

Original Research Article

Effect of Intercropping Systems with Different Levels of Sulphur on Protein content, Nitrogen uptake and Yield Attributes of Mungbean

ABSTRACT

Mungbean is the most important crop in arid Rajasthan. Improving productivity by improving soil fertility is essential for farmers' economic viability. The effect of sulphur graded doses on yield attributes of mungbean grown as (mungbean + sesame) intercropping was studied in the field. For these four sulphur levels, viz., 0, 15, 30, and 45 kg sulphur ha⁻¹ in five intercropping systems, viz., sole mungbean and sole sesame, mungbean + sesame in 2:1, 3:1, and 4:1. Harvest index, MEY, LER, N concentration, total nitrogen uptake, protein content, seed, and straw yield were all significantly higher than other crop yield attributes. Mungbean protein content, nitrogen content, uptake, and yield were highest when mungbean and sesame (4:1) was used, with levels reaching 45 kg S/ha. In case of sulphur, the maximum quality parameters were observed when sulphur was applied to 45 kg/ha of mungbean.

KEYWORDS:MEY, LER, Protein content, Nitrogen uptake, Harvest index and Mungbean Yield

1. INTRODUCTION

Mungbean scientifically known as *Vigna radiate* (L.) Wilczek is a plant species in the legume family and commonly called as mungbean, moong in India. India is its primary origin and is mainly cultivated in East Asia, Southeast Asia and the Indian subcontinent. It is the third important pulse crop of India grown in nearly sixteen per cent of the total pulse area of the country. It contains protein rich seed with 20-25% protein and sometimes plants are cut and ploughed into the soil to enrich soil nitrogen[1]. The important mungbean producing states in the country are Rajasthan, Maharashtra, Andhra Pradesh, Madhya Pradesh and Bihar. Andhra Pradesh ranks 6th in mungbean production with 0.83 lakh tonnes under an area of 1.13 lakh ha with productivity of 735 kg/ha according to third advance estimates of 2020-21 (DES, AP). It has special importance in intensive crop production system of the country for its short growing period. They are Andhra Pradesh, Maharashtra, Orissa, Madhya Pradesh as well as, Uttar Pradesh also. It contains 24.7% protein, 0.6% fat, 60% carbohydrate, 0.9% fiber and 3.7% ash. It can also be used as a green manure crop in certain areas[16,18]. Crops, as well as every other

living organisms, require certain amounts of nutrients for normal and healthy. Each nutrient plays a different, regarding crop growth and development growth [14]. Green gram generally grown as a rain fed crop during Kharifseason[10]. Intercropping is practiced because of some of the established and anticipated advantages such as greater yield stability and land-use efficiency, increased competitive ability towards weeds and extraction of resources from different depths of soil[18,26]. The main advantage of intercropping is that the component crops are able to use resources differently and make better use of resources than when grown separately. The success of any intercropping system depends mainly on selection of component crops. The component crops should invariably have different maturity periods, growth rhythms and rooting pattern. This approach will also optimize the yield recovery of such system. The adjustment of planting geometry of mungbean is another possibility of increasing the planting density of relatively early-maturing intercrop components to harvest dependable yield in events of early withdrawal of monsoon rains. Paired-row planting technique is often exploited in intercropping trials to establish relatively more planting density of the intercrop components and/or provide a different planting geometry to change the inter-specific and intra-specific competition of the two crops in contrast to intercropping in uniform row widths of the main crop. The system of intercropping not only improves the yield and net returns but also reduces the risk of complete crop failure as compared to the sole cropping system [32]. The yield advantage obtained through intercropping is owing to efficient utilization of available growth resources like water [2], nutrients [29] and sunlight. Intercropping, besides utilizing growth resources efficiently, suppressed weeds [36] and disease-pest incidences [30], resulting in an overall improvement in crop production over sole cropping with an efficient land-use system. Research work done in different parts of the country indicates that application of sulphur to all crops and oilseeds and pulses in particular is highly profitable and seems essential for boosting the crop production. High crop yields can be maintained by judicious application of manures and fertilizers. Crop rotation with cereals and legumes, as well as organic manure addition and optimal N P K application to the soil system, are crucial for maize-chickpea crop yield and soil health [9,10]. Sulphur plays an inevitable and imperative role in formation of amino acids, viz. methionine, cystine and cysteine. It is also associated with synthesis of vitamins, metabolism of carbohydrates, proteins and fats. Sulphur deficiency results in poor flowering, fruiting, cupping of leaves, reddening of stems, petioles and stunted growth. Keeping these considerations in view, the present experiments was carried out

on growth, yield and quality parameters as influenced by different sulphur levels of (Mungbean + Sesame) intercropping system.

Comment [A1]: Very long Introduction! Please give an essential information!

2. MATERIALS AND METHODS

Field experiment was conducted during *kharif* season of 2017-18 at Agriculture Farm of O.P.J.S. University, Churu district of Rajasthan India. Experiment comprising of twenty treatment combinations including five inter-cropping systems (Cropping history Table 1) viz., sole mungbean (*var.*-RMG-268) and sole sesame (*var.*-RT-125), mungbean + sesame in 2:1, 3:1 and 4:1 row magnitude relation with 4 sulphur levels viz., 0, 15, 30 and 45 kg sulphur ha⁻¹. Experiment conducted in RBD with three replications. The soil samples were collected during the crop season prior to sowing of the both mungbean and sesame crop. The collected soil samples were ground, passed through 2 mm sieve and kept in air tight plastic containers. Soil was used for analysis of different physico-chemical parameters. The turbid metric method outlined by [25] used for determination of sulphur in soil. Available nitrogen was estimated by Kjeldhal's method [21]. Phosphorus was estimated by ammonium vando-molybdate yellow colour method as described by Chapman and Pratt (1961). Potassium was estimated by flame photometer [21]. The chemical character like pH [22], EC [33], Soil organic carbon [37]. The soil of experimental plots is loamy sand in texture, alkaline in soil reaction (pH 8.2), low in organic carbon (0.16%), available nitrogen (132.5 kg ha⁻¹), available phosphorus (16.0 kg P₂O₅ ha⁻¹), on the available SO₄ -2-S (8.16 mg/kg) and available potassium (142.2kg K₂O ha⁻¹) content. The mungbean equivalent yield was calculated by converting the grain yield of sesame into mungbean yield on the basis of existing market price. Crop was raised as per standard method and practices. Observations on growth and dry matter yield of mungbean and sesame were recorded. The mungbean equivalent yield was calculated by changing the seed yield of sesame into mungbean yield on the premise of existing market costs of the crops. The collected different parameter of the mungbean crop was analysed. Data were subjected to an analysis of variance. The mean values were grouped for comparisons and the least significant differences among them were calculated at $P < 0.05$ confidence level using ANNOVA statistics (Gomez and Gomez, 1983).

Table 1 Cropping history of the experimental field

Years	<i>Kharif</i> Season	<i>Rabi</i> Season
2014-15	Pearl millet	Mustard
2015-16	Clusterbean	Fallow

2016-17	Guar	Cumin
2017-18	Mungbean+sesame*	Mustard

3. RESULTS AND DISCUSSION

3.1. Yield and yield attributes

3.1.1. Seed, Straw yield and Harvest index

It is evident from data (Table 2) that among different intercropping systems, the sole mungbean gave significantly highest seed yield (1207 kg/ha) as compared to all intercropping in different row ratios. The increase in seed yield under sole mungbean was 70.48, 43.35 and 24.30 per cent as compared to 2:1, 3:1 and 4:1 row ratios, respectively. Among intercropping, 4:1 row ratio also recorded significantly higher seed yield over 2:1 and 3:1 row ratios to the tune of 37.15 and 15.32 per cent, respectively. Application of increasing levels of sulphur upto 30 kg/ha produced significantly higher seed yield (986 kg/ha) which was 23.40 and 9.80 per cent higher over control and 15 kg S/ha, respectively. The sole mungbean gave significantly highest straw yield (2457 kg/ha). The increase in straw yield under sole mungbean was 64.12, 42.76 and 26.65 per cent over 2:1, 3:1 and 4:1 row ratios, respectively. The intercropping in 4:1 row ratio also recorded significantly higher straw yield over 2:1 and 3:1 row ratios which was higher by 29.60, 12.72 per cent, respectively. Application of graded levels of sulphur upto 30 kg/ha significantly increased straw yield of mungbean. The increase in straw yield was 15.93 and 6.86 per cent higher as compared to control and 15 kg S/ha, respectively. Harvest index of mungbean could not influence significantly with different intercropping systems and sulphur. The seed and straw yields being the function of growth and yield attributes, reduced with the reduction in these parameters under influence of intercropping. The best productivity in terms of mungbean equivalent yield (1.21 t/ha) was obtained under sole mungbean followed by mungbean + sesame in 4:1. Higher growth and yield of mungbean and sesame was recorded with increase in levels up to 45 kg S/ha [16]. These results are in close conformity with those of [35] who reported significant reduction in yield of chickpea when grown in association with mustard. [19] also reported reduction in seed yield of pigeonpea, soybean, mungbean, urad bean and rajmah in intercropping with pigeonpea as compared to their sole stands. [11] Also reported seed and straw yield of fenugreek crop was found, the maximum 300 gm/pot of vermicompost and followed by FYM and Rhizobium. [24] Also reported application of 90 kg K₂O ha⁻¹ and 40 kg S ha⁻¹ significantly increased the yield of berseem crop. Application of poultry draige @ 3 ton/ha

increased the number of primary branches per plant, plant height and yield with maximum formation of nodule on plants of green gram [28].

Table 2 Effect of intercropping systems and sulphur on yields and harvest index of mungbean

Treatments	Seed yield (Kg/ha)	Straw yield (Kg/ha)	Harvest index (%)
A. Intercropping systems			
Mungbean sole	1199	2578	31.73
Mungbean + sesame (2:1)	700	1565	30.88
Mungbean + sesame (3:1)	834	1801	31.54
Mungbean + sesame (4:1)	963	2032	32.11
SEm +	22	49	0.79
CD (P=0.05)	64	142	NS
B. Sulphur (S Kg /ha)			
0	791	1786	30.60
15	890	1939	31.42
30	978	2074	32.01
45	1038	2177	32.23
SEm +	22	49	0.79
CD (P=0.05)	64	142	NS

NS=Non significant

3.2.Mungbean equivalent yield and land equivalent ratio

A perusal of data (Table 3) indicated that among the different intercropping systems, the sole planting of mungbean, being at par with 4:1 row ratio, recorded significantly highest mungbean equivalent yield which was 73.67, 19.15 and 12.49 per cent higher as compared to sole sesame, 2:1 and 3:1 row ratios, respectively. The 4:1 row ratio also produced significantly higher equivalent yield by 66.47, 14.21 and 7.83 per cent as compared to sole sesame, 2:1 and

3:1 row ratios, respectively. Further reference to data showed significant increase in mungbean equivalent yield to the application of increasing levels of sulphur upto 45 kg/ha. Application of 45 kg S/ha represented an increase of 32.65, 16.73 and 5.95 per cent over control, 15 and 30 kg S/ha, respectively. Among the different intercropping systems, 4:1 row ratio recorded significantly highest land equivalent ratio as compared to all other intercropping systems (Table 3) further indicated that increasing levels of sulphur upto 45 kg/ha recorded significantly highest land equivalent ratio as compared to control, 15 and 30 kg S/ha by 16.84, 8.82 and 3.74 per cent, respectively. The agricultural production in sufficient quantities in a sustainable way is the today's greatest challenge. The sustainable way here means without deteriorating the soil health. In current scenario, the cultivation of high yields varieties with synthetic fertilizer and agrochemicals helping to produce required food demand of growing population but in discriminate and imbalanced use of agrochemicals imparting negative effect on soil productivity, environmental health and food quality [13]. A significant effect of different intercropping systems on mungbean equivalent yield was observed (Table 3). The sole planting of mungbean remaining at par with 4:1 row ratio gave significantly highest mungbean equivalent yield (MEY) as compared to sole sesame, 2:1 and 3:1 row ratios. The higher equivalent yield of mungbean under sole planting might be due to higher production per unit area of mungbean along with higher prices of produce. But the highest land equivalent ratio (LER) was found under 4:1 row ratio as compared to 2:1, 3:1 row ratios and sole crops. [4] while studying the groundnut + sesame intercropping system at Akola have also reported that the maximum groundnut equivalent yield was obtained under the pure stand of groundnut. The higher LER under intercropping might be due to biological efficiency of system in terms of yield per unit area.

Table 3 Effect of intercropping systems and sulphur on mungbean equivalent yield (MEY) and land equivalent ratio (LER)

Treatments	MEY (Kg/ha)	LER
A. Intercropping systems		
Mungbean sole	1207	1.01
Sesame sole	695	1.01
Mungbean + sesame (2:1)	1013	1.06

Mungbean + sesame (3:1)	1073	1.02
Mungbean + sesame (4:1)	1157	1.02
SEm +	21	0.02
CD (P=0.05)	60	0.05
B. Sulphur (S Kg /ha)		
0	873	0.94
15	992	1.01
30	1093	1.06
45	1158	1.11
SEm +	19	0.01
CD (P=0.05)	54	0.04

3.3. Nutrient concentration, uptake and quality parameters of mungbean

3.3.1. Nitrogen concentration in seed and straw

It is evident from data (Table 4) that sole mungbean, being at par with 4:1 row ratio, gave significantly highest nitrogen concentration in seed as compared to 2:1 and 3:1 row ratios. The increase in nitrogen concentration under sole mungbean was 10.17 and 5.19 per cent over 2:1 and 3:1 row ratios, respectively. The 4:1 row ratio, being at par with 3:1 row ratio also increased the nitrogen concentration by 5.29 per cent over 2:1 row ratio. A further reference to data showed that increasing sulphur levels upto 30 kg/ha significantly increased the nitrogen concentration in seed of mungbean, indicating an increase of 12.22 and 5.66 per cent over control and 15 kg S/ha, respectively. The different intercropping systems did not affect the nitrogen concentration in straw of mungbean significantly. Application of sulphur upto 30 kg/ha significantly increased nitrogen concentration in straw of mungbean. The increase in nitrogen concentration due to 30 kg S/ha was 12.63 and 5.94 per cent over control and 15 kg, respectively. Application of 90 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} significantly increased the nutrient content and uptake of green gram [6].

3.3.2. Total uptake of nitrogen

A perusal of data (Table 4) indicated that all the intercropping systems were significantly different from each other so far as total nitrogen uptake by mungbean is concerned. The sole

mungbean gave significantly highest total nitrogen uptake which was 81.05, 48.44 and 29.55 per cent more as compared to 2:1, 3:1 and 4:1 row ratios, respectively. The total nitrogen uptake by mungbean under 4:1 row ratio was 39.75 and 14.57 per cent higher as compared to 2:1 and 3:1 row ratios, respectively. A critical examination of data showed that increasing sulphur levels significantly increased the total uptake of nitrogen by mungbean. Application of 45 kg S/ha significantly enhanced the total nitrogen uptake indicating an increase of 49.56, 26.66 and 10.84 per cent over control, 15 and 30 kg S/ha, respectively. A significant increase in nitrogen concentration in seed and sulphur concentration in seed and straw and protein content in seed of sole mungbean recorded as compared to different intercropping systems. The higher total nitrogen and sulphur uptake under sole crops as compared to their intercropping systems was primarily due to increased seed yield under sole mungbean as compared to yield obtained under intercropping [18,28]. The recorded significantly higher uptake of total nitrogen by sole clusterbean and sesame [27].

3.4. Protein content

The quality parameters such as protein content were significantly influenced by different intercropping systems (Table 4). The increase in protein content under sole mungbean was 10.17, 5.19 and 4.62 per cent as compared to 2:1, 3:1 and 4:1 row ratios, respectively. The 4:1 and 3:1 row ratios, being at par with each other, also increased the protein content in seed significantly by 5.30 and 4.73 per cent over 2:1 row ratio, respectively. Application of increasing levels of sulphur up to 45 kg/ha significantly increased the protein content in seed of mungbean. The protein content in seed with 45 kg S/ha registered an increase of 17.24, 10.40 and 4.49 per cent as compared to control, 15 and 30 kg S/ha, respectively. Application of 90 kg K₂O ha⁻¹ and 40 kg S ha⁻¹ significantly increased the protein content and sulphur uptake of berseem [23,24]. Rhizobium 30g/pot produced significantly higher protein content and fenugreek yield than other Rhizobium treatment and control [12]. Application of 90 kg P₂O₅ ha⁻¹ and 40 kg S ha⁻¹ significantly increased the protein content and yield of green gram [5].

Table 4 Effect of intercropping systems and sulphur on nitrogen concentration in seed and straw and total nitrogen uptake and protein content in seed of mungbean

Treatments	Nitrogen concentration (%)	Total nitrogen uptake (Kg/ha)	Protein content (%)
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	Seed		Straw	
A. Intercropping systems				
Mungbean sole	3.868	1.200	77.63	24.17
Mungbean + sesame (2:1)	3.503	1.143	42.59	21.89
Mungbean + sesame (3:1)	3.673	1.162	52.08	22.95
Mungbean + sesame (4:1)	3.693	1.175	59.74	23.08
SEm +	0.063	0.023	1.70	0.37
CD (P=0.05)	0.182	0.065	4.90	1.06
B. Sulphur (S Kg /ha)				
0	3.375	1.065	45.95	21.09
15	3.590	1.137	54.46	22.44
30	3.798	1.209	62.36	23.73
45	3.973	1.269	69.27	24.83
SEm +	0.063	0.023	1.70	0.37
CD (P=0.05)	0.182	0.065	4.90	1.06

NS=Non significant

3.5.Sulphur concentration in seed and straw

A reference to data in table 5 indicated that among the different intercropping systems, the sole mungbean, being at par with 4:1 and 3:1 row ratios, recorded significantly highest sulphur concentration in seed of mungbean which was 9.77 per cent higher over 2:1 row ratio. The 4:1 and 3:1 row ratios being at par with each other also increased sulphur concentration in seed by 4.56 and 3.58 per cent as compared to 2:1 row ratio, respectively. The sulphur concentration increased significantly with increasing levels of sulphur. Application of 45 kg S/ha significantly increased the sulphur concentration in seed, indicating an increase of 31.87, 15.01 and 6.82 per cent over control, 15 and 30 kg S/ha, respectively. Among the different intercropping systems, sole mungbean recorded significantly highest sulphur concentration in straw of mungbean. The sole mungbean recorded 9.65, 8.16 and 7.43 per cent higher sulphur concentration in straw as compared to 2:1, 3:1 and 4:1 row ratios, respectively. The 2:1, 3:1 and

4:1 row ratios were being at par with each other in sulphur concentration in straw. Data (Table 5) further showed that increasing levels of sulphur upto 30 kg/ha significantly improved the sulphur concentration in straw. Application of 30 kg S/ha enhanced the sulphur concentration in straw by 24.41 and 8.96 per cent over control and 15 kg S/ha, respectively. Similarly [23,24] reported that application of 90 kg K₂O ha⁻¹ and 40 kg S ha⁻¹ significantly increased the sulphur content and sulphur uptake of berseem.

3.5.1. Total sulphur uptake

Data presented in table 5 indicated that significantly highest total sulphur uptake by mungbean observed under sole mungbean as compared to all other intercropping systems. The sole mungbean gave 83.94, 51.61 and 33.00 per cent higher total sulphur uptake as compared to 2:1, 3:1 and 4:1 row ratios, respectively. The intercropping in 4:1 row ratio also recorded significantly higher sulphur uptake registering an increase of 38.30 and 13.99 per cent over 2:1 and 3:1 row ratios, respectively. A study of data in table 5 indicated that application of sulphur in increasing levels upto 45 kg/ha significantly increased the total sulphur uptake by mungbean. The application of 45 kg S/ha registered an increase of 67.28, 32.67 and 12.46 per cent over control, 15 and 30 kg S/ha, respectively. Reported the 90 kg P₂O₅ ha⁻¹ and 40 kg S ha⁻¹ significantly increased the sulphur uptake of green gram crop [5]. Application of graded levels of sulphur from 0 to 45 kg S/ha significantly influenced the seed yield, total uptake of nitrogen and sulphur, protein content in seed of mungbean and oil content in seed of sesame over control. Similarly results [31] observed significantly higher uptake of total nitrogen and sulphur by sole mungbean and sesame intercropping. The maximum values of sulphur uptake but sesame under rainfed condition with application of 60 kg P₂O₅+45kg sulphur ha⁻¹[34].

Table 5 Effect of intercropping systems and sulphur on sulphur concentration in seed and straw and total sulphur uptake of mungbean

Treatments	Sulphur concentration (%)		Total sulphur uptake (Kg/ha)
	Seed	Straw	
A. Intercropping systems			
Mungbean sole	2.315	0.936	7.44
Mungbean + sesame (2:1)	2.733	1.029	3.98

Mungbean + sesame (3:1)	2.663	1.012	4.86
Mungbean + sesame (4:1)	2.643	1.006	5.54
SEm +	0.061	0.020	0.19
CD (P=0.05)	0.176	0.057	0.54
B. Sulphur (S Kg /ha)			
0	1.963	0.863	3.94
15	2.535	0.963	5.05
30	2.843	1.052	6.02
45	3.013	1.105	6.80
SEm +	0.061	0.020	0.19
CD (P=0.05)	0.176	0.057	0.54

4. CONCLUSIONS

Developing countries like India needs 377 million tonne of food grain production by the 2050 to feed the growing population. Hence, it needs to enhance the productivity of crops mainly in resource scare areas. In this experiment different inter-cropping row was evaluated with graded application of S. Results showed that mungbean- sesame inter-cropping at 4:1 was more enhanced the yield attributes in mungbean; whereas, mungbean-sesame 2:1 was more profitable in sesame. Application of S @ 45 kg/ha improved the quality, nutrient content, uptake and yield attributes in both the crops. Such studies are very much important to enhance the crop yield potential mostly in arid region of Rajasthan.

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