Mulching on Growth and Yield of *Zaid* Green gram (*Vigna radiate* L.)”, to study the response of green gram under various mulching techniques such as, Saw dust mulching, Paddy mulching and Without mulching along with combination of Phosphorus (20, 40 and 60 kg/ha). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 8.0), low in organic carbon

(0.62%), available N (225 kg/ha), available P (38.2 kg/ha) and available K (240.7 kg/ha). There were 10 treatments, each being replicated thrice and laid out in Randomized Block Design. The treatment combinations are treatment 1 [Phosphorous 20kg/ha + Sawdust mulching 22.5kg/ha], treatment 2 [Phosphorous 20kg/ha + Paddy mulching 5t/ha], treatment 3 [Phosphorous 20kg/ha + Without mulching], treatment 4 [Phosphorous 40kg/ha + Sawdust mulching 22.5kg/ha], treatment 5 [Phosphorous 40kg/ha + Paddy mulching 5t/ha], treatment 6 [Phosphorous 40kg/ha + Without mulching], treatment 7 [Phosphorous 60kg/ha + Sawdust mulching 22.5kg/ha], treatment 8 [Phosphorous 60kg/ha + Paddy mulching 5t/ha], treatment 9 [Phosphorous 60kg/ha + Without mulching] and treatment 10 [Control]. Growth parameters, yield attributes and economics was recorded. The Data recorded on different aspects of crop, such as, growth parameters, yield attributes were subjected to statistically analysis by analysis of variance method [15].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters of Green gram

3.1.1 Plant height (cm)

The data revealed that, significant and higher plant height (48.17 cm) was recorded in treatment 7 [Phosphorous (60kg/ha) + Sawdust mulching (22.5 kg/ha)]. However, treatments 8 [Phosphorous 60kg/ha) + paddy mulching (5 t/ha) and [Phosphorous (60kg/ha) + Paddy mulching (5t/ha)] was found to be statistically at par with the treatment 7 [Phosphorous (60kg/ha) + Sawdust mulching (22.5kg/ha)] [Table 1]. Significant and higher plant height was observed with application of dust mulching (22.5 kg/ha) might be due less competition among the plants for resource like moisture and nutrients was due to less density which might have led to an increased availability of resource resulted in higher plant height. Similar results were reported by Verma et al. [16]. Further, significant and higher plant height was with application of phosphorus (60 kg/ha) may be due to enhanced metabolic activities within plant system which increased cell division of the plant and resulted better plant growth particularly plant height. Similar, results were reported by Gadi et al. (2018).

3.1.2 Plant dry weight (g)

The data revealed that, significant and higher significantly higher plant dry weight (7.55 g) was recorded in treatment 7 (Phosphorous 60 kg/ha+ Sawdust mulching 22.5 kg/ha). However, treatment 8 (Phosphorous 60 kg/ha+ Paddy mulching (5 t/ha) was statistically at par with the treatment 7 (Phosphorous 60 kg/ha+ Sawdust mulching 22.5 kg/ha) [Table 1]. Significant and maximum plant dry weight was with application of sawdust mulching might be due to less competition among the plants for resources like moisture and nutrients reduce less density and dry weight of weeds which might have led to an increased availability of resources, resulting in highest growth and dry matter accumulation in green gram under dust mulching Verma et al. [16]. Further, significant and maximum plant dry weight was recorded with application of phosphorus (60 kg/ha)might be due to increased availability of phosphorous in the soil, which improves nutrient availability status resulting in increased root and shoot development of the plant and dry matter accumulation. Similar results were reported by Das et al. (2017).

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

The data revealed that, highest crop growth rate (4.96 g/m^2/day) was recorded in treatment 7 (Phosphorous 60 kg/ha+ Sawdust mulching 22.5 kg/ha) and there was no significant difference between them [Table 1].

3.1.4 Relative growth rate (g/g/day)

The data revealed that, highest and relative growth rate (0.1381) was recorded intreatment4 [(Phosphorous 40 kg/ha+ Sawdust mulching 22.5 kg/ha)] and there was no significance difference between them [Table 1].

4. YIELD AND YIELD ATTRIBUTES OF GREEN GRAM

4.1 Number of Pods/Plant

The data revealed that, significant and maximum of pods/plant (30.80) was observed in the treatment7[Phosphorous (60kg P_2O_5/ha) + Sawdust mulching (22.5kg/ha)].However, treatment-8 [Phosphorous (60kg P_2O_5/ha) + paddy mulching (5t/ha)]and treatment 4 [Phosphorous (40kg P_2O_5/ha)+sawdust mulching 22.5kg/ha)] were found statistically at par with treatment 7 [Phosphorous (60kg P_2O_5/ha) + Sawdust mulching (22.5kg/ha)] [Table 2]. Significant and maximum number of pods/plant was observed with application of sawdust mulching might be due to retaining higher amount of soil water with efficient use of nutrients

for enhancing plant growth particularly number of pods/ plant which is also directly correlated with yield. Similar results was also described by Singh et al. [17]. Further, significantly increase in number of pods/plant with the application of phosphorus() might be due to phosphorus enhance development of reproductive structure and increased metabolic activity in plant system, which leads to development of more number of pods/plant. Similar result was also reported by Gadi et al. [18].

4.2 Number of Seeds/Pods

The data revealed that, significant and maximum number of seeds/pod (11.73) was observed in the treatment 7 [Phosphorous 60kg P_2O_5/ha+ Sawdust mulching 22.5kg/ha)]. However, treatment 8 [Phosphorous 60kg P_2O_5/ha + Paddy mulching 5 t/ha] was found to be statistically at par with the treatment 7 [Phosphorous 60kg P_2O_5/ha + Sawdust mulching 22.5kg/ha)] [Table 2]. Significant and maximum number of seeds/pod was observed with application of sawdust mulching might be due to less competition among the plants for resources like moisture and nutrients was due to less density and dry weight of weeds which have led to an increased availability of resources, resulting in highest growth. Similar result were reported by Verma et al. (2017). Further, increase in number of seeds/pod with was the application of phosphorus may due to, it plays a vital role in plant growth, photosynthesis, flowering, seed setting and nitrogen fixation which ultimately resulted in enhancement of yield. Similar results were reported by Sahu et al. [19].

5. TEST WEIGHT (G)

The data revealed that, significant and higher test weight (31.20 g) was observed in the treatment 7[Phosphorous 60kg P_2O_5/ha + Sawdust mulching 22.5kg/ha]. However, treatment 8[Phosphorous 60kg P_2O_5/ha + Paddy mulching 5t/ha] found to be statistically at par with the treatment 7 [Phosphorous 60kg P_2O_5/ha + Sawdust mulching 22.5kg/ha] [Table 2]. "Significant and maximum test weight was observed with application of mulching might be due to better availability of moisture and moderation of soil temperature led to greater uptake of nutrients and reduced number of days taken to meet the required heat units for proper growth, development of plants and ultimately the yield attributes" Paradhan et al. (2021). **"**Further increase in test weight with application of phosphorus may be due to root growth resulted plant absorbed more nutrients from soil for effective dry matter production and translocation of photosynthates from leaves to reproductive parts for better development of seeds" Gadi et al. [18].

6. SEED YIELD (t/ha)

The data revealed that, significant and higher seed yield (1.29 t/ha) was observed in treatment 7 [Phosphorous 60kg P_2O_5/ha + Sawdust mulching 22.5kg/ha]. However, treatment 8 [Phosphorous 40kg P_2O_5/ha + Sawdust mulching 22.5kg/ha] found to be statistically at par with the treatment 7 [Phosphorous 60kg P_2O_5/ha + Sawdust mulching 22.5kg/ha] [Table 2]. Significant and maximum seed yield was observed with application of mulching might be due to favourable soil moisture regime and its better utilization in production of large number of seeds possibly by reducing floral abortion, maintenance of a steady flux of assimilates during grain filling, reducing the rate of leaf senescence and maintenance of photosynthetic activity of surviving leaves and enhanced remobilization of pre anthesis assimilates to seed during seed filling which helped in higher seed yield. Similar results were reported by Pradhan et al. [20]. "Further increase in seed yield with application of phosphorous may be due to increase in source capacity like plant height, number of branches and leaf area index as well as sink capacity like number of pods, number of grains, test weight and also better utilization of photosynthates towards sink due to increase in translocation from source to sink" [17].

7. HAULM YIELD(t/ha)

The data revealed that, significant and higher halum yield (1.29 t/ha) was observed with on treatment 7 [Phosphorous 60kg P_2O_5/ha + Sawdust mulching 22.5kg/ha]. However, treatment 8[Phosphorous 60kg P_2O_5/ha + Paddy mulching 5t/ha] found to be statistically at par with the treatment 7 [Phosphorous 60kg P_2O_5/ha + Sawdust mulching 22.5kg/ha] [Table 2]. Significant and maximum halum yield was observed with application of phosphorous might be due to increased the production of plant biomass, nodule number and weight and chlorophyll content in leaf exhibited significant positive correlation with stover yield. Similar results were reported by Prajapathi et al. [21].

Table 1. Effect of Phosphorus and Mulching on Growth Parameters of Green gram

S. No	Treatments	Growth Parameters			
		Plant Height (cm) 60 DAS	Plant Dry weight (g) 60 DAS	Crop Growth Rate ($g/m^2/day$) 45-60 DAS	Relative growth rate (g/g/day) 15-30 DAS
1.	Phosphorous 20 kg/ha+ Sawdust mulching 22.5 kg/ha	45.20	5.95	4.89	0.1305
2.	Phosphorous 20 kg/ha+ Paddy mulching 5 t/ha	44.90	5.35	4.82	0.1275
3.	Phosphorous 20 kg/ha+ Without mulching	43.13	4.95	4.85	0.1321
4.	Phosphorous 40 kg/ha+ Sawdust mulching 22.5 kg/ha	46.61	7.15	4.94	0.1381
5.	Phosphorous 40 kg/ha+ Paddy mulching 5 t/ha	46.10	6.95	4.81	0.1350
6.	Phosphorous 40 kg/ha+ Without mulching	45.40	6.35	4.87	0.1333
7.	Phosphorous 60 kg/ha+ Sawdust mulching 22.5 kg/ha	48.17	7.55	4.96	0.1340
8.	Phosphorous 60 kg/ha+ Paddy mulching 5 t/ha	47.57	7.35	4.69	0.1366
9.	Phosphorous 60 kg/ha+ Without mulching	45.50	6.75	4.89	0.1342
10.	Control [R.D.F – 20:40:20]	45.30	6.15	4.95	0.1285
	F-test	S	S	NS	NS
	S Em (±)	0.39	0.04	0.12	0.0077
	CD (p = 0.05)	1.15	0.13	--	--

Table 2. Effect of Phosphorus and Mulching Yield and Yield Attributes of Green gram

S No	Treatments	Number of pods/ Plant	Number of Seeds/ Pod	Test Weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Phosphorous 20kg/ha+ Sawdust mulching 22.5kg/ha	24.20	9.60	28.00	0.91	2.46	26.96
2.	Phosphorous 20kg/ha+ Paddy mulching 5t/ha	23.60	9.40	27.40	0.87	2.42	26.26
3.	Phosphorous 20kg/ha+ Without mulching	23.20	9.20	26.60	0.83	2.38	25.37
4.	Phosphorous 40kg/ha+ Sawdust mulching 22.5kg/ha	28.80	11.20	29.80	1.16	2.71	29.12
5.	Phosphorous 40kg/ha+ Paddy mulching 5t/ha	27.40	10.80	29.40	1.10	2.65	28.86
6.	Phosphorous 40kg/ha+ Without mulching	24.60	10.20	28.80	1.03	2.58	28.48
7.	Phosphorous 60kg/ha+ Sawdust mulching 22.5kg/ha	30.80	11.73	31.20	1.29	2.89	30.67
8.	Phosphorous 60kg/ha+ Paddy mulching 5t/ha	30.20	11.47	30.60	1.26	2.79	30.89
9.	Phosphorous 60kg/ha+ Without mulching	25.40	10.40	29.00	1.07	2.62	28.83
10.	Control [R.D.F – 20:40:20]	24.40	10.00	28.20	0.97	2.52	27.68
	F-test	S	S	S	S	S	S
	S Em (±)	0.28	0.11	0.34	0.07	0.08	0.99
	CD (p=0.05%)	0.84	0.33	0.72	0.22	0.25	2.93

Table 3. Effect of Phosphorus and mulching on Economics of green gram

S No	Treatments	Total cost of cultivation (INR)	Gross Returns	Net Returns	B:C ratio
1	Phosphorous 20kg/ha + Sawdust mulching 22.5kg/ha	30985.00	63700.00	32715.00	1.06
2	Phosphorous 20kg/ha+ Paddy mulching 5t/ha	33735.00	60900.00	27165.00	0.81
3	Phosphorous 20kg/ha+ Without mulching	28735.00	58100.00	29365.00	1.02
4	Phosphorous 40kg/ha+ Sawdust mulching 22.5kg/ha	31185.00	81200.00	50015.00	1.60
5	Phosphorous 40kg/ha+ Paddy mulching 5t/ha	33935.00	77000.00	43065.00	1.27
6	Phosphorous 40kg/ha+ Without mulching	28935.00	72100.00	43165.00	1.49
7	Phosphorous 60kg/ha+ Sawdust mulching 22.5kg/ha	31385.00	90300.00	58915.00	1.88
8	Phosphorous 60kg/ha+ Paddy mulching 5t/ha	34135.00	88200.00	54065.00	1.58
9	Phosphorous 60kg/ha+ Without mulching	29135.00	74900.00	45765.00	1.57
10	Control [R.D.F – 20:40:20]	28935.00	67900.00	38965.00	1.35

8. HARVEST INDEX (%)

The data revealed that, significant and higher harvest index (30.89 %) was observed on treatment 7[Phosphorous (60kg P_2O_5/ha) + Paddy mulching (5t/ha)]. However treatment-6 [Phosphorous (40kg P_2O_5/ha)+ without mulching], found to be statistically at par with the treatment 7[Phosphorous (60kg P_2O_5/ha) + Paddy mulching(5t/ha)] [Table 2]. Significant and maximum harvest index was observed with application of phosphorous may be due to increased in source capacity like plan height, number of branches and leaf area index as well as sink capacity like number of pods/plant, number of grains/pod, test weight and also better utilization of photosynthesis towards sink due to increase in translocation from source to sink. Similar results were reported by Singh et al. [3].

9. ECONOMICS

The data on cost of cultivation, gross returns, net returns and B:C ratio as influenced by different treatments was presented in [Table 3].

9.1 Cost of Cultivation (INR/ha)

Maximum cost of cultivation (34135.00 INR/ha) was recorded in treatment [8 Phosphorous (60 kg/ha) + Paddy mulching (5 t/ha)] as compared to other treatments and lowest cost of cultivation (28735.00 INR/ha) was recorded in the treatment 3 [Phosphorous (20 kg/ha) + Without mulching].

9.2 Gross Returns (INR/ha)

Maximum gross returns (90300.00 INR/ha) was recorded in the treatment 7 [Phosphorous (60 kg/ha) + Sawdust mulching (22.5 kg/ha)] as compared to other treatments.

9.3 Net Returns (INR/ha)

Maximum net returns (58915.00 INR/ha) was recorded in the treatment 7 [Phosphorous (60kg /ha) + Sawdust mulching (22.5 kg/ha)] as compared to other treatments.

9.4 Benefit Cost Ratio (B:C)

Benefit Cost Ratio (1.88) was recorded highest in the treatment 7 [Phosphorous (60kg/ha) + Sawdust mulching (22.5kg/ha)] as compared to other treatments.

Higher B:C ratio was recorded with the application of Phosphorus (60/kg) may be due to increase in yield attributes, higher gross returns, net returns. Similar results were reported by Verma et al. (2017)

10. CONCLUSION

Based on the above findings it is concluded that, green gram with the application of Phosphorous (60kg) along with Sawdust mulching (22.5kg/ha) recorded highest yield and benefit cost ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/105228