

Original Research Article

<http://dx.doi.org/10.20546/ijcmas.2017.602.059>

Effect of Different Levels of Phosphorus and Sulphur on Growth and Nutrient Uptake of Green gram (*Vigna radiata* L.) under Teak (*Tectona grandis* L.) based Agroforestry System

Jaiveer Singh Dhewa^{1*}, Sameer Daniel¹ and Sulochana²

¹Department of Agroforestry, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad-211007, India

²Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Raj) -313001, India

*Corresponding author

ABSTRACT

Application of phosphorus and elemental sulphur is an important tool to obtain high yield of green gram (*Vigna radiata* L.) under teak based agroforestry system in *kharif* season 2014 and 2015. The overall goal of the present experiment was to assess the impacts of phosphorus and elemental sulphur application on green gram growth under teak based agroforestry system in eastern Uttar Pradesh, India. Green gram was grown in an alley cropping system, which integrates trees with grain crops. Specific objectives of the study were to: (a) determine the effect of phosphorus and sulphur on growth of green gram under teak based agroforestry system during *Kharif* season; (b) evaluate the interaction effect between phosphorus and sulphur levels, if any (c), to find the effect of phosphorus and sulphur levels on nutrient content and uptake by green gram under teak based agroforestry system during *kharif* season. The impacts on green gram growth were assessed for different rates of phosphorus (25, 45 and 65 kg/ha) and S (20, 35 and 50 kg/ha) under teak based agroforestry system during *kharif* season. The field experiment was laid out according to a factorial randomized block design with three replications of 9 treatment combinations. Application of phosphorus at 65 kg/ha produced the best results in terms of the green gram growth attributes like plant height, number of trifoliolate leaves/plant, dry matter accumulation, number of nodules/plant, CGR, RGR and NPKS content and uptake by crop compared with the phosphorus at 45 kg/h and 25 kg/ha under both condition open and teak based agroforestry system. However application sulphur at 50 kg/ha also gives higher growth and nutrient content and uptake by the crop as compared with S35 kg/ha, S 20kg/ha in both condition open and teak based agroforestry system.

Keywords

Phosphorus, Sulphur, Agroforestry system, Growth, and uptake, Green gram.

Article Info

Accepted:

15 January 2017

Available Online:

10 February 2017

Introduction

Pulses production is very low and become challenging problem against the requirement of increasing population of our country. The pulses availability per capita was 69.9g in 1951, by increasing in 1971, it comes to 50g and in 1982 remained only 40g and in 2005, it

was 27g. The availability of pulses is very negligible at present as against required 85g day⁻¹capita⁻¹ for balanced diet to recover this deficit of production. It is high time to cultivate pulses crops scientifically with increasing area (Patel *et al.*, 2013). The

United Nations, declared 2016 as “International Year of Pulses” (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition. India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20 per cent of the area under food grains and contribute around 7-10 per cent of the total foodgrains production in the country (Mohanty and Satyasai, 2015).

Green gram (*Vigna radiata* L.) is cultivated in tropical and subtropical regions of India as a summer (*Kharif*) rainfed crop (Anilakumar *et al.*, 2010). Pulses are consumed all over the world; their consumption is higher in those parts of the world where animal proteins are scarce and expensive (Ofuya and Akhidue, 2005). Green gram commonly known as ‘Moongbean’ or ‘Moong’ contains 24.3 per cent protein fairly rich in carbohydrates and also contains small amount of riboflavin and thiamine, also rich in phosphorus and iron (Patel *et al.*, 2013). It’s also contains high quality of lysine (4600 mg/g N) and tryptophan (60 mg/g N) and consumed as whole grain or as well as in the form of Dal for table purposes. Mungbean is supposed to be easily digestible and, hence preferred by patients. The sprouted seeds of mungbean are rich in ascorbic acid (Vitamin C), riboflavin and thiamine (Choudhary, 2010)

Alley cropping is a type of agroforestry system in which seasonal crops are grown in between the rows of trees. There are several types of alley cropping systems depending upon different associations of trees and crops (Torquebiau, 2000). Teak (*Tectona grandis* L.) is the most important timber tree in India, especially for furniture making. The species belongs to family Lamiaceae and locally known as *Sagwan*. It fetches higher prices due to quality of timber. It can be grown in all

parts of the country except dry western zone. Mostly it prefers a deep, fertile, well-drained deep alluvial soil. The sandy soil is considered to be the best soil texture for this tree. It fails to grow in the soil with pH below 6.5. Mr. Chatu Menon of Malabar (Kerala) is known as the father of teak plantation in India. He had raised more than a million teak plants in Kerala during 1842 – 1862 (Parameswarappa, 1995; Dotaniya *et al.*, 2013).

The phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986). Phosphorus shortage restricts the plant growth and remains immature. Common diagnostic properties of phosphorus deficiency are a darker green leaf colour due to higher chlorophyll contents (often with red pigments from anthocyanins), reduced leaf extension and a higher root-to-shoot ratio, since root growth is much less affected by phosphorus deficiency than shoot growth (Wild, 1988; Marschner, 1995). A high phosphorus supply is needed for nodulation of legumes and hence phosphorus deficiency can also seriously reduce biological nitrogen fixation (Marschner, 1995). Phosphorus availability is a limiting factor for plant production in many agricultural soils (Fairhurst *et al.*, 1999). In regions of the world without a history of use of phosphorus fertilizers, phosphorus deficiency is very common (Wild, 1988). A large portion of applied fertilizer phosphorus may be fixed to iron and aluminium oxides and is then not available for plant uptake (Pal *et al.*, 2014). These facts make sound phosphorus management imperative, especially in situations where funds for fertilizer purchases are limited, as in tropical smallholder agriculture. Agro forestry techniques can help to overcome some of these constraints (Buresh, 1999). However, because of generally low phosphorus concentrations in mulch materials, low atmospheric inputs and low release by mineral weathering, adequate

applications of phosphorus fertilizers are necessary in permanent agriculture to ensure economic and ecological sustainability (Buresh *et al.*, 1997 and Newman, 1997). The deficiency of S, one of the fourth most important nutrient after N,P and K (McGrath *et al.*, 1996; Walker and Dawson 2003; Matula 2004) is a major constraint to sustainable production of oilseed crops in many parts of the world including India (Saha *et al.*, 2001; Biswas *et al.*, 2003; Grant *et al.*, 2003; Malhi and Gill, 2007). About 41% of soils in India are deficient in S, and yield of oilseed crops is adversely affected (Lakkineni and Abrol, 1992; Tewatia *et al.*, 2007). Deficiency of S is also reported in soils of the Allahbad region of India (Singh, 2001; Ahmad *et al.*, 2005; Singh and Kumar, 2012; Scherer, 2001, 2009). Deficiency of S adversely affects flowering, fruiting, and cupping of leaves, reddening of stems, petioles and stunted growth of oilseed crops (Salwa *et al.*, 2010; Saha *et al.*, 2001). The requirement of S is higher in oilseed crops due to its critical role in synthesis of oil and production of bold grains (Havlin *et al.*, 2004; Malhi *et al.*, 2007). Therefore, the sustainable production of oilseed crops (i.e., sesame) in acidic soils requires knowledge of the site-specific rates of liming and S fertilization (Tiwari *et al.*, 2000; Singh *et al.*, 2011).

Research information on the conjunctive rate of phosphorus and S application under site-specific conditions of growing green gram are not widely available, especially in an alley cropping system where pulses crops are grown in between the rows of fruit trees. Yet, this information is necessary to effectively sustain the productivity of the green gram while also alleviating S deficiency. Therefore, the present study was conducted to assess the impacts of application of phosphorus and Sulphur on growth, and nutrient content and uptake of green gram under teak (*Tectona grandis* L.) based agroforestry system and open condition of Allahbad.

Materials and Methods

Experimental site

A field experiment was conducted during *Kharif* season of 2014 and 2015. The experimental site is situated at Forest Nursery, School of Forestry and Environment, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed-To-Be-University) Allahabad, India. The Centre is situated at 25.41°N latitude and 81.84°E longitude and at an altitude of 98 meter sea level.

Crop and climate

Allahabad is situated at an elevation of 25.4°N latitude and 81.84°E longitude, and 98 meter above the mean sea level. It is located in the South-eastern part of Uttar Pradesh and has tropical to sub-tropical climate with extremes of summer and winter. During the winter months especially December and January, temperature drops down to as low as 5°C while in the summer temperature reaches above 45°C, hot scorching winds (commonly known as Loo) is regular feature during the summers whereas there may be an occasional spell of frost during the winter. The annual rainfall is 1100 mm mostly during the monsoon autumn i.e. July to September, with a few occasional showers during the winter months.

Soil analysis

Soil samples were collected randomly from 0-30cm depth within each 10 m interval at the three physiographic positions of the experimental field prior to sowing and after harvest of the crop. Soil samples were air dried, gently ground and passed through 2mm sieve.

The plow layer contains 245.08 kg/ha alkaline permanganate oxidizable N (Subbiah and

Asija, 1956), 25.30 kg/ha of available P extracted by 0.5 M NaHCO₃ at pH 8.5 (Olsen and Sommers, 1982), 128.60 kg/ha of available K as determined by the flame photometer method with 1N KCl and titrating with 0.05N NaOH (McLean, 1982), 13 kg/ha of S as determined by the turbidity method (Chesnin and Yein, 1950), soil organic carbon (SOC) concentration of 0.31% and converted to SOC stock by using the American Society for Testing and Materials (ASTM, 2000), and soil pH (7.45) as determined in 1:2 (soil: water) extract of the soil using deionized water, and electrical conductivity (EC) 0.034 dS/m at 25°C in 1 : 2 (soil : water) suspension using 0.01M potassium chloride solution (Reeuwijk, 2002).

Treatment details and field layout

The field experiment was laid out according to a factorial randomized block design with three replications. The experiment comprised of 9 treatment combinations consisting three levels of phosphorus (25, 45 and 65 kg/ha) and S (20, 35 and 50 kg/ha). Green gram was grown within the alleys of 12-years old teak (*Tectonagrainsdis* L.) plantation. The teak trees were planted at a spacing of 9×3m. Green gram was sown on 30 cm between the rows and 10 cm spacing within the plants between the teak trees.

The row of green gram next to the guava trees was 100 cm away and there were a total of 10 rows of green gram within the alley of two rows of teak. The gross and net plot size was 3 ×4 m, 2.10 ×3 m, respectively. The distance between the teak and green gram row was 1m on both sides. The crop also grown in open condition with same spacing and gross or net plot size.

Variety

Samrat is a recommended variety of green gram for cultivation in summer and *Kharif*

season and matures in 60-65 days. Plant height is 40-45 cm. Growth habit is erect. Pod shape is long slender, medium in size. Pod length is 6.5 cm and number of seed pod⁻¹ is 10-11. 1000 grains weight is 38-40g. The grain is green and medium bold. Yield potential is 09-10 q.ha⁻¹.

Cultural practices and observations

Phosphorus (P₂O₅) and elemental sulphur (S⁰-S) were applied as per treatments 30 and 15 days before sowing, respectively. Phosphorus (25, 45 and 65 kg/ha) and S (20, 35 and 50 kg/ha) was drilled at the depth of 5 cm. as single super phosphate and elemental sulphur, respectively. The fertilizer was drilled in furrows at 5 cm below the seedling depths before sowing. The green gram was seeded at the recommended seed rate of =15 kg /ha, and at 2.5 cm soil depth. The seeds were covered by the soil from the other side of furrow. At 15 days after sowing (DAS), thinning was done to maintain the desired plant population. Periodic hand weeding was done as and when needed. Growth attributes are recorded at different stage of crop like plant height (cm), number of trifoliolate leaves/plant, number of branches/plant, leaf area index (cm), dry matter accumulation (g/plant), number of nodules/plant, number of pods at 50 and 100 percent maturity, respectively. Nutrient content and total uptake by crop also recorded.

Statistical analysis

The Microsoft Excel was used as a statistical software package for analyzing the data for the analysis of variance and other statistical parameters (McCullough and Wilson 2005).

Critical difference (CD) values at p = 0.05 were used to determine the significance of differences between mean values of treatments. The standard level of significance used to justify a claim of a statistically

significant effect is 0.05(Draper and smith, 1998).

Results and Discussion

Effect of phosphorus levels

Significantly higher pooled values of growth parameters year 2014 and 2015 under shade (teak) were obtained for the phosphorus application at 65 kg/ha in comparison with other treatment. These parameters included plant height(cm) at 20DAS (14.08), 40DAS (23.44) and at harvest (44.47), number of trifoliolate leaves/plant at 20DAS, 40DAS and at harvest was recorded 1.82, 11.21, 9.31 number of branches/plant at 20DAS (1.91) and 40 DAS (6.26) (Table 1), leaf area index (cm) at 20DAS (1.23), 40DAS (2.41) and at harvest (2.0) number of nodules/plant at 20 DAS and 40DAS was recorded 6.46 and 14.91, respectively, and crop growth rate at 20-40DAS (0.456) and 40- 60DAS (0.268) (Table 2), relative growth rate at 20-40DAS and 40-60DAS was recorded 1.241 and 0.730 and dry matter accumulation (g/plant) at 20 DAS (5.61), 40DAS (15.09) and at harvest (20.46), number of pods at 50 and 100 percent maturity was recorded 9.71 and 12.40 respectively (Table 3).

Moreover, nutrient content (%) and uptake (kg/ha) by crop were also recorded the application phosphorus found significantly higher value in comparison of the other treatment. These parameters included nitrogen content in grain and straw (2.37, 1.38), phosphorus content in grain and straw (0.35, 0.189), potassium content in grain and straw (0.50, 1.04), sulphur content in grain and straw (0.21, 0.082) (Table 4), respectively. Moreover the total N, P, K and S uptake was recorded (36.90, 5.29, 20.29 and 2.62), respectively (Table 5).

The data shows that significantly higher pooled values of growth parameters year 2014

and 2015 under open condition were obtained for the phosphorus application at 65 kg/ha in comparison with other treatment. These parameters included plant height (cm) at 20DAS (16.27), 40DAS (31.22) and at harvest (51.19), number of trifoliolate leaves/plant at 20DAS, 40DAS and at harvest was recorded 4.10, 20.33, 11.64 number of branches/plant at 20DAS (3.96) and 40 DAS (11.57) (Table 1), leaf area index (cm) at 20DAS (3.36), 40DAS (5.10) and at harvest (5.94) number of nodules/plant at 20 DAS and 40DAS was recorded 2.63 and 24.00, respectively, and crop growth rate at 20-40DAS (0.926) and 40- 60DAS (0.128) (Table 2), relative growth rate at 20-40DAS and 40-60DAS was recorded 2.52 and 0.128 and dry matter accumulation (g/plant) at 20 DAS(6.70), 40DAS (25.22) and at harvest(27.78), number of pods at 50 and 100 percent maturity was recorded 12.71 and 14.72 respectively (Table 3). Moreover, nutrient content (%) and uptake (kg/ha) by crop were also recorded the application phosphorus at 65 kg/ha found significantly higher value in comparison of the other treatment.

These parameters included nitrogen content in grain and haulm (3.68, 1.61), phosphorus content in grain and straw (0.69, 0.25), potassium content in grain and straw (0.85, 1.56), sulphur content in grain and straw (0.48, 0.20) (Table 4), respectively. Moreover the total N, P, K and S uptake was recorded (100.33, 17.12, 66.56 and 12.57), respectively (Table 5). Similar results were reported Patil *et al.*, (2011); Ali *et al.*, (2010); Dhewa *et al.*, (2015); Dhewa *et al.*, (2017). In general, the overall increase in growth of summer mungbean with P application can be ascribed to its pivotal role in several physiological and biochemical processes necessary for crop growth and development. It is an established fact that among nutrients, P is the most important for exploiting genetic potentials of the crop/variety (Tisdale *et al.*, 2003). But in

the shade condition the growth attributes and nutrient uptake and content found than open condition due interaction between the teak plant and alley crop like light limitation, nutrient use efficiency, water requirement and defoliation of the teak plant because their leaf are very large and not easily decomposable that effect the alley crop germination and plant growth Kumar *et al.*, (2015); Prasad *et al.*, (2014). Mutanal (1998) reported that a significant decrease in plant height and leaf area of groundnut when grown in teak based agroforestry systems especially under rainfed conditions. The reason for this paucity of information appears to be the dominance of entrenched notion that trees and annual crops are mutually incompatible (Nadagoud, 1990). Reduced plant height in agroforestry system compared to sole crop could be attributed to reduction in cell turgidity as a result of stress imposed due to competition for water, which lead to decrease in cell elongation and decreased plant height.

The observations of the present study are in line with those of Kramer (1959) who observed reduced cell elongation due to reduced cell turgidity which decreased not only the size of the plants but also the yield. It is observed that the number of leaves was greatly influenced by intercropping with teak trees indicating beneficial effects of complementing with teak. When reduction in leaf size is more, decreases the photosynthetic surface and finally affected the yield (Padeyannavar, 2002 and Venkata Rao, 2006; Mutanal, 1998).

Effect of sulphur levels

The data showed that significantly higher pooled values of growth parameters year 2014 and 2015 under shade (teak) were obtained for the sulphur application at 50 kg/ha in comparison with other treatment.

These parameters included plant height(cm) at 20DAS (12.50), 40DAS (20.80) and at

harvest (39.42), number of trifoliolate leaves/plant at 20DAS, 40DAS and at harvest was recorded 1.72, 9.97, 8.27 number of branches/plant at 20DAS (1.70) and 40 DAS (5.57) (Table 1), leaf area index (cm) at 20DAS (1.09), 40DAS (2.13) and at harvest (1.77) number of nodules/plant at 20 DAS and 40DAS was recorded 5.71 and 13.24, respectively, and crop growth rate at 40-60DAS (0.205) but 20-40 DAS found non – significant in both the year (Table 2), relative growth rate at 40-60DAS was recorded 0.559 but 20-40 DAS found non – significant in both the year and dry matter accumulation (g/plant) at 20 DAS (5.16), 40DAS (13.35) and at harvest (17.46), number of pods at 50 and 100 percent maturity was recorded 8.63 and 11.01 respectively (Table 3). Moreover, nutrient content (%) and uptake (kg/ha) by crop were also recorded the application sulphur at 50 kg/ha found significantly higher value in comparison of the other treatment. These parameters included nitrogen content in grain and haulm (2.12, 1.22), phosphorus content in grain and haulm (0.31, 0.168), potassium content in grain and haulm (0.43, 0.92), sulphur content in grain and haulm (0.18, 0.073), respectively (Table 4). Moreover the total N, P, K and S uptake was recorded (30.02, 4.32, 16.47 and 2.14), respectively (Table 5). The data showed Significantly higher pooled values of growth parameters year 2014 and 2015 under open condition were obtained for the sulphur application at 50 kg/ha in comparison with other treatment. These parameters included plant height (cm) at 20DAS (14.45), 40DAS (27.71) and at harvest (45.36), number of trifoliolate leaves/plant at 20DAS, 40DAS and at harvest was recorded 3.65, 18.04, 10.33, number of branches/plant at 20DAS (3.51) and 40 DAS (10.27) (Table 1), leaf area index (cm) at 20DAS (2.99), 40DAS (4.53) and at harvest (5.28) number of nodules/plant at 20 DAS and 40DAS was recorded 2.33 and 21.27, respectively.

Table.1 Effect of phosphorus and sulphur levels on plant height (cm), number of trifoliolate leaves/plant and number of branches/plant of kharif green gram(pooled data 2014 and 2015)

Treatment	Plant height (cm)						Number of trifoliolate leaves/plant						Number of branches /plant			
	Pooled Under shade 2014-2015			Pooled Under Open 2014-2015			Pooled Under shade 2014-2015			Pooled Under Open 2014-2015			Pooled Under shade 2014-2015		Pooled Under Open 2014-2015	
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	40 DAS	At harvest	20 DAS	At harvest
Phosphorus Level (kg/ha)																
25	9.23	15.36	29.09	10.67	20.43	33.42	1.34	7.34	6.11	2.69	13.31	7.62	1.26	4.11	2.59	7.58
45	12.08	20.06	38.02	13.95	26.71	43.70	1.65	9.62	8.01	3.53	17.40	9.96	1.65	5.39	3.39	9.91
65	14.08	23.44	44.47	16.27	31.22	51.19	1.82	11.21	9.31	4.10	20.33	11.64	1.91	6.26	3.96	11.57
SEm±	0.20	0.33	0.62	0.23	0.43	0.702	0.04	0.16	0.13	0.059	0.281	0.162	0.03	0.09	0.055	0.165
CD (P=0.05)	0.59	1.00	1.87	0.69	1.31	2.124	0.13	0.48	0.40	0.178	0.849	0.49	0.08	0.28	0.166	0.498
Sulphur Level (kg/ha)																
20	11.21	18.63	35.32	12.96	24.81	40.61	1.51	8.92	7.42	3.27	16.14	9.26	1.53	4.99	3.15	9.20
35	11.67	19.42	36.83	13.48	25.84	42.34	1.58	9.29	7.74	3.41	16.86	9.63	1.59	5.20	3.28	9.59
50	12.50	20.80	39.42	14.45	27.71	45.36	1.72	9.97	8.27	3.65	18.04	10.33	1.70	5.57	3.51	10.27
SEm±	0.20	0.33	0.62	0.23	0.436	0.702	0.04	0.16	0.13	0.059	0.281	0.162	0.03	0.09	0.055	0.165
CD (P=0.05)	0.59	1.00	1.87	0.69	1.317	2.124	0.13	0.48	0.40	0.178	0.849	0.49	0.08	0.28	0.166	0.498

DAS= Days after Sowing

Table.2 Effect of phosphorus and sulphur levels on leaf area index (cm), number of nodules/plant and crop growth rate (g m² day⁻¹) of kharif green gram (pooled data 2014 and 2015)

Treatment	Leaf Area Index (cm)						Number of nodules/plant				Crop Growth Rate (g m ² day ⁻¹)			
	Pooled Under shade 2014-2015			Pooled Under Open 2014-2015			Pooled Under shade 2014-2015		Pooled Under Open 2014-2015		Pooled Under shade 2014-2015		Pooled Under Open 2014-2015	
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	20 DAS	40 DAS	20-40 DAS	40-60 DAS	20-40 DAS	40-60 DAS
Phosphorus Level (kg/ha)														
25	0.81	1.58	1.30	2.21	3.36	3.90	4.21	9.78	1.72	15.68	0.332	0.058	0.605	0.084
45	1.06	2.06	1.70	2.89	4.38	5.12	5.53	12.78	2.26	20.52	0.411	0.166	0.791	0.110
65	1.23	2.41	2.00	3.36	5.10	5.94	6.46	14.91	2.63	24.00	0.456	0.268	0.926	0.128
SEm±	0.018	0.037	0.03	0.048	0.072	0.083	0.09	0.21	0.037	0.332	0.010	0.013	0.013	0.002
CD (P=0.05)	0.055	0.111	0.091	0.144	0.216	0.25	0.28	0.63	0.111	1.005	0.031	0.039	0.039	0.005
Sulphur Level(kg/ha)														
20	0.98	1.92	1.59	2.68	4.07	4.76	5.14	11.87	2.09	19.06	0.392	0.119	0.735	0.102
35	1.02	1.99	1.64	2.79	4.23	4.93	5.34	12.36	2.19	19.88	0.398	0.169	0.767	0.106
50	1.09	2.13	1.77	2.99	4.53	5.28	5.71	13.24	2.33	21.27	0.410	0.205	0.821	0.114
SEm±	0.018	0.037	0.03	0.048	0.072	0.083	0.09	0.21	0.037	0.332	0.010	0.013	0.013	0.002
CD (P=0.05)	0.055	0.111	0.091	0.144	0.216	0.25	0.28	0.63	0.111	1.005	NS	0.039	0.039	0.005

DAS= Days after sowing; NS= Non significant

Table.3 Effect of phosphorus and sulphur levels on dry matter accumulation (g/plant), relative growth rate (mg g⁻¹ day⁻¹) and number of pods at 50 and 100 per cent maturity of kharif green gram (pooled data 2014 and 2015)

Treatment	Dry matter accumulation (g/plant)						Relative growth rate (mg g ⁻¹ day ⁻¹)				Number of pods at 50 and 100 per cent maturity			
	Pooled Under shade 2014-2015			Pooled Under Open 2014-2015			Pooled Under shade 2014-2015		Pooled Under Open 2014-2015		Pooled Under shade 2014-2015		Pooled Under Open 2014-2015	
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20-40 DAS	40-60 DAS	20-40 DAS	40-60 DAS	50%	100%	50%	100%
Phosphorus Level (kg/ha)														
25	9.85	11.02	5.28	4.39	16.49	18.17	0.903	0.159	1.65	0.084	6.37	8.13	8.33	9.62
45	12.88	16.20	6.96	5.75	21.57	23.76	1.119	0.451	2.15	0.110	8.34	10.62	10.88	12.59
65	15.09	20.46	7.80	6.70	25.22	27.78	1.241	0.730	2.52	0.128	9.71	12.40	12.71	14.72
SEm±	0.212	0.326	0.158	0.095	0.350	0.39	0.028	0.035	0.035	0.002	0.139	0.176	0.178	0.205
CD (P=0.05)	0.642	0.987	0.477	0.286	1.058	1.17	0.084	0.106	0.105	0.005	0.42	0.532	0.539	0.619
Sulphur Level (kg/ha)														
20	11.98	14.36	6.40	5.34	20.03	22.07	1.068	0.323	2.00	0.102	7.73	9.87	10.12	11.68
35	12.50	15.87	6.61	5.56	20.89	23.01	1.082	0.458	2.09	0.106	8.06	10.28	10.51	12.20
50	13.35	17.46	7.04	5.95	22.37	24.64	1.114	0.559	2.23	0.114	8.63	11.01	11.29	13.06
SEm±	0.212	0.326	0.158	0.095	0.350	0.39	0.028	0.035	0.035	0.002	0.139	0.176	0.178	0.205
CD (P=0.05)	0.642	0.987	0.477	0.286	1.058	1.17	NS	0.106	0.105	0.005	0.42	0.532	0.539	0.619

DAS= Days after sowing; NS= Non significant

Table.4 Effect of phosphorus and sulphur levels on nitrogen, phosphorus, potassium and sulphur content on grain and haulm of kharif green gram (pooled data 2014 and 2015)

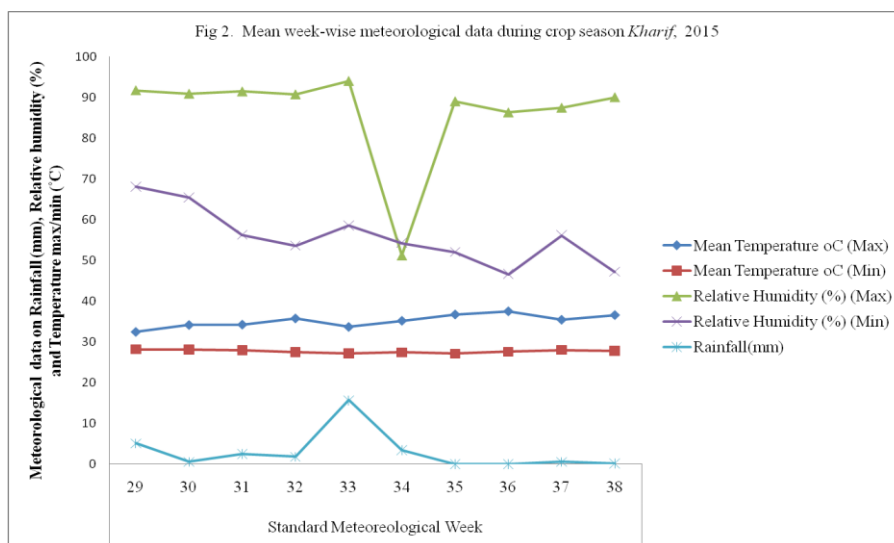
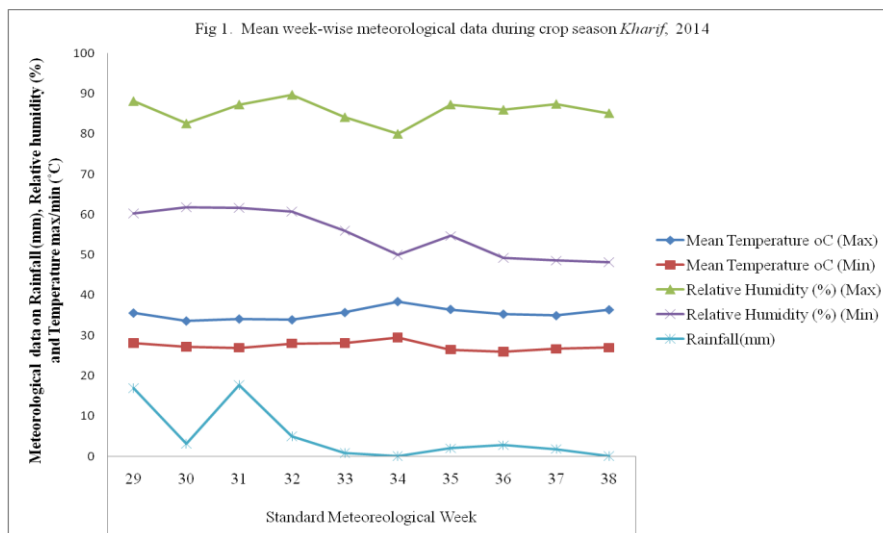
Treatment	NPKS content in grain and haulm															
	Pooled Under shade 2014-2015		Pooled Under Open 2014-2015		Pooled Under shade 2014-2015		Pooled Under Open 2014-2015		Pooled Under shade 2014-2015		Pooled Under shade 2014-2015		Pooled Under shade 2014-2015		Pooled Under Open 2014-2015	
	N content grain	N content haulm	N content grain	N content haulm	P content grain	P content haulm	P content grain	P content haulm	K content grain	K content haulm	K content grain	K content haulm	S content grain	S content haulm	S content grain	S content haulm
Phosphorus Level (kg/ha)																
25	1.52	0.90	2.39	1.04	0.23	0.123	0.45	0.17	0.32	0.68	0.56	1.03	0.14	0.054	0.31	0.13
45	2.00	1.18	3.14	1.38	0.30	0.16	0.59	0.22	0.41	0.89	0.73	1.34	0.18	0.071	0.41	0.17
65	2.37	1.38	3.68	1.61	0.35	0.189	0.69	0.25	0.50	1.04	0.85	1.56	0.21	0.082	0.48	0.20
SEm±	0.037	0.02	0.056	0.029	0.006	0.003	0.010	0.004	0.009	0.017	0.012	0.024	0.003	0.001	0.007	0.003
CD (P=0.05)	0.111	0.059	0.17	0.086	0.017	0.008	0.030	0.011	0.027	0.053	0.036	0.071	0.009	0.004	0.02	0.01
Sulphur Level (kg/ha)																
20	1.84	1.10	2.90	1.28	0.28	0.15	0.55	0.20	0.40	0.81	0.68	1.24	0.16	0.066	0.38	0.16
35	1.92	1.13	3.04	1.34	0.29	0.154	0.57	0.21	0.40	0.88	0.70	1.29	0.17	0.068	0.39	0.16
50	2.12	1.22	3.27	1.41	0.31	0.168	0.61	0.22	0.43	0.92	0.75	1.40	0.18	0.073	0.42	0.17
SEm±	0.037	0.02	0.056	0.029	0.006	0.003	0.010	0.004	0.009	0.017	0.012	0.024	0.003	0.001	0.007	0.003
CD (P=0.05)	0.111	0.059	0.17	0.086	0.017	0.008	0.030	0.011	0.027	0.053	0.036	0.071	0.009	0.004	0.02	0.01

DAS= Days after sowing

Table.5 Effect of phosphorus and sulphur levels on Total uptake (kg/ha) of nitrogen, phosphorus, potassium and sulphur by grain and haulm of kharif green gram (pooled data 2014 and 2015)

Treatment	Total N, P, K, Suptake (kg/ha) grain and haulm							
	Pooled Under shade 2014-2015		Pooled Under Open 2014-2015		Pooled Under shade 2014-2015		Pooled Under Open 2014-2015	
	N Total uptake	P Total uptake	N Total uptake	P Total uptake	K Total uptake	S Total uptake	K Total uptake	S Total uptake
Phosphorus Level(kg/ha)								
25	16.16	2.33	44.07	7.54	9.09	1.14	29.38	5.53
45	27.10	3.91	74.53	12.80	15.07	1.92	49.57	9.36
65	36.90	5.29	100.33	17.12	20.29	2.62	66.56	12.57
SEm±	1.03	0.15	2.658	0.464	0.637	0.069	1.793	0.335
CD (P=0.05)	3.10	0.44	8.039	1.403	1.93	0.21	5.421	1.014
Sulphur Level(kg/ha)								
20	23.91	3.46	66.83	11.47	13.34	1.69	44.56	8.39
35	26.22	3.76	70.93	12.12	14.63	1.85	47.17	8.89
50	30.02	4.32	81.17	13.88	16.47	2.14	53.78	10.18
SEm±	1.03	0.15	2.658	0.464	0.637	0.069	1.793	0.335
CD (P=0.05)	3.10	0.44	8.039	1.403	1.93	0.21	5.421	1.014

DAS= Days after sowing



The crop growth rate at 20-40DAS (0.821) and 40- 60DAS (0.114) (Table 2), relative growth rate at 20-40DAS and 40-60DAS was recorded 2.23 and 0.114 and dry matter accumulation (g/plant) at 20 DAS (5.95), 40DAS (22.37) and at harvest (24.64), number of pods at 50 and 100 percent maturity was recorded 11.29 and 13.06 respectively (Table 3). Moreover, nutrient content (%) and uptake (kg/ha) by crop were also recorded the application sulphur at 50 kg/ha found significantly higher value in comparison of the other treatment. These parameters included nitrogen content in grain

and haulm (3.27, 1.41), phosphorus content in grain and straw (0.61, 0.22), potassium content in grain and straw (0.75, 1.40), sulphur content in grain and straw (0.42, 0.17), respectively (Table 4). Moreover the total N, P, K and S uptake was recorded (81.17, 13.88, 53.78 and 10.18), respectively (Table 5). Similar result observed by De Datta *et al.*, (2005); Hegde and Babu (2004); Hegde and Murthy (2005). The positive role of S in formation of sulphhydryl group helping in building disulfide bond between the cysteine residues via oxidation and thus maintain the protein structure (Leustek and Saito, 1999). They also take part in transportation of sucrose and thereby take part in improving

protein, oil content and yield in sesame (Fismes *et al.*, 2000; Matula, 2004; Jan *et al.*, 2010). Additionally, S also has the beneficial effect on the availability of nutrients to improving the growth and development of green gram crop.

In conclusion, this field experimentation suggested that the application of 65 kg phosphorus along with 50 kg sulphur/ha enhance growth and nutrient content and uptake of green gram crops grown under open condition but alley cropping with teak green gram growth and nutrient content and uptake are reduced but teak tree gives extra income as timber uses for best furniture of eastern Uttar Pradesh, India. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion to be passed on the farmers.

Acknowledgement

Author is thankful to Dean of Department Agroforestry, School of Forestry and Environment for the providing necessary facility to carry out this work.

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How to cite this article:

Jaiveer Singh Dhewa, Sameer Daniel and Sulochana. 2017. Effect of Different Levels of Phosphorus and Sulphur on Growth and Nutrient Uptake of Green gram (*Vigna radiata* L.) under Teak (*Tectona grandis* L.) based Agroforestry System. *Int.J.Curr.Microbiol.App.Sci*. 6(2): 520-534. doi: <http://dx.doi.org/10.20546/ijcmas.2017.602.059>