RESPONSE OF GREEN GRAM [Vigna radiata (L.) Wilczek] TO FERTILIZATION THROUGH SOIL AND FOLIAGE – A REVIEW

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ABSTRACT
Greater emphasis is now laid on increasing the productivity and thereby the total production of pulses in order to mitigate the protein hunger of growing population of our country. Hence, cultivation of high yielding input responsive varieties of green gram is being recommended. In addition to other management practices such as irrigation and plant protection, green gram responds markedly to plant population level and mineral nutrition especially, when applied in balanced amount and by appropriate methods. However, the response of green gram to fertilizer application varies from place to place and variety to variety. Hence, to have an understanding on the works done on so far the literature pertaining to response of green gram to fertilizer application through soil and foliage is reviewed in this article.

Key words: Foliar, Green gram, Growth, Nutrient management, Soil, Yield.

India has the largest area in the world under grain legumes, cultivated in 23.63 million hectares with a production of 14.76 million tonnes of which green gram occupies an area of 3.78 million ha accounting for 16% of total pulses area and 10.3% of total production and which is the third most important pulse crop of India in terms of area cultivated and production (Anonymous, 2010) next to gram (Cicer arietinum) and pigeon pea (Cajanus cajan). The productivity gap analysis revealed that the national average yield of green gram is 413 kg ha\(^{-1}\) as against 667 kg ha\(^{-1}\) in Punjab. This indicates that there is a wide scope for increasing the productivity of green gram by proper management practice.

Low productivity of green gram is due to the cultivation of this crop in marginal and sub marginal lands with the non adoption of appropriate management practices. Availability of high yielding short duration varieties and the possibilities of raising them through out the year, offer a vast scope to remedy the protein malnutrition by increased productivity. To exploit the full genetic potential of any green gram variety, development of location specific management technology is of utmost importance. Use of improved crop management packages can invariably increase the productivity by 50 to 100 per cent. In addition to other management practices such as irrigation and plant protection, green gram responded markedly to plant population and mineral nutrition especially, when applied in balanced amount and by appropriate methods. Of late sulphur has become an important element apart from NPK in all the crops. Pulses are among the crops which have relatively high requirement of S and are particularly sensitive to S deficiency (Tandon, 1995).

However, information involving intensification of fertilizer inputs with a view to increase the productivity and economics of cultivating green gram are meager. Hence the present review was undertaken in green gram to study the effect of increased fertilization through soil as well as foliar on the growth and yield of green gram.

Nutrition management system
Among the pulses, green gram has not received much attention in proportion to its perspective potential in tropical and sub-tropical regions. Its present yield is one of the lowest among
major grain legumes, which could be improved by proper cultural and nutrient management systems. In recent years, though many high yielding varieties have been evolved, the productivity of green gram is still very low as against other pulses. This can be increased by judicious use of fertilizers, especially nitrogen and phosphorus in combination with biofertilizers, which have a greater role in the nutrition of pulses.

**Inorganic nutrient application**

**Nitrogen:** Grain legumes in general do not require high amount of N since the N requirement is met with by the N fixed by them. Even though, some amount of N as starter dose has to be applied initially to take care of the early requirement of N for the growth and development.

Green gram responded to the application of nitrogen to varying degrees. A maximum seed yield of 1820 kg ha⁻¹ could be obtained in kharif green gram raised in red sandy loam soil when nitrogen was applied through soil @ 30 kg ha⁻¹ in the form of ammonium sulphate (Thimmegowda, 1983). Raju and Varma (1984) observed that increasing the nitrogen level alone upto 45 kg ha⁻¹ considerably increased the grain yield over control. There was significant reduction in the yield at 60 kg N ha⁻¹ over 45 kg N ha⁻¹ in summer green gram raised on sandy clay loam soils of Varanasi.

The summer green gram raised on lateritic soil of Dapoli responded well for N application (Khade et al., 1986). They also stated that nitrogen application @ 25 kg ha⁻¹ significantly improved the yield contributing characters and grain yield over 12.5 kg N ha⁻¹ and it was on par with 37.5 kg N ha⁻¹. Bachchhav et al. (1994) reported from the experiments conducted in summer green gram at Pune that the favourable increase in leaf area plant⁻¹ was noticed upto 30 kg N ha⁻¹ at later stages of crop growth. Ayub et al. (1999) reported that application of 40 kg N ha⁻¹ was the optimum level for harvesting higher yield of green gram with maximum protein content (26.18%). It can be inferred that greengram responds well upto an amount of 30-40 kg N ha⁻¹ which could be the optimum dose.

**Phosphorus:** Green gram responded to the application of P₂O₅ to varying degrees. Maximum yields were realized at 26 kg ha⁻¹ (Venkateswarlu et al., 1983), 50 kg ha⁻¹ (Paroda et al., 1979) and 60 kg ha⁻¹ (Singh et al., 1991)

The highest grain yields through increase in yield attributes were recorded from summer green gram with the application of 20 kg P₂O₅ ha⁻¹ (Thakuria and Saharia, 1990 and Rajkhowa et al., 1992). In another trial 22.9 kg P₂O₅ ha⁻¹ was found to be optimum (Kumar and Singh, 1993). Shukla and Dixit (1996) found that summer green gram recorded better growth characters with the increasing levels of phosphorus upto 40 kg P₂O₅ ha⁻¹, but the flowering was delayed with increased levels of phosphorus. Kalita and Kalita (1992) reported that 40 kg P₂O₅ ha⁻¹ increased the seed yield of green gram. Balachandran and Sasidhar (1991) reported that increasing P₂O₅ @ 45 kg ha⁻¹ increased the pod number plant⁻¹ but not seed number pod⁻¹ and test weight. In winter green gram higher seed yield of 1234 kg ha⁻¹ was obtained with the application of 45 kg P₂O₅ ha⁻¹ (Patro and Sahoo, 1994).

Kushwaha and Singh (1992) found that seed yield was higher with the application of 50 kg P₂O₅ ha⁻¹ irrespective of method of application. Similarly, Rao et al. (1993) observed higher seed yield with 50 kg P₂O₅ ha⁻¹, whereas, Thakur et al. (1996) reported enhanced grain and biological yields in green gram when applied with 50 kg P₂O₅ ha⁻¹.

Khan et al. (1999) stated that application of P₂O₅ from 60–90 kg ha⁻¹ was optimum for realizing better yield of green gram. Similarly, maximum green gram yield was realized at 75 kg P₂O₅ ha⁻¹ (Ayub et al., 1998) and 100 kg P₂O₅ ha⁻¹ (Sharar et al., 1999). Maximum seed yield of 962 kg ha⁻¹ was obtained with 85 kg P₂O₅ ha⁻¹ under irrigated condition (Ali et al., 1999).

There is wide variation in the quantity of P to be applied. However, a quantity of 40 kg P₂O₅ would be optimum.
Potassium: Pulses like green gram are cultivated with little or no application of potassium and consequently only very meager research results are available. Maximum seed yield (753 Kg ha\(^{-1}\)) of green gram was obtained with the application of 90 Kg K\(_{2}\)O ha\(^{-1}\) (Hussain et al., 2011). Chaudhry and Mahmood (1999) reported that fertilization of 50 Kg K\(_{2}\)O ha\(^{-1}\) produced higher seed yield (832 kg ha\(^{-1}\)) and increased protein content in green gram.

Nitrogen and phosphorus

Maximum yield of green gram was recorded with 15 kg N and 40 or 60 kg P\(_{2}\)O\(_{5}\) ha\(^{-1}\) (Srivastava and Varma, 1982), 20 kg N and 40 kg P\(_{2}\)O\(_{5}\) ha\(^{-1}\) (Patel and Patel, 1994) and 50 kg each of N and P\(_{2}\)O\(_{5}\) ha\(^{-1}\) (Badole and Umale, 1994) in different locations.

Sadeghipour et al. (2010) found that application of 90 kg N and 120 kg P\(_{2}\)O\(_{5}\) ha\(^{-1}\) was optimum for obtaining the highest yield of green gram. Increased number of pods, seed yield, test weight and protein content were observed in green gram when sown after application with 30 kg N and 60 kg P\(_{2}\)O\(_{5}\) ha\(^{-1}\) (Nadeem et al., 2004). Oad et al. (2003) stated that fertilization of green gram with 100 kg P and K each helped to achieve maximum seed yield.

NPK nutrient: Manuriial schedule of 20:60:20 kg NPK ha\(^{-1}\) for sandy loam soils (Saxena et al., 1996) was found to be optimum in green gram. A significant response of applied P and K in combination with N on green gram productivity has been reported by Panwar and Singh (1981) and that of potassium and nitrogen on irrigated green gram by Duke et al. (1980).

Rahman and Miah (1988) reported that the green gram cultivated in flood plain soils of Bangladesh produced higher grain yield with the fertilizer schedule of 20:30:25 kg NPK ha\(^{-1}\) under rainfed conditions. Similarly, Luo et al. (1995) tried different combinations of NPK on the productivity of green gram and reported that the biomass yields were 9.79 to 12.4 t ha\(^{-1}\) with increased levels; the coefficient for return of biomass to the soil did not change with varied fertilizer levels and the anthropogenic return biomass was about 66 per cent of the total biomass yield. Highest grain yield of 876 kg ha\(^{-1}\) was recorded in sandy clay loam soil of irrigated green gram with addition of 30 kg N and 70 kg of P\(_{2}\)O\(_{5}\) ha\(^{-1}\) in combination with K (Tariq et al., 2001).

Sulphur: Sulphur deficiency induces chlorosis in young leaves and causes bleaching, necrosis of margins and inward curling during advanced stages in green gram. Sulphur deficiency decreased plant dry weight, seed yield, leaf concentration of chlorophyll, soluble proteins, starch, DNA and RNA and increased the concentration of total reducing sugars and nitrate-N and activities of peroxidase and ribonuclease (Chatterjee et al., 1992). Kamat et al. (1981) showed that soil application of sulphur as potassium sulphate (K\(_{2}\)SO\(_{4}\)) @ 30 kg ha\(^{-1}\) significantly increased the protein content of green gram grains and Bansal (1991) recorded the highest grain yield increase in green gram upto 1.3 t ha\(^{-1}\) when applied with 80 kg S ha\(^{-1}\) and the highest S content of seed.

Patel et al. (1992) reported from a field trial in green gram during rainy season at Gujarat that the seed yield increased with 20 kg N + 40 kg P\(_{2}\)O\(_{5}\) ha\(^{-1}\) and with increased rate of S upto 30 kg ha\(^{-1}\) as gypsum. But, application rate beyond 30 kg did not significantly increase the seed yield even in the presence of ammonium molybdate in loamy sand soils of Rajasthan during monsoon season (Jat and Rathore, 1994). Hence, sulphur application is essential in soil deficient in sulphur in order to get higher yield.

Foliar feeding of nutrients

It has been well established that most of the plant nutrients are absorbed through the leaves and absorption would be remarkably rapid and nearly complete. Moreover, foliar feeding practice would be more useful in early maturing crops which could be combined with regular plant protection programmes.

Thimmegowda (1983) found in green gram (kharif) raised in red sandy loam soils in Bangalore that 0.4 per cent nitrogen (urea) sprayed treatments at flower initiation recorded a maximum seed yield of 1229 kg ha\(^{-1}\) as compared to plants sprayed at flower initiation and pod development. Hamid (1991) observed in green gram that 10 mg N per liter increased seed yield in Bangladesh both in pot and field experiments.
Phosphorus applied as ½ soil + ½ foliar with 60 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} though showed increasing trend in the yield and yield attributes, did not reach the level of significance in summer green gram raised in Varanasi (Srivastava and Varma, 1981). Pandrangi et al. (1991) recorded seed yield of 1.00 to 1.13 t ha\textsuperscript{-1} with soil applied P, 0.80 to 0.84 t ha\textsuperscript{-1} with foliar applied P and 1.07 – 1.26 t ha\textsuperscript{-1} with soil + foliar application in green gram raised during rainy season in Maharashtra. Application of 40 kg P as single super phosphate + foliar applied P gave the highest seed yield and total N, P and K uptake.

Summer and rabi green gram raised in Assam, with combination of 3.0 per cent P\textsubscript{2}O\textsubscript{5} + 100 ppm NAA showed highest seed yield and harvest index (Kalita et al., 1995). The increased yield performance of treated plants was associated with higher number of pods plant\textsuperscript{-1} and seeds pod\textsuperscript{-1}. Patel and Patel (1994) reported that the summer green gram with the application of 20 kg N + 40 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} (recommended rate) gave the highest seed yield (1.74 t ha\textsuperscript{-1}) which was not significantly different from foliar application of urea (1.5\%) + DAP (0.5\%) at 30 and 40 days after sowing (1.67 t ha\textsuperscript{-1}).

Application of FeSO\textsubscript{4}, MnSO\textsubscript{4} and ZnSO\textsubscript{4} as 1 per cent solution and dilute H\textsubscript{2}SO\textsubscript{4} as 0.1 per cent solution to green gram foliage significantly increased the N and sulphur contents of leaves with increased grain yields (Mehta and Singh, 1979). Among KCl and K\textsubscript{2}SO\textsubscript{4} at one per cent foliar spray, K\textsubscript{2}SO\textsubscript{4} significantly increased the seed yield by 12.2 per cent (Chandra Babu et al., 1985). Radhamani et al. (2003) revealed that spraying of DAP (2\%) in combination with NAA (40 ppm) at 50 per cent flowering stage of green gram increased number of pods per plant, pod and seed yield (874 kg ha\textsuperscript{-1}). Applications of 125 per cent NP along with foliar sprays of two per cent DAP and one per cent SOP twice recorded higher N, K and S uptake by green gram and higher soil available N (Sathyamoorthi et al., 2007). Canopy bottom light quantum was the lowest and differential light quantum was the highest with 125 per cent recommended NP along with foliar spraying of DAP and SOP. (Sathyamoorthi et al., 2008a).

Application of 125 per cent NP with foliar sprays recorded higher root length, root volume and functional root nodules (Sathyamoorthi et al., 2008b). All the growth characters and yield of green gram were better when applied with 125 per cent NP along with foliar spraying of two per cent DAP and one per cent SOP twice (Sathyamoorthi et al., 2008c). Similarly, pods plant\textsuperscript{-1}, pod length, seeds pod\textsuperscript{-1} and seeds plant\textsuperscript{-1} were higher with 125 per cent NP along with foliar spraying of two per cent DAP and one per cent SOP twice (Sathyamoorthi et al., 2008d). Green gram applied with 125 per cent NP along with foliar spraying of two per cent DAP and one per cent SOP twice recorded higher yield, higher benefit – cost ratio and gross and net returns (Sathyamoorthy et al., 2008e).

It is evident from the review that foliar spray of DAP is more useful in increasing then yield even though the other chemicals like KCl and K\textsubscript{2}SO\textsubscript{4} are also useful.

**Integrated nutrient supply**

Nitrogen becomes a limiting factor during pod formation, when the nodules begin to disintegrate following a decline in photosynthetic activity of plants. Seed inoculation with efficient strains of *Rhizobium* and application of phosphorus increased the grain yields in green gram (Sinha, 1973). Inorganic fertilizer nutrient along with N and P mobilizing biofertilizers become imperative in the integrated nutrient supply systems. Application of 50 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} (50 per cent through single super phosphate + 50 per cent through press mud cake) also resulted in increased yield. It has also resulted in 50 per cent saving of P fertilizer by the use of press mud cake (Borde et al., 1983).

Maximum seed yield of green gram was obtained by the combined application of either *Rhizobium* + 15 kg N during different seasons (Venkateswarlu et al., 1983; Raju and Varma, 1984) and along with 26 kg P (Venkateswarlu et al., 1983) or at 10 kg N (Patel et al., 1988). This revealed that seed inoculation with efficient *Rhizobium* culture would help in reducing the inorganic N requirement of green gram crop to the extent of 10 kg ha\textsuperscript{-1}. Increased yields were also realized when green gram was supplied with 15 and 35 kg N and P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1}, respectively with specific strain of N fixing and P solubilising biofertilizers (Borah and Guha, 1994). Singh et al. (1994a) stated that the efficiency of the applied phosphorus was increased with the inoculation of *Rhizobium* in green gram by recording...
higher N and P uptake and better protein quality of seeds with higher grain yield.

Incorporation of strains of *Bacillus megatherium* in the soil and inoculation of seeds with *Rhizobium* coupled with application of super phosphate or rock phosphate resulted in better yields of green gram (Bhatnagar et al., 1979). Combined application of *Rhizobium* + varied doses of N and P either together or separately has resulted in high content of protein, phosphorus and dry matter accumulation (Srivastava and Varma, 1981 and Srivastava and Varma, 1982), nodules and grain and straw yields (Brar and Lal, 1991; Patel and Patel, 1991; Ardesheha et al., 1993).

Saraswathy et al. (2004) observed that application of 12.5:25:25 kg NPK ha⁻¹ along with composted coir pith @ 12.5 t ha⁻¹ increased the dry matter, yield attributes, grain and haulm yield and test weight of green gram under rainfed condition. Maximum growth and yield (529 kg ha⁻¹) was recorded under combined application of 20 kg N, 50 kg P₂O₅ and 10 t FYM ha⁻¹ in green gram (Singh, 2007). Increased grain yield of green gram was obtained with application of 2t compost + 1t gliricidia ha⁻¹ (Sharma et al., 2004).

Better grain (1220 kg ha⁻¹) and straw (2406 kg ha⁻¹) was recorded with application of Rhizobium + P₄O₁₀ kg ha⁻¹ (Rahman et al., 2002). Qureshi et al. (2011) reported that co-inoculation of *R. phaseoli* and *B. megaterium* with 20 kg N and 50 kg P ha⁻¹ enhanced the green gram growth, root mass (231.3 g), root length (50.54 cm), nodule number (78), nodular mass (0.216 g) and pod (24.3 g pot⁻¹) and straw (32.07 g pot⁻¹) yield. The dual inoculation of Rhizobium+PSB, application of S @ 30 kg ha⁻¹ through gypsum and 2% foliar application of DAP significantly recorded the highest number of pods plant⁻¹, fertility co-efficient, number of seeds per pod, seed yield, stover yield and test weight (Ghosh and Joseph, 2008)

**Soil-Plant nutrient status**

A significant correlation could be observed between the Olsen’s phosphorus in soil and phosphorus uptake by the crop. The highest availability and uptake of phosphorus were observed with 120 kg P₂O₅ ha⁻¹. However, higher grain yield of green gram was recorded with the application of 80 kg P₂O₅ ha⁻¹ (Sharma et al., 1984). Luo et al. (1995) reported that the proportions of nutrients returned from green gram straw were 43.6 – 55.7 per cent of N, 41.8 – 50.3 per cent of P₂O₅ and 55.7 – 61.0 per cent of K₂O and concluded that green gram is a K enriched plant when applied with recommended NPK schedule.

The amount of nutrient uptake increased markedly with increased rate of fertilizer application in legumes (Bansal, 1991; Patel et al., 1992). The P uptake at various stages of crop growth followed the dry matter accumulation pattern of the crop. Sharma *et al.* (1984) recorded highest availability and uptake of P in summer green gram experiments with the application of 120 kg P₂O₅ ha⁻¹ on alluvial soils of Karnal. Balaguravaiah *et al.* (1989) reported that in *kharif* green gram, there was significant response to phosphate equivalent to 60 kg ha⁻¹ in terms of made up level of soil available phosphorus. Green gram responded to phosphate fertilization in vertisols analyzing less than 60 kg available P₂O₅ ha⁻¹ in soil or upto 0.4 per cent P in the leaves at flowering. Tandon (1987) found that the average phosphorus removal varied widely for different crops per tonne production of grain or economic produce. On an average, P₂O₅ removal would be 14 kg ha⁻¹ for pulses in total and 22.6 kg ha⁻¹ for green gram in particular when grown with optimum ‘P’ application.

Higher uptake of N and P with application of 60 kg P₂O₅ ha⁻¹ in green gram raised during summer in Madhya Pradesh region was recorded by Dewangan *et al.* (1992). Rao *et al.* (1993) reported increased P uptake in seeds and haulms of green gram with 50 kg P₂O₅ ha⁻¹ raised during rainy season in Andhra Pradesh. Similarly, Singh *et al.* (1994b) found that application of 30 kg P₂O₅ ha⁻¹ significantly increased the total uptake of N and P by total biomass in *kharif* green gram raised on loamy sand soils of Rajasthan.

From the detailed analysis of the foregoing review, it could be inferred that attempts were made by several scientists in our country and elsewhere to increase the productivity of green gram by incorporating, one or two agronomic factors of production. However, information on technologies, involving input intensification with a view of fertilizer application through different sources, method and quantity are helpful to increase the productivity further efficiently and economically in cultivation of sole crop of green gram, is seldom or meagerly available.
REFERENCES


