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Effect of farmyard manure, source and level of sulphur on growth attributes, yield, quality and total nutrient uptake in pigeonpea (*Cajanus cajan*) and groundnut (*Arachis hypogaea*) intercropping system*

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India has largest area under grain legumes in the world but compared to world average the productivity is very low in India which is about 600 kg/ha and 1 000 kg/ha of pulses and oilseeds, respectively. Pigeonpea ranks second in both acreage (3.58 million ha) and production (2.74 million tonnes) among the pulses in India with average productivity of 765 kg/ha. It, being a deep-rooted crop and initial slow rate of growth for 45–60 days after sowing offers good scope for intercropping with a short-duration cover crop. Pigeonpea (*Cajanus cajan* L. Millisp.) + groundnut (*Arachis hypogea* L.) intercropping system is widely followed in several parts of the country, like Saurashtra, parts of Maharashtra, Andhra Pradesh, Uttar Pradesh etc. The wide space between the rows of pigeonpea is profitably utilized by growing groundnut which generates additional income without adversely affecting the yield of pigeonpea. Needless to say organic manures have crucial role in improving soil physical, chemical and biological properties but their importance in modern input-intensive crop production technologies needs to be further evaluated, especially in popular cropping systems like pigeonpea + groundnut intercropping system.

The development of modern technology has attracted the attention to sulphur nutrition due to cultivation of high-yielding varieties, intensive cropping, shifting of cropping pattern to S-loving crops including oilseeds, legumes and vegetables and decreased use of organic manures. Sulphur is important for biosynthesis of both oil and amino acids, like methionine, cysteine and cystine in oilseeds and pulses, respectively. There are a number of sulphur sources available in the country and their comparable evaluation along with optimum dose is needed. In view of the above facts, the present study was undertaken to study the profitability of pigeonpea + groundnut intercropping system and its response to farmyard manure and sulphur.

A field experiment was conducted during two consecutive *kharif* seasons of 2003 and 2004 at the research farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi. The soil of the experimental site was sandy loam having *p*H of 8.1, organic carbon (0.37%), available phosphorus 8.30 kg/ha, available potash 176.0 kg/ha and available sulphur 12.0 kg/ha. The treatments comprised two levels of farmyard manure (0 and 5 tonnes farmyard manure/ha) in main plot A and two levels of cropping system (sole pigeonpea and pigeonpea + groundnut) in the main plot B and 7 treatments, viz 0 kg S/ha, elemental S @ 35 kg S/ha, elemental S @70 kg S/ha, gypsum @ 35 kg S/ha, gypsum @ 70 kg S/ha, cosavet* @ 35 kg S/ha and cosavet @ 70 kg S/ha in the sub plots (*cosavet is a 90% sulphur-based fertilizer available in water dispersible granules form). The treatments were replicated thrice in split-plot design. The plot size was 5.4 m×4.0 m. Pigeonpea 'Pusa 855' variety was grown in additive series of intercropping with groundnut variety 'M 522', keeping seed rate of 15 and 100 kg/ha, respectively. Crop(s) was uniformly fertilized with recommended dose of N and P, applied before sowing of crops. The nitrogen, phosphorus and sulphur were analyzed by standard methods to calculate the N, P and S uptake, respectively.

Growth attributes, viz plant height, number of branch/plant and LAI at harvest of both pigeonpea and groundnut were significantly improved due to application of farmyard manure @ 5 tonnes/ha over no farmyard manure (Tables 1, 2). Significant response to the farmyard manure may be explained by the fact that most of the Indian soils are poor in organic matter and application of farmyard manure might have increased the supply of easily assimilated major as well as micro nutrients to plants, besides mobilizing unavailable form of nutrients into available form into the soil. However,

*Short note

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intercropping of pigeonpea with groundnut did not significantly affect the growth attributes. This may be due to lack of competition between pigeonpea and groundnut in respect of growth resources such as soil moisture, solar radiation and nutrients owing to different growth habits of both the component crops. Application of sulphur @ 35 and 70 kg S/ha over the sources, being at par, significantly increased the growth attributes, viz plant height, branches/plant and LAI over no sulphur in both the years. The overall improvement in growth with application of sulphur could be ascribed to its pivotal role in several physiological and biochemical processes which are of vital importance for development of the plants. Besides, sulphur is also involved in the formation of S containing amino acids, vitamins and chlorophyll. Among the sources of sulphur, cosavet recorded marked improvement in growth attributes as compared to elemental S and gypsum. This increase in growth attributes due to cosavet may be due to the fact that cosavet has smaller particle size, thereby having greater surface area which hastens the oxidation of sulphur to sulphate which is available form of sulphur to plants. Thus cosavet might have increased the availability of sulphate to plants during early growth phase when it is required more for proper root growth and nodulation.

Application of farmyard manure @ 5 tonnes/ha increased yield of pigeonpea by 5.95 and 7.11% in 2003 and 2004, respectively over no farmyard manure (Table 1). The corresponding increase in groundnut pod yield was 25.00 and 27.28% respectively (Table 2). However, intercropping had no negative effect on yield of pigeonpea as yield of pigeonpea was at par in both the systems. It might be due to similar values of growth attributes of pigeonpea in both the systems which resulted into almost identical yield levels in both the systems. Gupta and Rai (1999) also reported similar findings in pigeonpea + groundnut intercropping system. Application of sulphur @35 and 70 kg S/ha being at par significantly increased the yield of both pigeonpea and groundnut. The yield increment due to application of 35 and 70 kg S/ha over the sources was 14.11 and 15.64% in 2003 and 16.11 and 19.02% in 2004, respectively as compared to no sulphur. The corresponding values in groundnut were 38.25 and 38.79% in 2003 and 41.94 and 44.68% in 2004 respectively (Table 2). This is in conformity with the results reported by Maity and Giri (2003). Improvement in yield might have resulted from favourable influence of S on the growth characters, viz plant height, number of branch/plant and LAI and efficient and greater partitioning of metabolites and adequate translocation of nutrients to developing reproductive structures. Among the sources of sulphur, cosavet markedly improved the grain/pod yield of pigeonpea and groundnut as compared to the elemental S and gypsum.

Improvement in pigeonpea equivalent yield due to

Table 1 Effect of farmyard manure, source and level of sulphur on growth attributes (at harvest), yield and protein content in pigeonpea and pigeonpea equivalent yield

Treatment	Plant height (cm)		Branches/plant (Nos)		LAI		Protein content (%)		Grain yield (tones/ha)		Pigeonpea equivalent yield (tones/ha)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Farmyard manure (tonnes/ha)												
0	152.8	148.7	16.2	15.9	2.04	1.91	19.63	19.4	1.46	1.37	1.51	1.40
5	159.1	154.9	16.8	16.5	2.08	1.95	19.93	19.7	1.54	1.47	1.74	1.66
SEm±	1.1	0.9	0.1	0.1	0.01	0.01	0.11	0.11	0.02	0.00	0.01	0.01
CD (*P*=0.0 5)	3.2	2.8	0.3	0.2	0.03	0.03	NS	NS	0.07	0.02	0.03	0.03
Cropping system												
Sole pigeon pea	157.1	153.0	16.5	16.2	2.06	1.93	19.87	19.6	1.50	1.43	1.50	1.43
Pigeonpea + groundnut intercropping system	154.8	150.6	16.4	16.1	2.06	1.93	19.68	19.5	1.49	1.41	1.75	1.63
SEm±	1.1	0.9	0.1	0.07	0.01	0.01	0.11	0.11	0.02	0.00	0.01	0.01
CD (*P*=0.0 5)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.03	0.03
Source and rate of S (kg/ha												
0	146.4	139.8	15.4	15.0	1.95	1.83	18.0	17.8	1.33	1.23	1.50	1.39
Elemental sulphur @ 35	154.5	149.6	16.2	16.0	2.03	1.91	19.8	19.6	1.44	1.32	1.63	1.53
Elemental sulphur @ 70	156.5	151.6	16.5	16.2	2.05	1.92	19.9	19.7	1.46	1.35	1.72	1.59
Gypsum @ 35	155.4	150.5	16.3	16.1	2.08	1.93	20.0	19.8	1.46	1.38	1.66	1.57
Gypsum @ 70	157.5	151.6	16.6	16.2	2.09	1.94	20.1	19.9	1.48	1.41	1.81	1.64
Cosavet @ 35	160.5	159.8	17.1	16.9	2.12	2.00	20.2	20.0	1.66	1.60	1.88	1.76
Cosavet @ 70	160.7	159.8	17.1	16.9	2.12	2.00	20.4	20.1	1.67	1.64	1.95	1.80
SEm±	2.9	3.1	0.3	0.3	0.03	0.02	0.35	0.40	0.03	0.03	0.03	0.03
CD (*P*=0.0 5)	8.3	8.9	0.7	0.9	0.08	0.08	1.0	1.0	0.09	0.08	0.08	0.08

Table 2 Effect of farmyard manure, source and rate of sulphur on growth attributes (at harvest), oil content and yield of groundnut

Treatment	Plant height (cm)		Branches/plant		LAI		Oil content (%)		Pod yield (tonnes/ha)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Farmyard manure (tonnes/ha)										
0	34. 9	34.7	6.8	6.6	2.11	2.06	44.1	42.5	0.43	0.39
5	38.5	38.3	7.4	7.2	2.20	2.14	44.3	42.7	0.54	0.50
SEm±	0.3	0.4	0.07	0.07	0.02	0.02	0.2	0.2	0.00	0.00
CD (*P*=0.0 5)	0.9	1.2	0.2	0.2	0.07	0.07	NS	NS	0.006	0.006
Source and rate of S (kg/ha)										
0	32.1	31.9	5.9	5.7	1.90	1.84	40.2	40.0	0.36	0.32
Elemental sulphur @ 35	35.1	34.9	7.0	6.8	2.12	2.04	43.3	42.1	0.46	0.43
Elemental sulphur @ 70	37.0	36.8	7.1	6.8	2.13	2.10	44.1	42.9	0.47	0.43
Gypsum @ 35	36.1	35.9	7.0	6.8	2.13	2.05	43.3	42.1	0.46	0.43
Gypsum @ 70	37.2	36.9	7.1	6.8	2.14	2.11	46.0	43.3	0.47	0.43
Cosavet @ 35	39.2	39.1	7.9	7.7	2.33	2.25	46.1	43.8	0.58	0.54
Cosavet @ 70	40.1	39.9	7.9	7.7	2.34	2.30	46.6	43.9	0.58	0.55
-SEm±	0.8	0.96	0.20	0.2	0.06	0.05	1.2	1.0	0.01	0.01
CD (*P*=0.0 5)	2.4	2.7	0.57	0.5	0.18	0.14	3.4	2.9	0.03	0.03

application of farmyard manure was 14.47% and 16.31% in 2003 and 2004, respectively (Table 1). This could be attributed to the fact that farm yard manure significantly increased the yield of both pigeonpea and groundnut, which finally led to significant increase in pigeonpea equivalent yield. Intercropping of pigeonpea with groundnut recorded significantly higher pigeonpea equivalent yield over sole pigeonpea (16.55% in 2003 and 13.88% in 2004). This was due to similar yield of intercropped pigeonpea to that of its sole stand, and an extra yield of groundnut as a bonus in intercropping system. Application of sulphur at 35 and 70 kg S/ha enhanced the pigeonpea equivalent yield by 14.88% and 21.77% in 2003 and 16.54% and 20.62% in 2004, respectively over no sulphur. Among the sources, cosavet recorded markedly higher pigeonpea equivalent yield over elemental S and gypsum.

Application of farmyard manure and intercropping had no marked effect on protein content (pigeonpea) and oil content (groundnut) in both the years of study (Tables 1, 2). Application of sulphur at 35 and 70 kg S/ha, being at par, recorded significantly higher protein content in pigeonpea as compared to no sulphur. The increase in crude protein with S might be attributed to the fact that S is one of the constituents of S containing amino acids like cysteine, cystine, methionine etc (Singh 2004). However, significant increase in oil content in groundnut was recorded with elemental sulphur @ 70 kg S/ha, gypsum@ 70 kg S/ha and cosavet @ 35 and 70 kg S/ha. It was observed that different sources of sulphur failed to show any marked variation in protein content in both the years of study (Table 1).

Application of farmyard manure @ 5 tonnes/ha recorded higher total N, P and S uptake (186.65, 17.90 and 20.10 kg/ha respectively) as compared to no farmyard manure in both the years of study (Table 3). This could be attributed to marked increase in grain/pod and stalk/haulm yields coupled with marginal increase in N, P and S contents in pigeonpea and groundnut due to application of farmyard manure. Similarly, intercropping of pigeonpea with groundnut was having improved N, P and S uptake (184.35, 18.85 and 21.25 kg/ha respectively) over sole pigeonpea. The almost similar yields and nutrient content of pigeonpea in intercropping and

Table 3 Effect of farmyard manure, source and level of sulphur on total NPS uptake in cropping system (mean data of 2 years)

Treatment	Nutrient uptake (kg/ha)		
	N	P	S
Farmyard manure (tonnes/ha)			
0	169.75	16.10	18.70
5	186.65	17.90	20.10
SEm±	1.35	0.11	0.13
CD (*P*=0.0 5)	4.10	0.35	0.35
Cropping system			
Sole pigeonpea	172.25	15.15	17.60
Pigeonpea +groundnut	184.35	18.85	21.25
SEm±	1.30	0.10	0.10
CD (*P*=0.0 5)	4.10	0.35	0.35
Source and levels of S (kg/ha)			
0	133.90	13.20	15.20
Elemental sulphur @ 35	174.30	16.25	18.95
Elemental sulphur @ 70	179.55	17.00	19.60
Gypsum @ 35	178.85	17.00	19.15
Gypsum @ 70	184.00	17.30	19.80
Cosavet @ 35	194.50	18.75	21.05
Cosavet @ 70	202.30	19.50	22.10
SEm ±	3.65	0.25	0.35
CD (*P*=0.0 5)	10.55	0.85	1.20

sole stand, and an additional nutrient removal by groundnut led to higher nutrient uptake in intercropping system. Application of 35 kg S/ha being at par with its higher dose of 70 kg S/ha through various sources, significantly increased N (36.33%), P (31.31%) and S (29.71%) uptake as compared to no sulphur. Since, the uptake of nutrient is a function of dry matter (grain + non-grain) and nutrient content, the increased grain/pod and stalk/haulm yields together with higher N, P and S-content by S application resulted into higher uptake of these nutrients. Application of S through cosavet significantly enhanced total N, P and S uptake as compared to gypsum and elemental sulphur.

Thus, it can be concluded that for getting higher productivity from per unit of land intercropping of pigeonpea with groundnut should be practised by applying farmyard manure @ 5 tonnes/ha along with application of 35 kg S/ha through cosavet.

SUMMARY

A field experiment was conducted during the rainy (*kharif*) seasons of 2003 and 2004 at Indian Agricultural Research Institute, New Delhi to study the response of pigeonpea (*Cajanus cajan* L. Mill sp.) + groundnut (*Arachis hypogaea* L.) intercropping system to sources and levels of sulphur along with farmyard manure. Application of farmyard manure significantly increased the growth attributes, yield (1.54 and 1.47 tonnes/ha in pigeonpea and 0.54 and 0.50 tonnes/ha in groundnut in 2003 and 2004 respectively), pigeonpea equivalent yield (1.74 and 1.66 tonnes/ha in 2003 and 2004 respectively), and total nutrient uptake (186.65, 17.90 and 20.10 kg/ha of N, P, and S respectively). Intercropping of pigeonpea with groundnut had no significant adverse effect on growth attributes, and yield of pigeonpea; however pigeonpea equivalent yield and total nutrient uptake were higher under intercropping system than sole pigeonpea. Application of sulphur @ 35 and 70 kg S/ha, being at par, significantly improved the growth attributes and yield of both the component crops, pigeonpea equivalent yield, protein and oil content as compared to no sulphur. Among the sources of S, cosavet proved superior to increase the growth attributes, yield, pigeonpea equivalent yield and total nutrient uptake over elemental sulphur and gypsum.

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