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ASSESSMENT OF NUTRIENT UPTAKE AND QUALITY PARAMETERS DUE TO DIFFERENT NITROGEN AND SULPHUR LEVELS IN GARDEN PEA (*PISUM SATIVUM* L.) UNDER GUAVA (*PSIDIUM GUAJAVA* L.) BASED AGRI-HORTICULTURE SYSTEM

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ABSTRACT

The distribution of nutrients to the plants can be improved to advance plant growth and improve its yield. The goal of this study was to evaluate the uptake of several nutrients (nitrogen, phosphorous, potassium and sulphur) in garden pea straw and seeds. The experiment was carried out at the Rajiv Gandhi South Campus B.H.U. research farm in Barkachha, Mirzapur, Uttar Pradesh, during the *Rabi* season (2019-20) in garden pea (*Pisum sativum* L.) beneath the alleyways of Guava (*Psidium guajava* L.). The experiment used a split plot design with a total of 12 treatments and 3 replications. The main plot treatment was given to the nitrogen levels N_{15}, N_{30} and N_{45} and the subplot treatment was given to the sulphur levels S_{10}, S_{20} and S_{30}. The nutrient content (%), nutrient uptake (kg ha^{-1}) of the seed and straw and quality parameters were calculated. Results showed that the maximum and minimum nutritional contents and uptake of seed and straw were recorded in nitrogen 45 kg ha^{-1} and 15 kg N ha^{-1}, respectively. Similarly, as regards to the quality parameters the best results were recorded due to the application of 45 kg N ha^{-1}, while the minimum results were observed in nitrogen 15 kg ha^{-1}. On the other hand, for sulphur levels, the maximum and minimum amounts of nutrient content, uptake and quality parameters were found in 30 kg sulphur ha^{-1} and 10 kg S ha^{-1}, respectively.

Key words : Garden pea, Nitrogen, Nutrient content, Nutrient uptake, Sulphur.

Introduction

About 70% of the region's arable land is used for rainfed agriculture in Asia and the Pacific and 60–80% of the world's food supply is produced on these rainfed lands (FAO, 2019). Due to their capacity to symbiosis with papillary bacteria and the resultant utilization of nitrogen from the air, legume plants play a significant role in modern agriculture (Palermo *et al*., 2022). All around the world, species of this family are raised for food and fodder and extensive research has been done on their nutritional content and positive impacts on the yield of succeeding crops. Legume seeds are highly nutritious and beneficial (Uddin *et al.*, 2023). One of the most significant legumes in the world is the pea (*Pisum sativum* L.), which is currently grown in more than 90 countries and has a projected annual production of 13.5 million tonnes with a producer price of over $200 per tonne (WHO, 2018). In order to boost growth, maximize crop production and generate more profit, fertilizers are applied to the plants. In simpler terms, one may think of it as plant food. Fertilizers can drastically improve the production of crops. It is not quite wise to ignore the fertilizer requirements of plants since it can cause a severe reduction in the crop yield. In order to ensure food productivity and replenish nutrient reserves in the soil, it is essential to add fertilizers. Human nutritional requirements in the crops can also be assured through fertilization of the agricultural soil. However, the number of fertilizers that are to be added to the soil should be optimum without congesting the soil (Stewart and Roberts, 2012).

Excessive use of nitrogen fertilizers can have detrimental effects on the ecosystem, including soil erosion and water contamination. As a result, it's crucial to keep a careful eye on the crop's unique requirements plus the surrounding environment while figuring out the correct fertilizer application rates. Fertilizers can shield the world against hunger crisis and malnutrition by providing crucial nutrients to the growing population (Liu *et al.*, 2021). Largely used fertilizers across the world are of nitrogenous nature. In general, nitrogen is one of the essential components for increasing crop output. Protein synthesis depends on nitrogen as its foundation, and enhances the crop's nutritional value. In addition, it has been observed that nitrogen improves the photosynthetic activity in plants (Noor *et al.*, 2023). More protein and biomass are produced as a result of nitrogen administration. Nitrogen, which is a component of chlorophyll, also enables photosynthesis in plants, which fosters plant development and enhances output (Blumenthal *et al.*, 2008 and Muhammad *et al.*, 2022). Although nitrogen is generally linked with the enhancement of growth and yield, it has also occasionally been seen to reduce pest infestation (Aboelfadel *et al.*, 2023).

Sulphur is one of the crucial minerals required for effective plant growth and operation. Sulphur and nitrogen assimilation are closely tied to one another. Additionally, determining the nitrogen to sulphur ratio in the plant tissue can be used to diagnose a sulphur shortage. Sulphur is an essential macronutrient for the effective growth, developmental processes of plants and root expansion. Although, it can be used in gaseous form by plants, the roots are its main user. It cannot be digested directly; it must first be reduced. The structure of proteins and the function of enzymes is impacted by sulphur. It is essential for the creation of chlorophyll in addition to encouraging root growth and assisting in the production of vitamins and enzymes required for the plant to carry out its biochemical activities (Jat *et al.*, 2017). According to Zhao *et al.* (2008) and Yadav *et al.* (2020) sulphur (S) is essential for the formation of nodules and effective nitrogen fixation in legumes. The experiment was undertaken to study the enhancement of the production of garden peas through the application of nitrogen and sulphur.

Materials and Methods

In order to compare the variations in nutrient content, uptake and quality parameters in garden pea plants receiving various levels of nitrogen and sulphur, experiments were developed using a split-plot design (SPD). The research was carried out at the Rajiv Gandhi South Campus, B.H.U., Barkachha, Uttar Pradesh, located at 25º03′ 06.0′′ N, 82º35′ 21′′ E longitudes during the year 2019-20. The research study location is located in the semi-arid eastern plain zone of agroclimatic zone III A, where most crops are typically cultivated in rainfed conditions. The region typically had unpredictable rains and low fertility rates. It has a semi-humid climate, with an area-wide average humidity of between 60 and 70 percent. It is located in a semiarid area. The temperature ranges from 5.2°C to 44°C in the region. The monsoon arrives in June, bringing with it an average annual rainfall of 997.40 mm. During the experimental period rainfall in the area was frequently erratic and fertility rates were low. The soil at the experimental site as depicted in Table 1 was sandy clay loam with a pH of 5.93. The physical constituents of the soil are 58.63% sand, 19.63% silt and 21.74% clay. The status of nitrogen and sulphur (168.20 and 9.93 kg ha^{-1}, respectively) was comparatively low whereas, the presence of phosphorus (17.85 kg ha^{-1}), potassium (180.1 kg ha^{-1}) and soil organic carbon (0.62%) were found medium.

The experimental design was laid out in a split plot design manner under the alleyways of guava tress planted at a distance of 6m × 6m. The variety: P-3 of garden pea was selected for the experiment, developed at BHU, Varanasi for plantation during the Rabi season under rainfed situations and water stress. The spacing of the crop was 30cm × 10cm sown in the plot size of 3m × 3m. The treatments consisted of 3 main plots and 3 sub-plots. The main plot treatments consisted of 3 levels of nitrogen (15 kg ha^{-1}, 30 kg ha^{-1} and 45 kg ha^{-1}), while the sub-plot treatment comprised of levels of sulphur (10 kg ha^{-1}, 20 kg ha^{-1} and 30 kg ha^{-1}). The 9 treatments (N_1S_1= 15 kg N ha^{-1}+ 10 kg S ha^{-1},N_1S_2= 15 kg N ha^{-1}+ 20 kg S ha^{-1}, N_1S_3= 15 kg N ha^{-1} + 30 kg S ha^{-1}, N_2S_1= 30 kg N ha^{-1}+ 10 kg S ha^{-1}, N_2S_2= 30 kg N ha^{-1} + 20 kg S ha^{-1}, N_2S_3= 30 kg N ha^{-1}+ 30 kg S ha^{-1}, N_3S_1= 45 kg N ha^{-1} + 10 kg S ha^{-1}, N_3S_2= 45 kg N ha^{-1}+ 20 kg S ha^{-1}, N_3S_3= 45 kg N ha^{-1}+ 30 kg S ha^{-1}), which were replicated thrice in a randomized manner.

The Kjeldahl method (Jackson, 1973), Vanadomolybdate phosphoric acid yellow colour method (Jackson, 1973), Flame-photometric method (Jackson,

Table 1 : Initial soil characteristics of the experimental field.

Characteristic	Values	Method of determination	Remarks
A) Physical properties			
Sand (%)	58.63	Bouyoucos hydrometer, 1962	Sandy clay loam
Silt (%)	19.63		
Clay (%)	21.74		
Texture class	Sandy clay loam	Textural triangle method, Black *et al.* (1965)	
Bulk density (Mg m^{-3})	1.42	Core sampler method, Black *et al.* (1965)	
Particle density (Mg m^{-3})	2.56	Pycnometer method, (Black *et al.*, 1965)	
B) Chemical properties			
pH of soil (1:2 soil water suspension)	5.93	Digital pH meter	Slightly acidic
Electrical Conductivity (EC) dS/mat 25^0C	0.16	Systronics Electrical Conductivity Meter (Chopra and Kanwar, 1976)	
Organic carbon (C) (%)	0.62	Walkley and Black rapid titration method (Piper, 1966)	Medium
Available nitrogen (N) (kg ha^{-1})	168.20	Modified alkaline permanganate method (Subbiah and Asija 1956)	Low
Available phosphorous (P_2O_5) (kg ha^{-1})	17.85	0.5M $NaHCO_3$ extractable (Olsen *et al.*, 1954)	Medium
Available potassium (K_2O) (kg ha^{-1})	180.1	1*N* neutral ammonium acetate method (Piper, 1966)	Medium
Available sulphur (S) (kg ha^{-1})	9.93	Turbidimetric (Chesnin and Yien, 1950)	Low

1973) and the turbidimetry method (Chesnin and Yien, 1950) were employed to determine the nitrogen, phosphorus, potassium and sulphur content, respectively in seed and straw. The protein content in the seed and straw was determined by multiplying the nitrogen concentration by a factor of 6.25, according to the AOAC (Washington, 1970).

In addition, the nutrient intake of garden pea, namely nitrogen, phosphorus, and potassium, was determined in kg ha^{-1}. This was done by calculating the nutrient content and yield of the pea using the following formula.

Nutrient uptake (kg ha^{-1}) =

$$\frac{Nutrient\ content\ (\%) \times yield\ (kg\ ha^{-1})}{100}$$

Similarly, the protein yield present in the seed and straw of the experimental crop was determined by multiplying the protein content with the respective seed and straw yields, resulting in the seed protein yield and straw protein yield.

The Gomez and Gomez (1984) methodology was employed to quantitatively analyse the nutritional composition and absorption in both the seeds and straw.

Results and Discussion

Effect of nitrogen

According to data presented in Table 2 and illustrated in Fig. 1, it suggests nutrient content of levels of nitrogen significantly impacted the amount of nitrogen and the amount of sulphur absorbed by seed and straw, respectively. On the other hand, the effect on the concentration of phosphorus and potassium in seed and straw were recorded to be non-significant. The highest nitrogen, phosphorus, potassium and sulphur concentration among all nitrogen levels was found due to 45 kg N ha^{-1} in seed (2.2, 0.21, 0.38 and 0.26%, respectively) and straw (0.56, 0.16, 0.34 and 0.22%, respectively). However, due to the application of 15 kg N ha^{-1}, the lowest nitrogen, phosphorus, potassium and sulphur content and absorption were discovered. The contents of nitrogen, phosphate, potassium and sulphur increased as nitrogen levels rose in test crop. This could be as a result of increased nutritional availability drawn by application of higher levels of nitrogen and sulphur. The similar results were reported by Rabbi *et al.* (2011), Abdel-Aziz and Ismail (2016) Bai

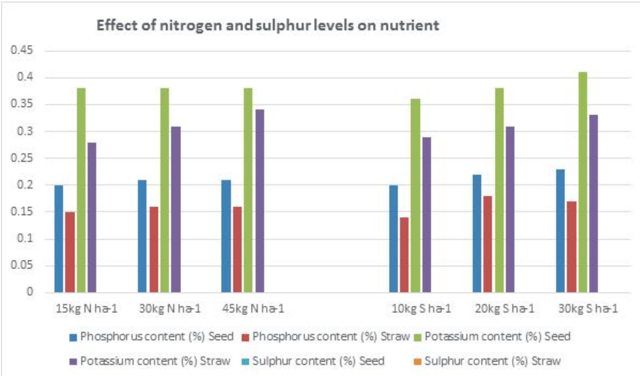

Fig. 1 : Effect of nitrogen and sulphur levels on nutrient content in seed and straw of garden pea under guava based agri-horticulture system.

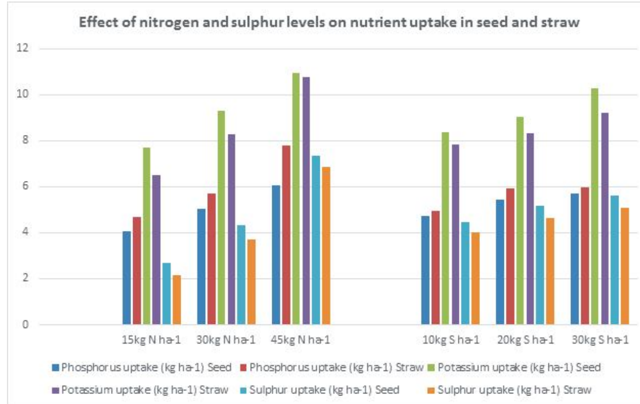

Fig. 2 : Effect of nitrogen and sulphur levels on nutrient uptake in seed and straw of garden pea under guava based agri-horticulture system.

et al. (2017), Kumar *et al.* (2020), Chanu and Sarangthem (2022).

The amount of nitrogen, potassium and sulphur that was absorbed in seeds was considerably influenced by nitrogen levels, according to data on nutrient uptake in seeds (Table 3 and Fig. 2). It was discovered to be non-significant for the uptake of phosphorus by seeds, though. However, it was shown that the nitrogen in straw significantly increased nutritional intake of nitrogen, phosphorus, potassium and sulphur. With regard to all nutrient uptake, 45 kg N ha^{-1} was shown to be the highest and it resulted in the maximum nitrogen, phosphorous, potassium and sulphur uptake in seed (62.29, 6.04, 10.96 and 7.35 kg ha^{-1}, respectively) and straw (17.74, 7.79, 10.77 and 6.88 kg ha^{-1}, respectively). Higher nitrogen dosages boosted nutritional availability because more nitrogen, phosphorous, potassium and sulphur were present despite the soil having little readily available nitrogen. Similar findings were made by Rabbi *et al.* (2011), Bai *et al.* (2016), Kumar *et al.* (2020) and Chanu and Sarangthem (2022).

Different levels of nitrogen had a substantial impact on quality metrics as stated in Table 4, depicted in Fig. 3 and 4, such as protein content and protein yield in garden pea seed. The quality parameters of test crop were found remarkably higher at 45 kg N ha^{-1} as compared such as 15 and 30 kg ha^{-1}. A higher amount of nitrogen assimilation was seen in the seeds of garden peas as a result of the higher degree of nitrogen treatment. Higher protein yield and content were observed as the result of application of higher nitrogen levels. Achakzai and Bangulzai (2006), Gul *et al.* (2006), Zaghloul *et al.* (2015), Kumar *et al.* (2018), Uddin *et al.* (2023), Priyadarshini *et al.* (2023) all noted that the quality indices of garden peas hiked when the nitrogen levels increased.

Table 2 : Effect of nitrogen and sulphur levels on nutrient content in seed and straw of garden pea under guava based agri-horticulture system.

Treatment	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Sulphur content (%)	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
Nitrogen levels (kg ha^{-1})								
15	1.45 c	0.21 c	0.20	0.15	0.38	0.28	0.12 c	0.09 c
30	1.81 b	0.36 b	0.21	0.16	0.38	0.31	0.19 b	0.14 b
45	2.2 a	0.56 a	0.21	0.16	0.38	0.34	0.26 a	0.22 a
SEm±	0.04	0.008	0.01	0.02	0.01	0.01	0.006	0.01
CD (P=0.05)	0.16	0.03	**NS**	**NS**	**NS**	**NS**	0.02	0.04
Sulphur levels (kg ha^{-1})								
10	1.68 b	0.31 c	0.2	0.14	0.36	0.29	0.16 c	0.14 b
20	1.83 a	0.37 b	0.22	0.18	0.38	0.31	0.18 b	0.16ab
30	1.91 a	0.44 a	0.23	0.17	0.41	0.33	0.21a	0.17 a
SEm±	0.04	0.01	0.01	0.01	0.01	0.01	0.003	0.006
CD (P=0.05)	0.14	0.04	**NS**	**NS**	**NS**	**NS**	0.011	0.01
Interaction	**Non-significant**							

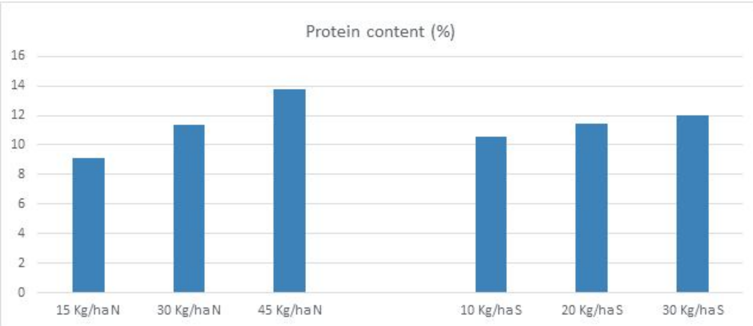

Fig. 3 : Effect of nitrogen and sulphur levels on protein content (%) in seeds of garden pea under guava based agri-horticulture system.

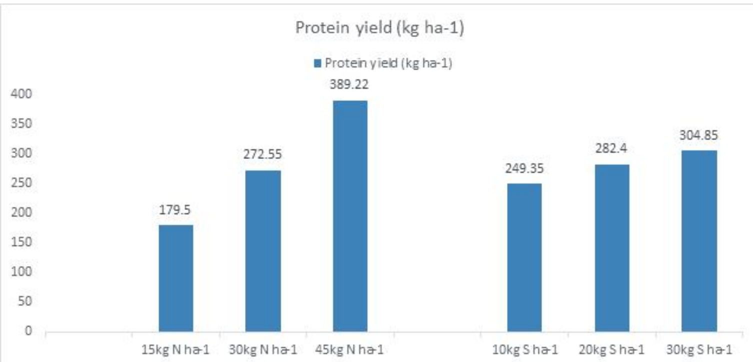

Fig. 4 : Effect of nitrogen and sulphur levels on protein yield (kg ha^{-1}) in seeds of garden pea under guava based agri-horticulture system.

was found to be insignificant. The application of 30 kg S ha^{-1} resulted in the maximum nitrogen, phosphorus, potassium and sulphur content in seed (1.91, 0.23, 0.41 and 0.21%, respectively) and straw (0.44, 0.17, 0.33 and 0.17%, respectively). However, 10 kg S ha^{-1} has the lowest yield result than other treatments. The increase of sulphur availability is improved through applied soil treatments. The level of sulphur was found low in the soil (Table 1). The results of Osman and Rady (20212), Scherer *et al.* (2012), Kala *et al.* (2017), Henreit *et al.* (2019), Kumar *et al.* (2020) and Chaudhari *et al.* (2012), Shankar (2022) came to similar conclusions.

According to data of nutrient uptake in seeds (Table 3), the amount of nitrogen and sulphur that was absorbed in seed and straw was significantly influenced by sulphur levels. Although, phosphorus and potassium absorption by seeds was shown to be non-significant, their absorption in straw was found to have significant effects. The maximum levels of nitrogen, phosphorus, potassium and sulphur were uptake

Table 3 : Effect of nitrogen and sulphur levels on nutrient uptake in seed and straw of garden pea under guava based agri-horticulture system.

Treatment	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})		Sulphur uptake (kg ha^{-1})	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
Nitrogen levels (kg ha^{-1})								
15	28.72 c	4.85 c	4.07	4.68 ab	7.68 c	6.49 c	2.67 c	2.16 b
30	43.62 b	9.93 b	5.02	5.69 ab	9.32 b	8.26 b	4.32 b	3.69 b
45	62.29 a	17.74 a	6.04	7.79 a	10.96 a	10.77 a	7.35 a	6.88 a
SEm±	1.05	0.60	0.57	0.88	0.27	0.38	0.32	0.4
CD (P=0.05)	4.12	2.36	NS	3.48	1.09	1.52	1.28	1.58
Sulphur levels(kg ha^{-1})								
10	39.9 c	8.58 c	4.74	4.93 ab	8.36	7.85 b	4.45 b	4 b
20	45.2 b	10.33 b	5.43	5.91 ab	9.05	8.32 ab	5.17 a	4.66 a
30	48.78 a	12.76 a	5.71	5.97 a	10.29	9.21 a	5.61a	5.07 a
SEm±	1.15	0.42	0.33	0.75	0.46	0.29	0.16	0.19
CD (P=0.05)	3.57	1.31	NS	2.31	NS	0.914	0.51	0.6
Interaction	**Non-significant**							

Effect of sulphur

The data present in Table 2, suggests the levels of sulphur had a significant influence on the amounts of nitrogen and sulphur that were absorbed by seed and straw, respectively. However, the effect on the phosphorous and potassium content in seed and straw by seed (48.78, 5.71, 10.29 and 5.61 kg ha^{-1}) and straw (12.76, 5.97, 9.21 and 5.07 kg ha^{-1}) through the application of 30 kg S ha^{-1}. Additionally, it was found very low nitrogen, phosphorus, potassium and sulphur content and its absorption after the application of 10 kg S ha^{-1}. Similar conclusions were reached by Osman and Rady (2012)

Table 4 : Effect of nitrogen and sulphur levels on protein content (%) and protein yield (kg ha^{-1}) in seeds of garden pea under guava based agri-horticulture system.

Treatment	Protein content (%)	Protein yield (kg ha^{-1})
Nitrogen level (kg ha^{-1})		
15	9.08 c	179.5 c
30	11.36 b	272.55 b
45	13.8 a	389.22 a
SEm ±	0.26	6.56
CD (P=0.05)	1.05	25.78
Sulphur level (kg ha^{-1})		
10	10.52 b	249.35 b
20	11.47 a	282.4 a
30	11.97 a	304.85 a
SEm ±	0.29	7.24
CD (P=0.05)	0.9	22.32
Interaction	**Non-significant**	

Kala *et al.* (2017), Kumar *et al.* (2020), Chaudhari *et al.* (2022) and Shankar (2022).

Sulphur levels had a significant impact on quality metrics (Table 4) such protein content and protein yield in garden pea seed. Ascompared to other levels of sulphur, the protein content in plant and yield were higher due to the 30 kg S ha^{-1} level. This might be because sulphur plays a key function in the production of amino acids and is more readily available at higher soil application levels. Additionally, according to Osman and Rady (2012), Singh (2017), Vaishali *et al.* (2020), Imsong *et al.* (2023) and Manoj *et al.* (2023) garden pea quality metrics rose as sulphur levels rose.

Interaction effect of nitrogen and sulphur

The content and uptake of nutrients in garden pea seed and straw had not been significantly impacted by the combination of nitrogen and sulphur.

Conclusion

The application of 45 kg of nitrogen and 30 kg of sulphur per hectare was shown to be the most effective for increasing nutrient content and uptake in garden pea plants, according to the aforementioned data.

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