ISSN: 2347-4688, Vol. 12, No.(2) 2024, pg. 988-996

Current Agriculture Research Journal

www.agriculturejournal.org

Effect of Seed Hydropriming, Plant Spacing and INM on Biomass Production, Yield, and Nutrients Uptake by Summer Green Gram Crop

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Abstract

Pulses form an integral part of vegetarian diet in the Indian sub-continent as these are good source of protein and help alleviating malnutrition on cost effective basis. Therefore, there is urgent need to increase the production and productivity of pulses not only to address the protein malnutrition but also to meet the massive requirement of 1500 million Indians by 2040. The study conducted at Bundelkhand University Jhansi in India during summer 2021 and 2022 aimed to assess the impact of seed hydropriming, plant spacing, and integrated nitrogen management practices (INM) on seed and biomass production and nutrient uptake by summer green gram crop. Seed hydropriming resulted in significantly higher pods/plant, pod length, seeds/pod, seed weight, harvest index, and seed index. Treatment G_1(30x10 cm) showed significantly higher pods/plant, pod length, seeds/pod, seed weight, harvest index, and seed index. Seed hydropriming led to a significant increase in seed and biomass production, with a yield of 858.61 kg/ha, 54.71% more than without seed priming treatment. Treatment G_1(30x10 cm) showed a 138.272% enhancement of yield up to 995.70 kg/ha over treatment G_2(30x20 cm). The biological yield was 1879 and 1985 kg/ha, respectively, significantly higher compared to the respective treatment factors. The INM treatment N5 led to the highest harvest index of 42.65%, which decreased in descending order to 41.70%, 40.61%, 38.80%, and 37.79% as a result of treatments N_4, N_3, N1, and N_2, respectively. Treatment P1 resulted in uptake of 30.59 kg/ha N, 5.10 kg/ha P, and 16.59 kg/ha K, which increased significantly in treatment P2. Nutrient management of N5 (50% RDF through chemical fertilizer+50% RDF through Vermicompost) resulted in high absorption of 41.44 kg/ha N, 7.31 kg/ha P, and 21.01 kg/ha K, respectively. Treatment N4 resulted in removal of 39.49 kg/ha N, 6.90 kg/ha P, and 21.01 kg/ha K from soil. It is

Article History

Received: 01 March 2024

Accepted: 02 June 2024

Keywords

Biological Yield; FYM; Green Gram; Hydropriming; Nutrient Uptake; Plant Geometry; Seed Yield; Vermicompost; Yield Attributor.

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Doi: http://dx.doi.org/10.12944/CARJ.12.2.39

concluded that practices of seed hydropriming, crop geometry of 30x 10 cm row x plant spacing and conjunctive use of N, P, K nutrients equivalent to 50% of recommended dose of fertilizers (RDF) coupled with 50% nutrients through organic sources (FYM and/ or vermicompost) were found optimum for maximizing vigor of plants through effective absorption of nutrients from soil, yield attributing characters, nutrient uptake, dry matter production and ultimately seed yield of green gram crop and recommended for large scale adoption by farmers.

Introduction

Green gram is one of the important pulse crops. Its native place is India and central Asia. Green gram is cultivated in the countries of India, Burma, Srilanka, Pakistan, China, Fiji, Queens land and Africa. Green gram (*Vigna radiata* L.) is commonly known as *moong*, golden gram, mung, etc. It is grown in India for its multipurpose uses as vegetable, pulse, fodder and green manure crop. It is highly nutritive and digestible than other pulses (Kumar *et al*, 2009).[1] It is grown almost in all the states and occupies about 5.13 million hectares area producing 3.09 million tonnes and yield level of 601 kg/ha (Anonymous, 2020-21).[2] The states of Uttar Pradesh and Andhra Pradesh are the main states occupying the top two positions contributing over 40 % of total production in India. While Maharashtra contributes about 14 %, Tamil Nadu and Madhya Pradesh share about 10 % and 8.5 % of total production. There is a wide gap between realizable potential productivity and productivity realized by farmers. The productivity of *moong* bean in research plots and frontline demonstrations is 10 - 12 quintals/ ha while it is only 8 - 9 quintals per hectare on farmers' fields and the national average yield is still low of 4 - 5 quintals per hectare. This yield gap needs to be addressed by improving seed production packages and supply of good quality seeds to the farmers (Marimuthu, and Surendran 2015)3 and other low-cost technology.

There are number of crop production factors which contribute to enhance productivity of any crop. Cost effective factors include seed treatment, plant geometry and INM practices including combination of simple and complex fertilizers and organics. Although, the use fertilizers can lead to enhanced productivity but its continuous application over the years is known to result in deleterious effects on soil health (Endris and Dawid, 2015).[4] Further, use of organics alone cannot compensate total production of crops per unit of land area obtained due to inorganic chemical fertilizers (Ahmad *et. al,* 2013).[5] Integrated use of reduced levels of fertilizers in conjunction with organic sources of nutrients has drawn the attention of the scientists and farmers to use on large scale for increasing productivity and profitability of various crops on cost effective basis. Thus, in view of above cited facts experiments were conducted to evaluate and quantify the impact of seed hydropriming, plant geometry and INM practices including combination with fertilizers and organic sources of nutrients viz; farmyard manure and vermicompost, on stover and grain yield and its contributor characters, as well as N, P and K removal by green gram crop.

Hypotheses

There exists a vast gap between potential productivity and present level of productivity realized by farmers. The productivity potential of *moong* bean in research plots and frontline demonstrations is 10 - 12 quintals/ ha while it is only 8- 9 quintals per hectare on most of the farmers' fields. The national average yield is still low at 4- 5 quintals per hectare. This yield gap can be minimized by employing various cost-effective measures e.g. seed treatment, plant geometry and INM practices including combination of simple and complex fertilizers and organics. Although, the use of fertilizers alone can lead to higher productivity but their continuous application over the years has deleterious effects on soil health. Use of organics alone cannot compensate the productivity of crops obtained due to inorganic chemical fertilizers. With this back ground, present study was formulated to find out the optimum plant geometry and cost-effective integrated nutrient management practice including reduced level of fertilizers, farmyard manure and vermicompost for maximising production, nutrient uptake during summer season.

Materials and Methods

The experiments were done at Bundelkhand University Jhansi (UP), during Summer 2020-21 and -2021-22 in split-split plot design having 3 replications. The treatments comprised combination of main plot treatments viz; 2 seed treatments (1) P_1(seed hydropriming) and (2) P_2(untreated) x 2 plant geometry treatments viz; (1) G_1(30×10cm) and G_2(30×20 cm), 5 sub plot treatments of integrated nutrient management (INM) practices (N) viz; (1) N_1(20+40+20 kg NPK ha^{-1} (RDF), (2) N_2(100 % RDF through FYM), (3) N_3(100 % RDF through Vermicompost) (4) N_4(50% RDF through chemical fertilizer+50% RDF through FYM) and (5) N_5(50% RDF through chemical fertilizer+50% RDF through Vermicompost). In all there were 20 treatment combinations of 2 seed treatments x 2 plant geometry treatments x 5 nutrients management treatments. Seed hydropriming was done by soaking of healthy seeds in normal water for 8 hours (P_2: Seed hydropriming) and compared with Untreated seeds P_1. Fertilizer urea, single superphosphate and muriate of potash, Farmyard manure, and vermicompost were the source of nutrients. The recommendation of nutrients (RDF) for mung crop is 20, 40 and 20 kg ha^{-1} of N, P_2O_5 and K_2O. Basal application of fertilizers was done in the quantity as per treatments. Broadcasting of farmyard manure and vermicompost was done in two equal halves as per the requirement of treatments during last ploughing and split application after 30 days of sowing. Prior to laying out of this experiment, rainfed wheat crop was taken in the previous season. The experimental soil was neutral in reaction (pH 7.3, EC 0.21 dS/m) having 0.53% organic carbon, 160.05 kg/ha available N, 30.10 kg/ha available phosphorus and 260 kg/ha K content in plough layer of soil.

The main objectives were to assess the efficacy of seed priming under different plant population and INM treatments on yield attributes, biological yield and nutrients uptake by *moong* bean crop grown in summer seasons. Observations on yield attributor characters viz; pods/ plant, pod length (cm), seeds/ pod, seed yield (g/plant), harvest index (HI), and seed index (g/1000 seeds) were recorded manually using standard procedures. Total N content in straw and grain samples was estimated according to Micro-Kjeldahl method (Yoshida *et al*, 1971),[6] total P content by the procedure of Olsen *et al* (1954)[7] and total K content determined by using Flame Photometer method (Jackson, 1973).[8] Statistical analysis of data was done as per the procedure suggested by Panse and Sukhatme (1985)9.

Results and Discussion

Yield Attributors

Pods per plant

Results (Table 1) that seed hydropriming of (P2) produced significantly a greater number of 14.66 pods/plant as against 11.32 pods/ plant due to P1(untreated seeds). The treatment G1(30×10 cm) recorded a higher number of 13.84 pods / plant compared to 12.15 pods /plant due to treatment of G_2(30×20 cm) and both were statistically at par. The treatment G1 produced 13.91 % more pods/ plant as compared with the treatment G_2. Treatment N5(50% RDF through chemical fertilizer+50% RDF through Vermicompost) produced significantly high 13.67 pods/ plant over rest of the treatments except the treatment N4. The treatment N2(100 % RDF through FYM) led to significantly less pods of 12.37/ plant only. The relative superiority of treatments with regards to number of green gram pods/ plant was in order of $N_5 > N_4, > N_1 > N_3 > N_2$, respectively. An enhancement pods/ plant because of treatments N_3, N1, N_4, and N_5 over N_2 was 2.42%, 4.77%, 7.52, and 10.51%, respectively. The results emphasized that seed priming, plant geometry of G_1(30×10 cm) and conjunctive use of FYM / vermicompost resulted in significantly high amount of pods/ plant. The bearing of pods/ plants is although governed by the genetic characteristics still some minor changes may be brought about by agronomical management practices including balanced nutrition of plants under the same environmental conditions. Seed priming, plant geometry of G_1(30×10 cm) and conjunctive use of FYM / vermicompost improved germination percentage, plant density, and nutrition maximized, accelerated vegetative and reproductive growth and therefore pod production per plant. Keerthi and others (2015)[10] also had similar observations. However, the interactions of different treatments were statistically non-significant, indicating their independent impacts on pod number.

Pod length (cm)

The shortest mean pod length of 8.16 cm was recorded under P1(untreated seeds) which was increased to 8.86 cm (8.57 %) due to seed hydropriming treatment P_2. Planting geometry of G_1(30×10 cm) caused significantly largest mean pod length of 8.80 cm which significantly decreased to 8.21 cm in wider plant spacing under G_2(30×20 cm). Closer plant spacing of 30x10 cm increased the mean pod length by 7.3% compared to wider 30x20 cm spacing. The mean length of pods due to these treatments N_1, N_2, and N_3 was 8.40, 8.28 and 8.33 cm, respectively and was on par in between them but significantly less as compared with N_4 and N_5 treatments. There was an increase of mean pod length by 0.61%, 1.45%, 3.74 % and 7.85 %, because of treatments N_3, N_1, N_5, and N_4, respectively over the treatment N_2. Seed hydropriming treatment P_2, plant geometry of 30x10 cm (treatment G_1) and conjunctive use of organics (treatments N_5 and N_4), were significantly more effective for growth of green gram pods with respect to pod length. No interaction was observed between treatments. The finding of present study is in accordance with those of Chaudhary *et al.* (2015).[11]

Table 1: Effect of different main and sub treatments on yield attributes of summer green gram (Mean of 2021 and 2022 years).

Treatments	Pods/ Plant	Pod length (cm)	Seeds/ pod	Seed yield (g/plant)	Harvest Index (%)	Seed Index (g/1000 seeds)
Seed treatment (P):						
P_1: Untreated seeds	11.32	8.16	6.43	2.37	37.06	33.36
P_2: Seed hydropriming	14.66	8.86	7.13	3.74	43.56	35.7
S. Em. ±	**0.36**	**0.08**	**0.01**	**0.11**	**0.46**	0.04
C.D. (P=0.05)	**2.21**	**0.51**	**0.05**	**0.7**	**2.77**	0.25
Plant Geometry (G):						
G_1: 30cm × 10cm	13.84	8.8	6.95	3.39	49.76	35.11
G_2: 30cm × 20cm	12.15	8.21	6.61	2.72	30.86	33.96
S. Em. ±	**0.4**	**0.06**	**0.04**	**0.1**	**0.68**	0.03
C.D. (P=0.05)	**1.57**	**0.23**	**0.17**	**0.41**	**2.67**	0.13
Nutrient Management (N):						
N_1: 20+40+20 kg NPK ha^{-1} (RDF)	12.96	8.4	6.77	2.94	38.8	34.52
N_2: 100 % RDF through FYM	12.37	8.28	6.64	2.74	37.79	34.09
N_3: 100 % RDF through Vermicompost	12.67	8.33	6.69	3.01	40.61	34.27
N_4: 50% RDF through fertilizer + 50% RDF through FYM	13.3	8.93	6.84	3.22	41.7	34.77
N_5: 50% RDF through fertilizer + 50% RDF through Vermicompost	13.67	8.59	6.94	3.36	42.65	35.01
S. Em. ±	**0.29**	**0.06**	**0.04**	**0.14**	**1.43**	0.07
C.D. (P=0.05)	**0.85**	**0.17**	**0.13**	**0.41**	**NS**	0.2
S. Em. ± (PxGxN)	**0.589**	**0.12**	**0.089**	**0.28**	**2.87**	**0.14**
CD (P=0.05) (PxGxN)	**NS**	**0.34**	**NS**	**NS**	**NS**	**NS**

Green Gram Seeds Per Pod

Seed hydropriming proved superior as it increased the seeds/ pod by 10.7 % over without seed hydropriming treatment. Seed hydropriming of P_2 produced significantly more seeds of 7.13 seeds/ pod than untreated seeds in treatment P_1 (6.43 seeds/ pod). Closer plant spacing treatment G_1(30×10 cm) proved its superiority as it increased seeds per pod by 5.14% compared to wider plant spacing in treatment G_2:30×20 cm (6.95 vs 6.61 seeds per pod). The INM treatment of N5(50% RDF from fertilizer+50% RDF through Vermicompost) produced significantly highest mean number of 6.94 seeds/ pod, next was the treatment N4 which recorded 6.84 mean number of seeds/ pod, both being at par. Results emphasized that integration fertilizers equivalent to 50% of RDF with 50% nutrients through organic sources (treatments N4 and N_5) proved more effective compared to nutrients through organic sources (treatments N_2 and N_3) alone and 100% RDF from fertilizers (N_1), respectively. None of the interactions of seed hydropriming x plant geometry x nutrient management treatments were observed significant in this respect. The findings of the present investigation endorse the results of Amruta *et al*. (2015).[12]

Seed yield (g/plant)

Seed hydropriming, plant geometry of 30x10 cm and nutrient management treatment of N_5 produced highest seed weight of 3.74, 3.39 and 42.65 g/plant, respectively as compared with respective factors of the treatments, respectively. Interaction of different treatments P x G x N were observed nonsignificant.

Harvest index (%)

Harvest index of any crop is the parameter which describes proportion of yield and straw production and therefore high harvest index is desired for getting maximum advantage in form of monetary returns. Seed hydropriming treatment of P_2 proved significantly superior over the treatment P_1. The mean harvest index of 37.06% and 43.56% was observed due to the treatments P_1 and P_2 respectively. Planting geometry treatment G1(30×10 cm) caused highest mean harvest index of 49.76%, while it significantly decreased to 30.86% due to wider plant spacing in the treatment G_2(30×20 cm). Harvest index is the resultant of overall impact of seed and stover production of green gram and therefore it followed the same trend. The treatments on integrated use of chemical fertilizers and/ or FYM and vermicompost (N_4 and N_5) were significantly different to influence the harvest index of green gram crop, although highest harvest index of 42.65% was recorded obtained from N_5(50% RDF through chemical fertilizer+50% RDF through Vermicompost) which gradually decreased in descending order to 41.70% > 40.61% > 38.80% and > 37.79 % because treatments N_4, N_3, N_1 and N_2, respectively. The results (Table 1) clearly indicated that combined use of fertilizers plus organics (FYM and/ or vermicompost), each equivalent to 50% of RDF, are optimum for realizing high harvest index and seed yield. Parvez *et al*. (2013)13 also reported similar results.

Seed Index (g/ 1000 seeds): Seed hydropriming increased the mean seed index from 33.36 to 35.70 g/ 1000 seeds, respectively to a significant level and is attributed to early germination and establishment and growth of roots for affecting better nutrients uptake. The treatment G1(30×10 cm) was associated with highest mean seed index of 35.11 g/ 1000 seed which was significantly decreased to 33.96 g/1000 seeds due to wider plant spacing (G_2:30×20 cm). Seed index of 34.09 g/ 1000 seed observed from treatment N_2(100 % RDF through FYM) was increased to 34.27 g, 34.52 g, 34.77 g and 35.01 g/ 1000 seeds due to treatments N_3(100 % RDF from Vermicompost), N1(20+40+20 kg NPK ha^{-1} (RDF)), N_4(50% RDF through fertilizer+50% RDF through FYM) and N_5(50% RDF from fertilizer+50% RDF through Vermicompost), respectively. The treatments involving organics proved better as organics help increasing nutrient availability and their translocation to reproductive parts producing bold seeds.

Seed and Biological Yield

Grain yield

The results (Table 2) showed that seed hydropriming (P_2) produced significantly higher *moong* bean yield of 858.61 kg/ha than the treatment P_1(without seed priming) which recorded yield of 554.97 kg/ ha. The mean increase in seed yield due to seed priming was 54.71 % over without seed priming, which is attributed to yield contributory characters. Planting geometry of G_1(30×10 cm) also produced significantly more mean yield of 995.70 kg/ha, while significantly decreased yield of 417.88 kg/ha was from plant geometry treatment G_2(30×20 cm). The treatment G1(30x10 cm) witnessed 138.272% increased yield of 995.70 kg/ha over wider plant geometry of G_2 (30x20 cm) yielding 417.88 kg/ha. Ali *et al*. (2001)14 also observed similar findings. INM treatment of N5(50% RDF from fertilizer+50% RDF through Vermicompost) led to grain yield of 800.96 kg/ha, being significantly high over all the treatments except treatment N_4. The treatment N4(50% RDF through chemical fertilizer+50% RDF through FYM) ranked second in merit which recorded seed yield of 753.91 kg/ha and was statistically on par with treatment N_5. The seed yield due to treatments N_1, N_2 and N_3 was 666.24, 617.49 and 695.35 kg/ha, respectively, being at par in between them but resulted in significantly less seed yield over the treatments N_4 and N_5. The minimum seed yield of 617.49 kg/ha was recorded from treatment N_2 which was increased by 7.89 %, 12.61%, 22.09 %, and 29.71% due to N_1, N_3, N_4 and N_5. The interactions of seed hydropriming, geometry of plants and INM treatments were observed non-significant. Earlier Bhise *et al*., (2011),[15] Chaudhary *et al*. (2015),[11] and Kalsaria *et.al.,* (2017)[16] have also drawn similar conclusions.

Table 2: Productivity and nutrient uptake by summer green gram affected by seed hydropriming, plants geometry and INM (Fertilizers x FYM x Vermicompost) (Mean of 2021 and 2022 years).

Treatments	Seed Yield (kg/ha)	Biological yield (kg/ ha)	Total Uptake of nutrients (kg/ha)		
			N	P	K
Seed treatment (P)					
P_1: Untreated seeds	554.97	1426	30.59	5.10	16.59
P_2: Seed hydropriming	858.61	1879	44.52	7.91	22.43
S. Em. ±	16.36	25	0.63	0.11	0.32
C.D. (P=0.05)	99.53	154	3.84	0.69	1.96
Plant Geometry (G)					
G_1: 30cm × 10cm	995.70	1985	48.19	8.50	22.83
G_2: 30cm × 20cm	417.88	1320	26.92	4.51	16.19
S. Em. ±	16.90	23	0.70	0.10	0.25
C.D. (P=0.05)	66.35	89	2.75	0.40	0.98
Nutrient Management (N)					
N_1: 20+40+20 kg NPK ha-1 (RDF)	666.24	1619	36.27	6.29	19.25
N_2: 100 % RDF through FYM	617.49	1530	33.77	5.77	18.05
N_3: 100 % RDF through Vermicompost	695.35	1629	36.82	6.28	19.03
N_4: 50% RDF through fertilizer + 50% RDF through FYM	753.91	1713	39.49	6.90	20.21
N_5: 50% RDF through fertilizer + 50% RDF through Vermicompost	800.96	1772	41.44	7.31	21.01
S. Em. ±	34.75	39	1.27	0.23	0.42
C.D. (P=0.05)	100.09	111	3.66	0.65	1.20
S. Em. ± (PxGxN)	69.49	77	2.54	0.45	0.83
C.D. (P=0.05) (PxGxN)	NS	NS	NS	NS	NS

Biological Yield (kg/ha)

The trend of variations of biological yield in different treatments followed the trend of seed yield and yield attributors for obvious reasons. Seed hydropriming (treatment of P_2), Closer plant spacing treatment G_1(30×10 cm) and Nutrient management of N_5(50% RDF through fertilizer+50% RDF through Vermicompost) proved significantly superior over respective factors of the treatments. The mean minimum biological yield of 1426 kg/ha was observed due to treatment P_1(untreated seeds), The increase in mean biological yield due to seed hydropriming treatment P_2 was 31.76 % as compared to the treatment P_1 (Table 2). Closer plant spacing treatment G_1(30×10 cm) recorded highest mean biological yield of 1985 kg/ha while significantly low of 1320 kg/ha due to wider plant spacing of treatment G_2(30×20 cm). Nutrient management of N5(50% RDF from fertilizer+50% RDF through Vermicompost) produced significantly higher mean biological yield of 1772 kg/ha. Next in order were the treatments N_4, N_3, N_1 and N_2, respectively producing biological yield of 1772, 1629, 1619 and 1530 kg/ha, respectively. Similar observations were concluded by Murade *et al*. (2014).[17]

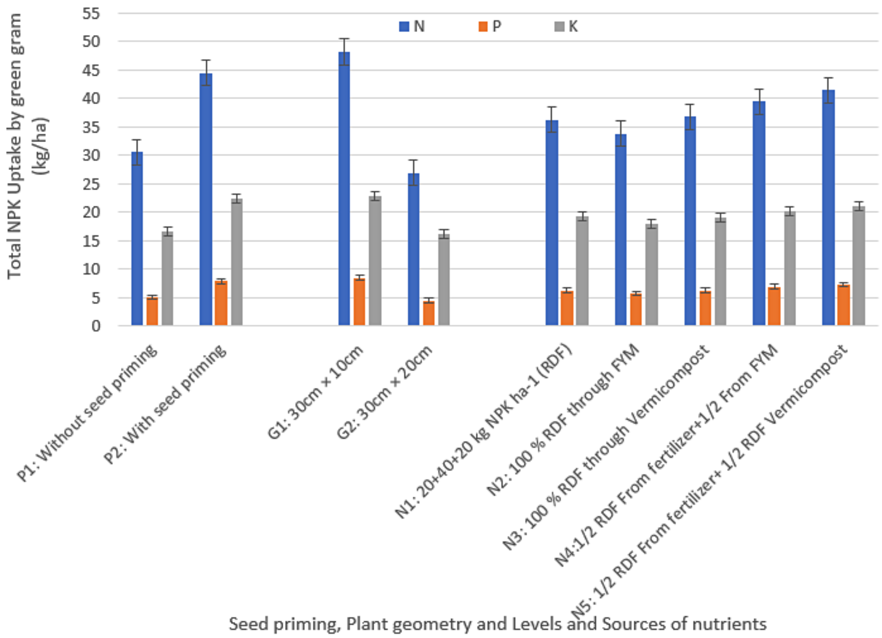

Fig .1: Total uptake of N, P and K by crop (kg /ha) as influenced by seed priming, plant geometry and different sources and levels of nutrients

Uptake of Nutrients

Uptake of NPK (kg/ha)

The results (Table 2 and Fig. 1) revealed that the treatment P_1 caused a mean uptake of 30.59 kg/ha N, 5.10 kg/ha P, and 16.59 kg/ha K, respectively. Seed hydropriming treatment (P_2) significantly increased it by 45.54 % (44.52 kg/ha N), 55.10 % (7.91 kg/ha P) and 35.20 % (22.43 kg/ha K), respectively. The plant geometry treatment of G_1(30×10 cm) recorded significantly high uptake of 48.19 kg/ha N, 8.50 kg/ha P and 22.83 kg/ha K which was decreased by 45.65 % (26.92 kg/ha N), 46.94 % (4.51 kg/ha P) and 29.08 % (16.19 kg/ha K), respectively because of treatment G_2. Nutrient management of N_5(50% RDF from fertilizer+50% RDF from Vermicompost) resulted significantly more uptake of 41.44 kg/ha N, 7.31 kg/ha P, and 21.01 kg/ha K, respectively. Next in order was the treatment N_4 which recorded mean gross absorption of 39.49 kg/ha N, 6.90 kg/ha P, and 21.01 kg/ha K, respectively, however, differences were statistically nonsignificant in between N_5 and N_4. Further, the pattern of nutrients uptake (N, P and K) by *moong* bean crop was in the order of $N_5 > N_4 > N_3 > N_1 > N_2$.

Increase in total mean removal of N by the treatments N_1, N_3, N_4 and N_5 was 7.40 %, 9.03 %, 13.98 % and 22.71 %, respectively. Increase in gross uptake of P by the treatments N_3, N_1, N_4 and N_5 was 8.44 %, 9.01%, 19.58%, and 28.07%; and the same of K was 5.43%, 6.64%, 11.97%, and 16.40%, respectively compared to treatment N_2 which recorded minimum total uptake. It is concluded that seed hydropriming (P_1), plant geometry of 30×10 cm (G_1) and nutrient management treatment N_5(50% RDF from fertilizer+50% RDF from Vermicompost) recorded higher uptake of nitrogen, phosphorus and potassium as these treatments produced highest seeds, stover and grain production also. Earlier reports of Shelke *et al*. (2013)[18] and Twinkle (2016)[19] endorse these findings on *moong* bean.

Conclusion

Based on two years study, it is concluded that practices of seed hydropriming, crop geometry of 30x10 cm row x plant spacing and conjunctive use of N, P, K nutrients equivalent to 50% of recommended dose of fertilizers (RDF) coupled with 50% nutrients through organic sources (FYM and/ or vermicompost) were found optimum for maximizing vigor of plants.

Acknowledgement

Authors are thankful to the authorities of Institute of Agriculture Sciences, Bundelkhand University Jhansi, Uttar Pradesh, India for providing all the facilities including logistic support and financial assistance to carry out research work.

Funding Sources

The experiment was the part for Ph.D. thesis and therefore University provided all the logistic support and funding for carrying out the study.

Conflict interest

There are no conflicts of any kind. including financial, personal, or other relationships with other people or organizations The Synopsis and all the detailed plans for the experiments were approved by the committee formed by the University.

Authors' Contribution

The major contributor is First author/Corresponding author. The first author /corresponding author (myself) carried out experiments, recorded observations, processed the data, analyzed and interpreted the data, wrote thesis and therefore the main contributor. Second author is guide and Advisor for research work. His contribution was to help formulation of Synopsis for the research work, providing guidance from time to time, supervision of the research work, help editing the thesis write up etc.

Data Availability Statement

The manuscript incorporates all datasets produced or examined throughout this research study.

Ethics Statement

Not Applicable.

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