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Effect of Different Levels of Sulphur and Nitrogen on Growth Yield and Quality of Sesame *(Sesamum indicum* L.) under Bael (*Aegle marmelos* L.) based Agri-horti system

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ABSTRACT

An investigation was performed during Rainy (*Kharif*) season of 2018-19 at agricultural research farm of R.G.S.C., Banaras Hindu University, India in order to explore the effect of nitrogen and sulphur on sesame under bael based agri-horti system. The texture of the soil of experimental field is sandy loam and comes under rainfed with invariably poor fertility status. The experiment was performed in factorial RBD with 12 treatments consisting of 4 nitrogen levels (0, 25, 50 and 75 kg ha^{-1}) and 3 levels of sulphur (0, 25 and 45 kg ha^{-1}) which is replicated 3 times. The Sesame variety 'RT 364' was sown between alleys of bael @ 5 kg ha^{-1} with spacing of 30 × 15 cm. The findings showed the highest plant height, Primary branches $plant^{-1}$, secondary branches $plant^{-1}$, Dry matter accumulation $plant^{-1}$, number of capsule $plant^{-1}$, number of grain $capsule^{-1}$, test weight, Seed yield and stover yield was obtained with the application of 45 kg sulphur ha^{-1} and 75 kg nitrogen ha^{-1}. Similarly maximum nutrient content (i.e. N, P, K& S), oil content and protein content was also obtained when applied with 45 kg sulphur ha^{-1} and 75 kg nitrogen ha^{-1}. It is concluded that sulphur @ 45 kg ha^{-1} and nitrogen @ 75 kg ha^{-1} can be applied for the higher yield and oil content of sesame under agri-horti system.

Keywords : *Agri-horti system, Nitrogen, Oil content, Protein content, Sesame*

Introduction

Agroforestry system has been considered as one of the efficient land use system which provides more benefits by combining the profits of agriculture with tangible as well as intangible benefits of the tree farming (Singh *et al*., 2020). In India several cereals pulses and oilseed crops are grown along with fruit trees like guava, mango, bael, custard apple etc. Sesame (*Sesamum indicum* L.) is an important oilseed crop belongs to family pedaliaceae that is cultivated since ancient time (Weiss, 1983) with evidence of origin in India (Bedigian, 2015). It is famous as queen of oilseeds due to its delicious flavor, high oil content and nutty aroma (Johnson *et al.* 1979). Sesame seeds are rich in oil, protein, vitamins with some quantity of trace elements and are good source of iron, phosphorus and calcium (Myint *et al.* 2020). Sesame seeds are widely used as edible products in roasted or raw form and also used in industries for lubricants, soaps, animal feed pharmaceuticals and cosmetics ingredients (Bedigian, 2011). The sesame oil is very stable and has anti-fungal, anti-bacterial, antiviral, and antioxidant properties. India ranks first, both in area and production of sesame in the world. The productivity of sesame crop is lower than its potential because of poor cultivation and management of sesame in sub-marginal and marginal lands where there is deficiency of N, P, K, S and other micronutrients, and also due to inadequate rate of fertilizers (Das and Biswas, 2019). Nitrogen plays an important role for plant nutrition and metabolism activities (Minz *et al*., 2021) in agricultural ecosystem. It is essential constituent of protein, impart green colour to plant, encourages vegetative growth and also help in synthesis of auxin. There are also some facts to indicate that excess nitrogen can also adversely affect in seed oil content. The application of nitrogen should preferably be done at the time of planting and if necessary top dressed before emergence of the first bud. In sandy soil, foliar spray of urea give result in yield increase (Nair *et al.*, 1976) but in general, top dressing gives similar yield at lesser cost. But according to some reports the yield of sesame seed can be raised by 50% with proper fertilization (Prakash and Gowda, 1992). In oilseeds, Sulphur plays significant role in increasing the yield and oil content of sesame (Deshmukh *et al.*, 2010) and helps in improving quality and boldness in seeds. Therefore, oilseed crops require large amount of sulphur for better development and growth to obtain higher yield (Salwa *et al.*, 2010). Sulphur act as a primary and secondary plant metabolites which is a component of glucosinolates, proteins and other compounds that are related to various parameters which determine the nutritive quality of crops (Jamal *et al.*, 2010). The response of sulphur to oilseed is increasing due to increase in cropping intensity (Ghosh *et al.*, 2002). Most of the Indian soil is deficient of sulphur and crop response with the application of sulphur has been reported (Raja *et al.*, 2007). Therefore, realizing the importance of nitrogen and sulphur in the production of sesame, present investigation was conducted to evaluate the effect of nitrogen and sulphur on growth and yield of sesame (*Sesamum indicum* L.) under bael (*Aeglemarmelos* L.) based agri-horti system.

Materials and Methods

The experiment was carried out during rainy (*Kharif*) season of 2018-19 at the agricultural research farm Rajeev Gandhi south campus, Banaras Hindu University, Barkachha, Mirzapur (U.P.). The field is located in Vindhyan region of district Mirzapur at $25^0$10'N latitude 82^0 37' E longitudes and an altitude of 427 meter above the sea level. The mean rainfall of locality is 1100 mm annually in which nearly 90 per cent of rainfall occurred by south-west monsoon between July to September. Composite soil samples experiment was collected to determine mechanical and physico-chemical properties of soil. The nature of experimental field soil was sandy loam in texture with low drainage, acidic in reaction having pH 5.8 (Jackson, 1973) poor in nitrogen (176.72 kg ha^{-1}; Subbiah and Asija, 1956) and phosphorous (114.13 kg ha^{-1}; Hanway and Heidal, 1952) and moderate in potassium (9.81 kg ha^{-1}; Bray and Kurtz method, 1945). The soil organic carbon (%, Walkley and Black, 1934) and Electrical conductivity (1:2 Soil: Water suspension, dSm^{-1} at 25^0C) of the initial soil sample were 0.49 and 0.31 respectively. The experiment was arranged in Factorial RBD with 3 replication of 12 treatment combinations consists of four nitrogen levels (0, 25, 50 and 75 kg/ha) and three sulphur levels (0, 25 and 45 kg/ha). The field was ploughed at optimum tilth and made ready for sowing. The fertilizer doses were calculated and applied to each plot depending on the treatments. The seeds of variety 'RT364' were manually sown in the alleys of 10 year old Bael tree having spacing 7m x 7m planted in 2008. Seeds were sown in the rows by *kudal* at a distance of 30 cm between row to row and 15 cm between plant to plant with relatively higher seed rate of 4 kg/ha. Observations on growth parameters i.e. Plant height, No. of primary branches $plant^{-1}$, No. of secondary branches $plant^{-1}$ and dry matter accumulations were recorded in 5 sample plants from each plot at 20, 40, 60 DAS and at maturity stage of the crop and average was taken for calculation. Harvesting of crop was done separately for each plot at the physiological maturity stage and observation of yield parameters i.e. No. of capsule plant^{-1}, No. of seed capsule^{-1}, Test weight and Grain yield were recorded for each plot. After harvesting, sesame seed and stover samples were processed and analyzed for quality parameters such as nutrient content (i.e. N, P, K and S), protein content and oil content. For estimating the nutrient content, representative samples of seeds and stover grinded by electric grinder and the nutrient content in seed and stover was determined using standard methods as shown in table 1.Protein content of sesame seeds were determined by using content of nitrogen in seeds and calculated according to Humpshire (1956).

Protein content = Nitrogen content (%) × 6.25

Estimation of oil content in seed

10 g of grinded seeds were used for estimation of oil content using petroleum ether for 6 h in Soxhlet apparatus (AOCS, 1993).

Grain oil percentage has been calculated as follows:

$$\text{Oil per centage} = \frac{\text{Constant weight of oil}}{\text{Weight of seed taken}} \times 100$$

Data obtained from various observations were statistically analyzed by following the procedure of Gomez and Gomez, (1976).

Results and Discussion

Effect of sulphur on growth, yield and quality of sesame

Application of sulphur significantly affected the growth, yield and quality parameters of sesame. Among the growth parameters the maximum plant height (108.83 cm), Primary branches plant^{-1} (10.78), secondary branches plant^{-1} (12.27) and dry matter accumulation plant^{-1} (28.83 g) were recorded with the application of 45 kg sulphur ha^{-1} as represented in table 2 and it is superior over rest of the treatments. Ahmad *et al.* (2018) and Jat *et al.* (2017) reported the similar result of increased height and number of branches plant^{-1} with the application of adequate sulphur. Importance of sulphur in cell elongation, cell division and setting of cell structure was also stated by Ghosh *et al.* (1997). Sarkar and Saha (2005) also revealed that Sulphur application improved dry matter production in plant at all stages. Sulphur application greatly influences chlorophyll synthesis, carbohydrates as well as protein metabolism which in turn resulted in improvement in growth characters, contributing higher dry matter accumulation in plant.

Average mean data of the yield parameters showed that yield parameters is significantly affected by the application of sulphur. The yield and yield attributes viz., number of capsule plant^{-1} (53.93), number of grain capsule^{-1} (51.18), test weight (2.79 g), Seed yield (574.92 kg ha^{-1}) and Stover yield (1458.92 kg ha^{-1}) was obtained maximum by applying 45 kg sulphur ha^{-1} as presented in the Table 2. Accumulation of photosynthates and its efficient partitioning resulted from S application, enhanced yield attributes, which ultimately increased the seed yield. The availability of Sulphur at higher levels of fertility may induce translocation of photosynthates from leaves via stem to sink i.e. seed and capsule. This resulted in increase in capsule length and more number of seeds capsule^{-1} at maturity became bold with maximum test weight. The high yield might be attributed to effect of sulphur that stimulates the synthesis of protein that results into the enhanced yield contributing components (Mondal *et al.,* 2012). The similar results have also been reported in sesame by Umata and Dabalo (2017) and Jadhav *et al.*(2010). Ahmad *et al.* (2018) reported that maximum sesame yield produced by applying 40 kg sulphur ha^{-1}. Shah *et al.* (2013) also revealed that the elemental S application @ 45 kg ha^{-1} as basal dose significantly enhanced the yield and yield attributes of sesame i.e. grain yield, biological yield, 1000-seed weight and number of capsules per plant.

Increased rates of S increased the N and S content in seed. The protein and oil contents are also in the positive relationship with levels of sulphur. Highest nitrogen, phosphorus, potassium and sulphur content in Grain and stover (Table 3), oil (48.35 %) and protein content (21.56 %) (Figure 1) were also recorded with application of 45 kg sulphur ha^{-1}. The application of Sulfur promotes the activity of enzymes which catalyze the biochemical reactions results into higher oil content of sesame seed (Maragatham *et al.*, 2006). These results are in confirmation with the findings of Raja *et al.* (2007). Ahmad *et al.* (2018) also reported higher oil content with higher rate of sulphur application.

Table 1. Methods used for estimation of nutrient contents

Nutrient	Analytical Method	References
Nitrogen (N)	Micro-Kjeldahl method	Jackson (1973)
Phosphorus (P)	Di-acid Digestion Method by Spectrophotometer	Bhargava and Raghupathi (1993)
Potassium (K)	Di-acid Digestion Method by Flame Photometer	Bhargava and Raghupathi (1993)
Sulphur (S)	Di-acid Digestion Method by Spectrophotometer	Bhargava and Raghupathi (1993)

Effect of nitrogenon growth, yield and quality of sesame

Growth parameters increased with increasing rate of nitrogen upto 75 kg ha^{-1} which produced maximum plant height (111.82 cm), Primary branches per plant (11.29), secondary branches per plant (12.38) and Dry matter accumulation per plant (29.75 g) as presented in the (Table 2). The positive response of sesame to nitrogen application was also stated by Akhtar *et al.* (2015). In the present investigation it was observed that taller plants produced more branches at higher nitrogen levels and thus helped the plants in producing more number of functional leaves per plant. The increased foliage might have accelerated the photosynthetic activity in plants caused more production of plant food material which lead healthy growth. Similar findings were reported by Ur Rehman *et al.* (2013).

Average mean data of the yield parameters showed that yield parameters are significantly affected with the increasing rate of nitrogen. The maximum yield attributes viz., number of capsule plant^{-1} (57.21), number of grain capsule^{-1} (52.80), test weight (2.84 g), Seed yield (596.38 kg ha^{-1}) and stover yield (1519.16 kg ha^{-1}) are obtained with the application of nitrogen @ 75 kg ha^{-1} as represented in the (Table 2). Adequate availability of nitrogen under higher rate thus enabled the plants for production of better yield attributes. Thus improved in overall growth stages and chlorophyll content of the leave with the nitrogen fertilization coupled with increased net photosynthesis on other hand greater mobilization of photosynthates toward reproductive structures and increased the yield significantly. Mankar and Satao (1995) and Noorka *et al.* (2011) also reported that nitrogen fertilizer has positive effect on the growth as well as yield of sesame parameters.

Similarly maximum nitrogen, phosphorus, potassium and sulphur content in Grain and stover (Table 3), oil (47.35 %) and protein content (22.32 %) (Figure 1) were also obtained with application of nitrogen @ 75 kg ha^{-1} and superior over rest of the treatments. The formation of protein is the important function for the supply of nutrients and availability of energy to the plant cells. Protein content of the

Table 2. Effect of different levels of nitrogen and sulphur on growth, yield parameter and seed yield of sesame seed and stover under bael based agri-horti system.

Treatment	Plant height (cm)	Primary branch plant^{-1}	Secondary branch plant^{-1}	Dry matter accumulation plant^{-1} (g)	No. of capsule plant^{-1}	No. of seed capsule^{-1}	Test weight (g) (1000-seed)	Seed yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})
Sulphur (kg ha^{-1})									
0	96.47	9.19	10.54	24.90	47.82	46.10	2.43	499.78	1308.70
25	102.30	10.19	11.39	26.88	51.82	49.45	2.58	512.33	1406.33
45	108.83	10.78	12.27	28.83	53.93	51.18	2.79	574.92	1458.92
SEm±	3.26	0.37	0.41	0.96	1.66	1.37	0.08	15.87	41.03
CD (P=0.05)	9.56	1.08	1.19	2.82	4.88	4.01	0.25	46.54	120.34
Nitrogen (kg ha^{-1})									
0	94.89	8.64	9.93	23.38	43.47	44.80	2.43	465.13	1233.09
25	99.16	9.39	11.31	26.22	50.19	47.92	2.52	516.94	1345.60
50	104.27	10.88	11.97	28.10	53.88	50.12	2.61	537.58	1467.42
75	111.82	11.29	12.38	29.75	57.21	52.80	2.84	596.38	1519.16
SEm±	3.77	0.43	0.47	1.11	1.92	1.58	0.10	18.32	47.38
CD (P=0.05)	11.04	1.25	1.37	3.26	5.64	4.63	0.28	53.74	138.96

Table 3. Effect of different levels of nitrogen and sulphur on N. P. K and S content (%) of sesame seed and stover under bael based agri-horti system.

Treatment	Content (%)							
	Seeds				Stover			
	N	P	K	S	N	P	K	S
Sulphur (kg ha^{-1})								
0	3.61	0.43	0.31	0.18	1.82	0.23	0.76	0.14
25	3.66	0.45	0.36	0.27	1.87	0.26	0.78	0.22
45	3.78	0.51	0.42	0.46	1.94	0.31	0.82	0.43
SEm±	0.04	0.01	0.02	0.06	0.03	0.01	0.02	0.05
CD (P= 0.05)	0.11	0.03	0.05	0.17	0.10	0.03	0.05	0.14
Nitrogen (kg ha^{-1})								
0	3.61	0.43	0.31	0.18	1.82	0.23	0.76	0.14
25	3.78	0.47	0.38	0.27	1.87	0.27	0.79	0.22
50	4.14	0.53	0.46	0.42	1.94	0.33	0.84	0.43
75	4.52	0.64	0.58	0.54	2.18	0.42	0.93	0.56
SEm±	0.13	0.03	0.04	0.02	0.07	0.03	0.02	0.04
CD (P=0.05)	0.37	0.08	0.11	0.06	0.20	0.09	0.07	0.11

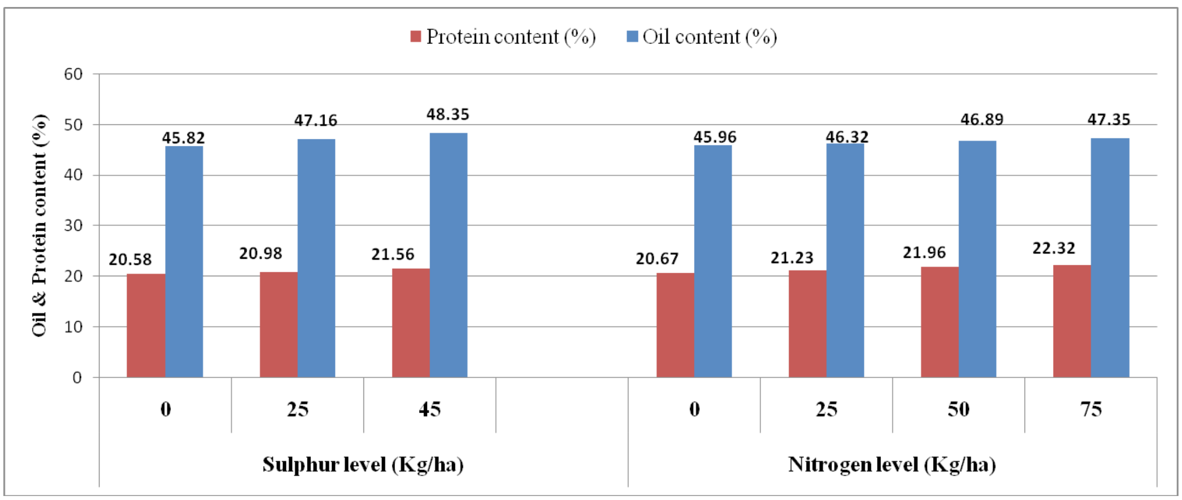

Fig. 1. Effect of different levels of nitrogen and sulphur on Oil and Protein content (%) of sesame seed under bael based agri-horti system.

seed depends upon the availability of nitrogen content which further found to improve with the increasing levels of nitrogen as there is a direct correlation between uptake and availability of nitrogen in plants. This result is in close proximity with the findings of Veeramani *et al.* (2012) and Mamatha *et al.* (2017). The oil content of sesame ranged between 30.23 % and 40.69 % as reported by Mondal (2016). Ahmad *et al.* (2018) reported that oil content increases with increment in nitrogen rates upto 100 kg ha^{-1}.

From the above experiment it is concluded that the application of optimum nitrogen and sulphur doses will act as a mojor factor for obtaining better growth, yield attributes, yield and quality of sesame. Among the several treatments the application of sulphur @ 45 kg ha^{-1} and Nitrogen @ 75 kg ha^{-1} is adjudged as the best suitable treatment for enhancing growth, yield and quality of sesame under agri-horti system.

Conflict of Interest

All the authors hereby declare that there is no conflict of interest regarding the publication of this article.

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