AATCC Review

20 April 2024: Received
26 May 2024: Revised
22 June 2024: Accepted
12 August 2024: Available Online

www.aatcc.peerjournals.net

Research Article Open Access

Sesame Response to Nitrogen Management under Coarse Textured Soils of Sami Arid Region

M. K. Jat[1*], P. K. Yadav[2] Rameshwar Singh[2], Ashish Shivran[3] Sushil Kumar Singh[4] Shubham Lamba[1] and Jitender Kumar[5]

[1]Department of Soil Science, CCSHAU, College of Agriculture, Hisar (Haryana) India
[2]Department of Soil Science, CCSHAU, Regional Research Station, Bawal (Haryana) India
[3]Department of Agronomy, CCSHAU, Krishi Vigyan Kendra, Mahendragarh (Haryana) India
[4]Department of Agronomy, CCSHAU, Hisar (Haryana) India
[5]Department of Agronomy, CCSHAU, Regional Research Station, Bawal (Haryana) India

ABSTRACT

Sesame is mainly cultivated under traditional, low-input agro-systems. However, Adequate application of nitrogenous fertilizers not only improves the crop yield but also maintains soil N status and thus sustains productivity. The experiment was carried out during the kharif season 2015 to 2017 in a randomized block design with four replications. There were five graded levels of nitrogen application viz., 0, 30, 37.5, 45 and 60 kg N ha^{-1}. In coarse-textured, low-nitrogen status soil with an average nitrogen content of 106.45 kg/ha, the study found that sesame seed yield increased significantly with nitrogen application up to 45 kg N/ha.The increase in mean seed yield was 19.23, 24.52, 39.26, and 41.18 percent and in mean stalk yield was 19.59, 23.81, 30.62, and 34.64 percent due to the application of 0, 30, 37.5, 45, and 60 kg N/ha, respectively over control. The mean N-uptake also increased with N application. The mean N-use efficiency varied from 43.10 to 52.38 percent being the maximum (52.38 %) with the application of 45 kg N/ha. The mean post-harvest available N status was 105.43, 107.51, 108.11, 109.15, and 110.23 kg/ha at 0, 30, 37.5, 45 and 60 N/ha, respectively. The economic data analysis revealed that the benefit-cost ratio also increased with nitrogen application and was 0.93, 1.10, 1.15, 1.27, and 1.28 at 0,30, 37.5, 45 and 60 kg N/ha, respectively. Application of 45 kg N/ha was optimum for the cultivation of sesame crop yield, soil N fertility status, and economics under coarse textured low nitrogen status soils.

Keywords: *Available soil N, Yield, Uptake, Sesame, N use efficiency, Economics*

Introduction

Sesame (*Sesamum indicum* L.; genome 2n = 2x = 26) is an important oilseed crop, that being used for a wide range of products in the food industry, such as cooking oil, paste (tahini), baking, and pharmaceutical (Mushtaq *et al.,* 2020). Sesame seeds contain a considerable amount of essential mineral nutrients, with high bio-accessibility (Teboul *et al.,* 2020). Its health properties are attributed to various nutritional quality characteristics, including its high protein and mineral contents (Lu *et al.,* 2019), as well as to several nutraceutical phytochemicals. In recent years, the demand for sesame seeds (and secondary products) has been increasing as part of the global trends toward healthier plant-based food products.

Sesame is one of the oldest cultivated plants in the world. It has early origins in East Africa and India. Til oil cake is good feed for poultry, goats, sheep, fish, cattle, etc. Its seeds and young leaves are eaten as stews and soaps in Asia. In India, sesame is cultivated on 1.56 million ha with a total production of 0.78 million tonnes. The average productivity of the crop is 502 kg/ha (Anonymous, 2021). But the average productivity is very low in comparison to global as well as national levels.

Corresponding Author: **M. K. Jat*

DOI: https://doi.org/10.58321/AATCCReview.2024.12.03.43

Increasing global demand has opened prospective market options for sesame. The use of mineral fertilizers and organic manures in balanced amounts can ensure sustainable production at higher productivity and higher quality levels of this oil seed crop. The average productivity of sesame in Haryana is very low in comparison to the global as well as national level. Low and scanty rainfall, cultivation of crops on marginal and sub-marginal lands under very poor agronomic practices, and inadequate use of fertilizers are the major factors responsible for the low productivity of the crop. For optimum utilization of other essential inputs, fertilizer requirements need to be fine-tuned. Poor soil fertility is one of the most important factors limiting productivity aggravated by poor cultural practices such as mono-cropping. The repeated sesame production (mono-cropping) has resulted in the depletion of nutrients from the topsoil with a subsequent reduction in yield. Many researchers have shown that sesame is very responsive to nitrogen fertilizer (Adam, N.M *et al.,* 1986 & Akhtar *et al.,* 2015). Nitrogen is the most dynamic nutrient element and becomes the first limiting nutrient as land use intensifies (Tiessen *et al.,* 2003; Lafond *et al.,* 2003; Akanbi *et al.,* 2006).

Nitrogen is a structural constituent of chlorophyll and protein therefore, the adequate supply of nitrogen is beneficial for both carbohydrates and protein metabolism as it assists cell division and cell enlargement, resulting in more leaf area and thus ensuring good seed and dry matter yield (Ibrahim et al. 2014). It's also important because nitrogen is a: Major component of amino acids, the building blocks of proteins (Pandey and Sinha, 1986 & Akanbi et al., 2006).

Fertilizer application to sesame in either organic or inorganic form is a key component to good growth, high yield, high seed quality, and oil content (I. Haruna 2011). It is taken up in the highest amount by crops and its role in plants cannot be easily substituted (Olaniyi and Akanbi, 2008). Its supply in the soil is the most important factor limiting growth and yield (Akanbi, *et al.,* 2000). Refinement of on-site nutrient management for sesame is very important. The objective of this study was to investigate the impact of different levels of N on the yield of a local common-grown variety of sesame (HT-1 and HT-2) in low-fertile soils in southern Haryana. The aim was to help farmers increase their yield and estimate how much fertilizer the farmers should apply from an economic point of view. We hypothesize that just applying a small amount of N which could be economically feasible for farmers, could increase the yield significantly and maintain nitrogen status in soils.

Materials and Methods

The experiment was conducted at the Regional Research Station, CCS HAU, Bawal, Haryana during the *kharif* seasons of 2015 to 2017. The site is situated at latitude 28.1°N, longitude 76.5°E having an altitude of 266 m above mean sea level. The soil properties of the experimental site (mean of three years) are presented in Table 1.

Table 1 Physico-chemical properties of the experimental field at 0-15 cm depth

Soil properties	Mean value
Soil texture	loamy sand
pH (1:2)	8.30
EC (dS/m)	0.20
OC (g/kg)	1.90
Available N (kg/ha)	106.45
Available P (kg/ha)	11.38
Available K (kg/ha)	168.05

The climate of the site was characterized by hot summers and cold winters with an average annual rainfall received was 378, 575.5 6, and 565.10 mm during 2015, 2016, and 2017 respectively. The experiment was laid out in randomized block design with thrice replications. There were five graded levels of nitrogen application *viz.,* 0, 30, 37.5, 45 and 60 kg N ha^{-1}. The recommended dose of fertilizers for the crop was applied as per package practices. Irrigation and plant protection measures were taken as per recommended practices. The crop was harvested at physiological maturity, threshed and plot-wise yield was recorded. Seed, stalk, and soil samples were taken and analyzed for N concentration in seed and stalk and available N in soil, respectively. Electrical conductivity (EC) and soil reaction (pH) were determined in (1: 2) Soil: Water Suspension using a digital pH meter (Jackson 1973). Available N was extracted by using the Alkaline permanganate method as described by (Subbiah and Asija, 1956). Grain and straw samples were analyzed for N content to calculate total N uptake by the above-ground portion of the crops at maturity. Nutrient use efficiency (NUE) of added fertilizer N was calculated as:

$$\text{NUE (\%)} = \frac{\text{(Total N uptake in N fertilized plot – Total N in control plot)}}{\text{(Quantity of fertilizer N applied)}} \times 100$$

The data were statistically analyzed using the 'OPSTAT' (Sheoran *et al.* 1998) software of CCS Haryana Agricultural University, Hisar, Haryana. The significance of treatments was judged with the help of the 'F' test at a 5% level of significance.

Results and Discussion

Effect of N fertilization on seed and stalk yield

The results revealed that there was a consistent increase in seed and stalk yield of sesame by increasing graded levels of nitrogen fertilization from 30 to 60 kg/ha in three *kharif* seasons (Table 2 & Figure 1). In coarse-textured low N status soils, sesame seed yield increased significantly with the application of N up to 45 kg N/ha whereas, the seed yield of sesame crop was statistically at par with the application of 60 kg N/ha. The increase in mean seed yield was 19.23, 24.52, 39.26, and 41.18 percent and in mean stalk yield was 19.59, 23.81, 30.62, and 34.64 percent due to the application of 0, 30, 37.5, 45, and 60 kg N/ha, respectively over the control.

The positive effect of nitrogen fertilization on the seed and stalk yield of sesame might be attributed to the deficit level of the available nitrogen content of the experimental soil. This necessitated the high demand for nitrogen by the crop as N is known to enhance the development of plant growth systems (Russel, 1973) which in turn increases the efficiency of the roots in absorbing various nutrients. Marschner (1986) reported that the application of phosphorus stimulates photosynthesis, carbohydrate metabolism, and synthesis of protein in turn increases the amount of metabolites synthesized by sesame plants. Also, it plays an important role in enhancing translocation of metabolites which might be the reason for the increasing seed and stalk yield. The improved growth and profuse branching due to N fertilization as discussed earlier coupled with increased photosynthates and constituent of chlorophyll and greater mobilization of photosynthates toward reproductive parts of the plants on the other hand the adequate supply of nitrogen is beneficial for both carbohydrates and protein metabolism as it assists cell division and cell enlargement, resulting in more leaf area and thus ensuring good seed and dry matter yield. These findings follow those reported by Singh *et al.* (1994), Ravinder *et al.* (1996) Patra (2001), and Ibrahim et al. 2014 in sesame crops.

Effect of N fertilization on protein content in seed and oil content

Experimental data indicated that different levels of nitrogen application exerted a significant influence on the quality parameters of sesame in terms of protein and oil content (Table 3). Application of 45 kg N/ha recorded significantly higher protein content in seed (22.52 %) and oil content (48.20 %) which was statistically at par with that of 60 kg N/ha. This might be due to the synergistic effect of nitrogen fertilization on nitrogen uptake which facilitates protein synthesis and activates different enzymes it is also known that N facilitates the uptake and assimilation of N into simple amino acids and amides, which in turn increases the peptide synthesis leading to protein synthesis. Hence, **an** increased concentration of N in the seed might have increased the protein content. These results are in close conformity with the findings of Thakur *et al.* (1998) in sesame. The increased content of oil coupled with the significantly higher seed yield of sesame could be the most possible reason for the higher oil yield obtained due to nitrogen fertilization. Thakur *et al.* (1998) and Thanki *et al.* (2004) have also reported improvement in these quality characteristics of sesame due to nitrogen application.

N uptake, N use efficiency, and available N content

The total N-uptake in the sesame plant was also significantly influenced by levels of N application.

The nitrogen uptake increased significantly with the increased levels up to 60 kg N/ha. The uptake was increased from 43.10 to 52.38 kg/ha with increasing levels of nitrogen from 0 to 60 kg N/ha (Table 4 & Figure 2). The progressive increase in the supply of nitrogen to the crop resulted in higher availability of this nutrient, resulting in higher biomass yield. The impact of higher uptake of nitrogen under these treatments was reflected in the growth and yield performance of the crop. Similarly, a good supply of phosphorus is usually associated with increased root density and proliferation which aid in extensive exploration and supply of nutrients and water to the growing plant (Shehu *et al.,* 2010).

The N-use efficiency varied from 43.10 to 52.38 percent being the maximum (52.38 %) with the application of 45 kg N/ha. The increased supply of nutrients and a good response by the plants resulted in enhanced translocation of nutrients and ultimately build-up of the available N content in the soil and improved N-use efficiency as reported by Ulukan (2008).

Increasing levels of nitrogen fertilization from 0 to 60 kg/ha significantly improved the available nitrogen in soil after harvesting of the crop. The initial available N status was 106.45 kg N/ha whereas it was 105.43, 107.51, 108.11, 109.15, and 110.23 kg/ha at 0, 30, 37.5, 45, and 60 N/ha, respectively (Table 4). The soil available N significantly increased up to the application of 30 kg N/ha. The highest available N content of 110.23 kg/ha was observed with the application of 60 kg N/ha which was significantly superior to control. Javia *et al.* (2010) also observed improved post-harvest build-up of soil available N as compared to without N application in sesame crops.

Effect of N fertilization on crop economics

It is evident from the data presented in Figure 3 that gross returns and net returns of sesame increased with increasing levels of nitrogen at 0, 30, 37.5, 45, and 60 N/ha, respectively which might be due to the increasing seed and stalk yield with increasing nitrogen levels.

The minimum and maximum gross returns of Rs. 34967 and Rs. 49243 were recorded with control and application of 60 kg N/ha, respectively. The results also indicated that the total cost of cultivation followed the same trend. The economic data analysis revealed that the benefit-cost ratio also increased with nitrogen application and was 0.93, 1.10, 1.15, 1.27, and 1.28 at 0,30, 37.5, 45 and 60 kg N/ha, respectively. These findings are in agreement with what has been reported by Sharma (2005), Hanumanthappa *et al.* (2008) and Javia *et al.* (2010).

Conclusion

Based on the results of a research trial carried out for three years, it could be concluded that in coarse-textured low N status soils, application of 45 kg N/ha resulted in significant found optimum in terms of crop yield, quality parameters, use efficiency, soil nitrogen status, and economics.

Acknowledgements

The authors are thankful to the Regional Director, RRS, Bawal, and Professor and Head, Department of Soil Science, CCSHAU, Hisar, for providing facilities, technical support, and necessary guidance for this study.

Author contributions

The experiment was conducted at the Regional Research Station, CCS HAU, Bawal, Haryana, from 2015 to 2017 and was carried out by M.K. Jat, P.K. Yadav, and Rameshwar Singh.

The soil and analysis were done by M.K. Jat and P.K. Yadav. All authors contributed to the manuscript preparation and approved the final version of the same.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Table 2 Effect of N fertilization on seed yield and stalk yield in sesame

N level (kg/ha)	Seed yield (q/ha)				Stalk yield (q/ha)			
	2015	2016	2017	Mean	2015	2016	2017	Mean
0	6.24	6.20	6.28	6.24	18.90	18.95	18.98	18.94
30	6.85	7.74	7.73	7.44	22.15	22.86	22.94	22.65
37.5	7.23	8.12	7.96	7.77	23.52	23.38	23.45	23.45
45	8.95	8.45	8.68	8.69	24.90	24.60	24.72	24.74
60	9.02	8.62	8.78	8.81	25.54	25.46	25.50	25.50
CV (%)	12.05	12.10	11.80	12.90	10.05	10.90	11.10	10.68
CD (P=0.05)	0.54	0.56	0.57	0.55	1.18	1.15	1.10	1.14

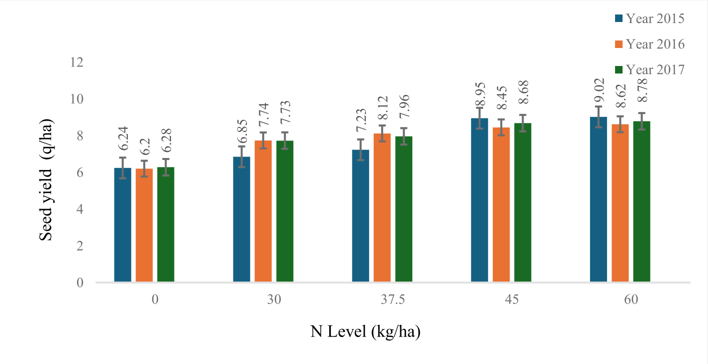

Figure 1. Seed yield (q/ha)

Table 3 Effect of N fertilization on protein and oil content in sesame seed

N level (kg/ha)	Protein content in seed (%)	Oil content (%)
0	18.20	42.20
30	19.70	43.15
37.5	21.08	45.08
45	22.52	48.20
60	22.90	49.10
CD (P=0.05)	1.40	3.05

Table 4 Effect of N fertilization on total N uptake, NUE and available nitrogen in sesame

N level (kg/ha)	Total N uptake (kg/ha)				NUE (%)	Available N (kg/ha)			
	2015	2016	2017	Mean		2015	2016	2017	Mean
0	52.86	51.79	53.97	52.87	-	106.30	104.30	105.70	105.43
30	65.98	64.76	66.65	65.80	43.10	108.40	106.32	107.80	107.51
37.5	69.50	67.35	72.02	69.62	44.67	108.98	107.25	108.10	108.11
45	76.44	75.35	77.52	76.44	52.38	109.60	108.65	109.20	109.15
60	79.38	78.02	81.02	79.47	44.33	109.98	110.28	110.42	110.23
CD (P=0.05)	2.71	3.02	2.81	2.85	-	2.05	1.98	2.10	2.04

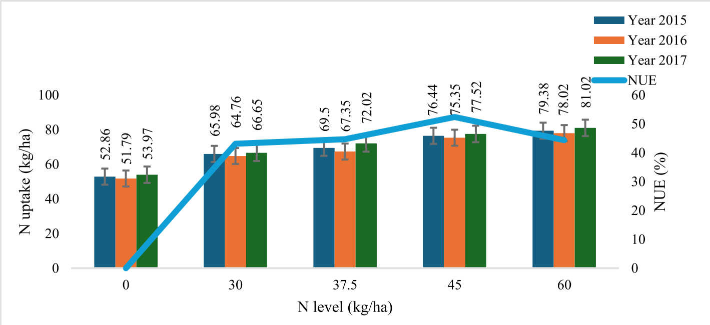

Figure 2. N uptake and efficiency

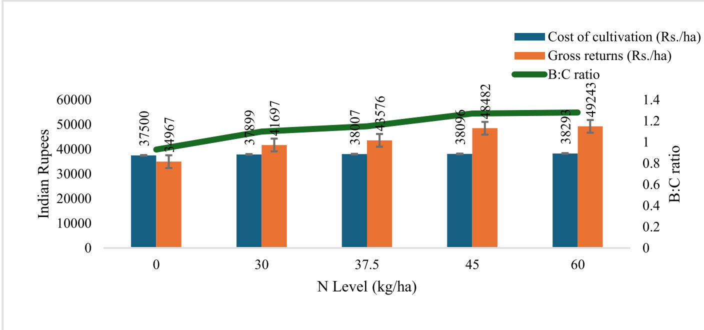

Figure 3. Economics of Cultivation

References

1. Adam NM (1986) Agronomy of Sesame, Sunflower, and Soybean; Annual Report; Kenana Research Station: Kanana, Sudan.

2. Akanbi WB, Akande MO, Baiyewu RA, Akinfasoye JO (2000) Effect of Maize Stover Compost and Nitrogen Fertilizer on Growth, Yield and Nutrient Uptake of Amaranth. Moor J of Agricultural Sci 1:6-15.

3. Akanbi WB, Oyediran GO, Olaniran OA, Adeyeye SA, Akande MO Adediran, JA (2006) Effects of organic and inorganic fertilizers and their combination on Growth, Nutrient uptake and shoot yield of Celosia (*Celosia argentea* L.). Sci Focus 11: 84-90.

4. Akhtar J, Baqa S, Khan S, Kakar AK, Abro BA,Baloch PA(2015) Effect of diff erentlevels of nitrogen and phosphorus on growth and yield of sesame. Int J Biol Biotech 12:493–498.

5. Anonymous (2021) Agriculture Statistics. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India.

6. Hanumanthappa M, Dalavai BL (2008) Dry matter production nutrient uptake and economics of sesame (Sesamum indicum L.) as influenced by organic manure and fertilizer levels. Mysore J of Agriculture Sci 42: 629-634.

7. I Haruna (2011) "Growth and yield of sesame (Sesamum indicum L.) as influenced by nitrogen and intra row spacing in Lafia, Nasarawa state of Nigeria. Elixir Agri 41: 5685–5688.

8. Ibrahim M, Hussain M, Khan A, Jamal, Y Ali, M, Malik MFA (2014) Effect of nitrogen andphosphorus on yield and yield components of Sesame. International J of Sci Basic and Applied Res 18:95-101.

9. Jackson ML (1973) Soil chemical analysis. Prentice Hall of India Pvt. Ltd. New Delhi.

10. Javia RM, Vora VD, Sutaria GS, Akbari KN, Padmani DR (2010) Effect of nutrient management on productivity of sesame and soil fertility of sandy loam soils under rainfed condition. An Asian J of Soil sci 5:80-82.

11. Lafond GP, CA Grant AM, Johnston DW, McAndtrew WE May (2003) Nitrogen and Phosphorous management of no-tll flax. In Better Crops with. AgDex. 541-1982.

12. Lu X, Zhang, L, Sun Q, Song GJ (2019) Huang Extraction, identification and structure-activity relationship of antioxidant peptides from sesame (*Sesamum indicum* L.) protein hydrolysate. Food Res Int 116:707-716.

13. Marschner H (1986) Mineral Nutrition of Higher Plants. Academic Press Inc., USA, pp. 674 (1986).

14. Mushtaq A, Hanif MA, Ayub MA, Bhatti IA, Jilani MI (2020) Sesame, Medicinal Plants of South Asia Elsevier. 601-615.

15. Olaniyi JO, Akanbi WB (2008) Effects of cultural practices on mineral compositions cassava peel compost and its effects on the performance of cabbage (*Brassica oleraceae* L.). Journal of Applied Biosci 8:272-279.

16. Pandey SN, Sinha BK (1986) Plant Physiology. Vikas Publishing House Pvt. Ltd., New Delhi, pp. 112-130.

17. Patra AK (2001) Yield and quality of sesame (Sesamum indicum L.) as influenced by N and P during post rainy-season. Ann of Agricultural Research 22:249-252.

18. Ravinder N, Satyanarayana V, Rao, VP, Latchanna A, Varaprasad PV (1996) Influence of irrigation and fertilization on seed yield, nutrient uptake and fertilizer use efficiencies in summer sesame (Sesamum indicum L.). Journal of Oilseeds Research 13:173-177.

19. Russel EW (1973) Soil conditions and plant growth. Language Book Society and Longman, London, pp. 30-37.

20. Sharma PB (2005) Fertilizer management in sesame (Sesamum indicum L.) based intercropping system in tawa command area. Journal of Oilseeds Res 22:63-65.

21. Shehu HE, Kwar JD, Sandab MK (2010) Effects of N, P and K fertilizers on yield, content and uptake of N, P and K by sesame (Sesamum indicum). International J. of Agriculture and Bio 12:845-850.

22. Sheoran OP, Tonk, DS, Kaushik LS, Hasija RC, Pannu R S (1998) Statistical Software Package for Agricultural Research Workers. In Recent Advances in information theory, Statistics& Computer Applications (Eds.), Department of Mathematics Statistics, CCS HAU, Hisar.139-143.

23. Singh I, Nagda BL, Choudhary LS (1994) Response of sesame (Sesamum indicum L.) varieties to nitrogen and phosphorus. Annals of Agri Res 15:250-251.

24. Subbiah BV, Asija GL (1956) A rapid procedure for determination of available nitrogen status in soil. Current Sci 25:259-260.

25. Teboul N Gadri Y, Berkovich Z, Reifen RZ (2020) Peleg Genetic architecture underpinning yield components and seed mineral–nutrients in sesame. Genes, 11:1221.

26. Thakur DS, Patel SR, Lal N (1998) Yield and quality of sesame (*Sesamum indicum* L.) as influenced by nitrogen and phosphorus in light textured inceptisols. Indian Journal of Agronomy 43:325-328.

27. Thanki JD, Patel AM, Patel MP (2004) Effect of date of sowing, phosphorus and biofertilizer on growth, yield and quality of summer sesame. Journal of Oilseeds Res 21:301-302.

28. Tiessen KD, Flaten CA, Grant RE, Karamanos DL, Burton, Entz MH (2003) Efficiency of fall banded N: Effects of application date, landscape position and inhibitors. In proc. of 2004 Manitoba Agronomist's conference, Winnipeng. 118-132.

29. Ulukan H (2008) Effect of soil applied humic acid at different sowing times on some yield components in wheat (Triticum spp.) hybrids. International Journal of Bot 4:164-175.