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Graded application of sulphur mediated yield attributes of sesame and mungbean grown in sandy soil

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Abstract
Sesame and mungbean both are the important crop of arid Rajasthan. To enhance the productivity by mediating the soil fertility is a necessity to sustain the economic viability of the farmers. A field was carried to monitor the effect of sulphur graded doses on yield attributes of mungbean and sesame growing as inter-cropping. For this four sulphur levels *viz*., 0, 15, 30 and 45 kg sulphur ha^{-1} in five inter-cropping systems *viz*., sole mungbean and sole sesame, mungbean + sesame in 2:1, 3:1 and 4:1. Yield attributes of mungbean like number of pods per plant, number of seeds per pod and test weight whereas attributes of sesame *viz.,* number of capsules per plant, number of seeds per capsule & test weight, growth, yield of crops gave considerably higher various attributes crop yield. The growth and yield attributes of mungbean was maximum recorded under mungbean + sesame (4:1), whereas in sesame it was mungbean + sesame (2:1). In both the crop growth and yield parameters were recorded maximum with increasing levels up to 45 kg S/ha. This study showing the efficacy of inter-cropping and application of S during mungbean-sesame cropping pattern.

Keywords: Crop growth parameters, intercropping, mungbean, sesame, yield attributes

Introduction
Pulses are a major source of protein, especially for vegetarians, accounting for roughly 14% of total protein in the normal Indian diet. Pulse production and productivity are far below what is required to meet even the bare minimum of per capita consumption. Rajasthan state-wise normal area, production and yield of Mungbean-Sesamum (Average of 2015-16 to 2019-20). Mungbean is grown on Area 1901.84 ('000 Hect.), Production 934.06 ('000 Tonnes), Yield 491 (Kgs./Hect.) in India and adds Sesamum crop Area 281.51 ('000 Hect.), Production 90.37 ('000 Tonnes) and Yield 321 (Kgs./Hect.) to pulse output (Anonymous, 2020-21) [2]. Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Rajasthan, and Bihar are the most prominent mungbean-growing states. In this sense, sesame is the most important oil seed crop in Rajasthan.
The supply of pulses per capita has decreased from 74.9 g in 1959 to 33 g in 2008, compared to the ICMR's minimal need of 70 g per capita/day, which could lead to malnutrition among the rising population. Pulse crop productivity is currently declining due to competition from high-yielding crops such as coarse cereals and millets. India facing the scarcity of pulses and oilseeds, our country has been compelled to import pulses and edible oil. Under these conditions, intercropping pulses and oilseeds could be a viable option for increasing per unit area productivity of those crops through temporal intensification, which could be similar to other higher-producing crops [Dharwe *et al.*, 2018, Malvi *et al.*, 2021] [6].
Mungbean and sesame are important food crops that have become a key element of the protein intake in Rajasthan's semi-arid areas [Doutaniya *et al.*, 2021] [10]. Crop productivity is declining due to a drop in soil fertility, particularly NPK and micronutrients, and Sulphur plays an important role in production [Dharwe *et al.*, 2018, Dotaniya *et al.*, 2020b] [6, 9]. Farm yard manure, bovine dung manure, poultry manure, pig manure, compost, vermicompost, city waste compost, municipal solid waste compost, green manure, and other organic nutrients are used in agriculture [Dotaniya *et al.*, 2020] [8].
Sulphur, like nitrogen and phosphorus, is a necessary element for plant growth. It aids in the production of plant protein. Sulphur insufficiency has been documented in more than 70 nations around the world, including India [Dharwe *et al.*, 2019, Malvi *et al.*, 2019] [5, 15].

Sulphur is also required for the synthesis of vitamins (biotin and thiamine), Sulphur-containing amino acids, and legume nodulation. Sulphur application resulted in the highest grain and straw yield of green gramme [Dharwe *et al.*, 2018, Mohbe *et al.*, 2019] [6, 5]. Pulse crops require more sulphur than cereals, particularly in low S soils in Rajasthan's semi-arid region [Doutaniya *et al.*, 2021] [10]. Keeping these points under consideration an investigation was undertaken to assess inter-cropping ratios with sulphur levels on yield and quality of mungbean and sesame crop under sandy soils.

Materials and methods

Experimental soil properties

The soil samples were collected during the crop season prior to sowing of the both mungbean and sesamum 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 Singh *et al*. (2005) [26] used for determination of sulphur in soil. Available nitrogen was estimated by Kjeldhal's method (Jackson, 1973). Phosphorus was estimated by ammonium vando-molybdate yellow colour method as described by Chapman and Pratt (1961). Potassium was estimated by flame photometer (Jackson, 1973). The chemical character like pH (Kumar *et al.*, 2018) [14], EC (Richards, 1954) [23], Soil organic carbon (Walkley and Black method, 1934) [28]. 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 P_2O_5 ha^{-1}), on the available SO_4 -2-S (8.16 mg/kg) and available potassium (142.2kg K_2O ha^{-1}) content.

Treatment details

A 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 *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.

Experimental Details

Both the crops were raised as per the standard agronomic crop management practices. The experimental crops were planted in lines 10 x10 cm insole crops and 10 x 30 cm in intercrops. Intercropping, third, fourth and fifth row of mungbean was replaced by one row of sesame in 2:1, 3:1 and 4:1 row proportion. A common recommended dose of nitrogen and phosphorus (20 kg N and 40 kg P_2O_5 /ha) was applied to all the plots through urea and di-ammonium phosphate, respectively, as basal at the time of sowing and sulphur through gypsum ($CaSO_4.2H_2O$) was incorporated in the soil before sowing as per treatments. 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.

Table 1 Cropping history of the experimental field

Years	*Kharif* Season	*Rabi* Season
2014-15	Pearl millet	Mustard
2015-16	Clusterbean	Fallow
2016-17	Guar	Cumin
2017-18	Mungbean+sesame*	Mustard

*Experimental crop

Statistical analysis

The experiment was conducted in Randomized Block Design (RBD) with three replications. The collected different growth and yield parameters of both the crops were 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) [11].

Results and Discussion

Growth attributes of Mungbean and Sesame

The collected data during the conducted experiment was analysed and found that sole planting of mungbean and sesame gave considerably higher plant stand compared to 3:1 (mungbean and sesame) ratios (Table 2). In mungbean crop, the plant height at 40 DAS and harvest stage was recorded maximum plant height 27.04 and 53.28 cm in the mungbean + sesame (2:1). However, plant height of sesame was recorded highest in 4:1 (mungbean and sesame) at 30 DAS, whereas at 60 DAS and harvest stage showed only in sole mungbean crop (Table 2). Application of sulphur levels increased plant height of mungbean and sesamum with increasing the graded doses. Significant (p=0.05) plant highest plant height was measure, when S applied at the rate of 45 kg/ha in during the crop grown (Table 2). The Mohbe *et al*. (2015) [20] found the significant mungbean height increment due to inter-cropping. Sulphur is an essential plant nutrient and enhanced the uptake pattern of N and K in plant and converts the source to sink and directly enhanced the crop yield (Doutaniya *et al.*, 2021) [10]. Another experiment was showed that plant height was more in 2:1 row magnitude relation as 8.8 and 8.1 per cent at 40 DAS and at harvest over sole crop, respectively (Salame *et al.*, 2020) [24]. The application of accelerating levels of sulphur up to 30 kg/ha considerably recorded the plant height to the extent of 22.6 and 9.7 per cent at 40 DAS and 4.8 and 5.9 per cent at harvest over management and 15 S/ha [Salame *et al.*, 2020] [24]. Some of the researchers were also conducted different experiment in different soil and measured that per cent increase in dry matter accumulation and also enhanced the crop yield [Prajapat *et al.*, 2011] [22].

Yield attributes of mungbean and sesame

The collected data showed that mungbean- sesame sowing was at 4: ratio was reported maximum (15.13) number of pod /plant, after it 3:1 row ratio showed 14.72 (Table 2). Number of seed per pod and test weight was also reported significantly different from other row treatments of both the crops. Maximum number of seed/pod was 9.51 and test weight 30.72 g in mungbean crop was reported. However in sesame crop maximum number of capsules/plant, number of seed/capsule and test weight was 29.31, 42.62 and 2.61g, respectively in mungbean + sesame (2:1) cropping pattern. This increase in plant height and per pod, seed yield might be primarily due to increased competition between plants for sunlight and nutrients and secondly due to shading effect of sesame on

mungbean which compelled the mungbean plants to grow more vertically rather than horizontally for light and ultimately increased the height (Ahlawat *et al.* 2005) [1]. It was probably due to more space and nutrients available for growth and development of sesame, which led to higher photosynthesis owing to greater exposure of sesame plants to sunlight. It might also be due to conducive environment created by main crop (mungbean) as it fixed atmospheric nitrogen and increased its availability in soil. Mohbe *et al.*, (2015) [20] reported that different inter-cropping systems, sole mungbean, being at par with 4:1 and 3:1 row ratios, produced significantly highest number of pods per plant as compared to 2:1 row ratio. Further elaborated that the 4:1 and 3:1 row ratio was also significantly different from 2:1 row ratio in producing the pods per plant. The sole mungbean produced 15.4 per cent more pods per plant compared to 2:1 row ratio. Suggested that the sesame intercrop had significant effect on growth (DMA) and yield attributes (pods per plant and seeds per pod) of mungbean. The 2:1 row ratio significantly reduced these growths and yield attributes of mungbean as compared to sole planting of mungbean (Dharwe *et al.*, 2019) [5].

Application of S in both the crop significantly (*p=0.05*) enhanced the yield attributes (Table 2). Application of S 45 kg/ha improved the yield parameters of mungbean and sesame crop. The highest number of pod/plant, number of seed/pod and test weight were 16.75, 9.40, 31.08g, whereas, in sesame crop it was 31.29, 41.96, 2.52 g, respectively. The test weight of sesame showed non-significant different by application of S during the experiment. Sulphur is an essential plant nutrient for root development of the both the crop. In oilseed crop it is more necessary for the oil content development. It is the essential key element of the many plant enzymes, which are directly involve in enhancing yield and yield attributes (Doutaniya *et al.*, 2021) [10]. Further data indicated that application of graded levels of sulphur upto 30 kg/ha significantly increased the number of seeds per pod which was 43.0 and 13.0 per cent over control and 15 kg S/ha, respectively. Similar results of increasing seed index, seed yield attributes under sole crops were also reported by Sarkar *et al.* (2003) [25] and Kumar and Thakur (2006) [13]. Data further indicated that application of increasing levels of sulphur upto 45 kg/ha significantly increased the number of capsules per plant which were superior over control, 15 and 30 kg S/ha by 33.8, 16.08 and 6.8 per cent, respectively (Dharwe *et al.*, 2019, Salame *et al.*, 2020) [5, 24]. A similar result was also reported by the different researchers in different crops (Sarkar *et al.* 2003; Kumar and Thakur, 2006) [25, 13].

Table 2: Effect of Intercropping Systems with Different Sulphur Levels on Growth and Yield Attributes of Mungbean and Sesame

Treatments details	Mungbean (*Vigna radiata* L.)					Sesame (*Sesamum indicum* L.)					
	Plant Height(cm0		Yield Attributes			Plant Height(cm)			Yield Attributes		
	40 DAS	At Harvest	Number of pods per plant	Number of seeds per pod	Test weight (g)	30 DAS	60 DAS	At Harvest	Number of capsules per plant	Number of seeds per capsule	Test weight (g)
Intercropping systems											
Mungbean sole	24.83	49.26	14.01	9.62	31.14	20.92	105.53	110.43	24.13	40.75	2.385
Mungbean + sesame (2:1)	27.04	53.28	13.11	8.93	30.29	21.99	103.53	106.89	29.31	42.62	2.604
Mungbean + sesame (3:1)	25.33	52.13	14.72	9.26	30.53	21.23	102.7	105.91	28.23	41.75	2.492
Mungbean + sesame (4:1)	25.03	51.09	15.13	9.51	30.72	21.46	101.22	105.79	28.18	40.95	2.413
S.Em +	0.59	0.89	0.42	0.33	0.69	0.42	1.52	1.57	0.76	0.68	0.064
CD (P=0.05)	1.70	2.56	1.21	0.97	NS	1.21	NS	NS	2.18	1.95	NS
Sulphur (S Kg /ha)											
S-0	22.06	46.47	11.76	9.22	30.16	20.99	96.5	100.35	22.97	40.74	2.384
S-15	24.62	50.43	14.08	9.33	30.58	21.39	101.37	105.81	26.62	41.58	2.478
S-30	26.93	53.36	15.63	9.38	30.87	21.56	105.96	110.42	28.97	41.79	2.513
S-45	28.62	55.50	16.75	9.40	31.08	21.66	109.16	112.44	31.29	41.96	2.518
S.Em +	0.59	0.89	0.42	0.33	0.69	0.42	1.52	1.57	0.76	0.68	0.064
CD (P=0.05)	1.70	2.56	1.21	0.97	NS	1.21	4.39	4.53	2.18	1.95	NS
NS=Non-significant											

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 crop growth 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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