ISSN: 0976-1675

www.rjas.org

Research Journal of Agricultural Sciences

Research Paper

DI: 6248-0607-248

Comparative Studies of Effects of Fertilizers and Manures on Biochemical Characteristics of Sesame (*Sesamum indicum* L.) Plant

Kusum Kurdiya*, Jyoti Kumari Meena, Ruchi Khedia, K C Sharma and Manju Sharma
Department of Botany,
University of Rajasthan, JLN Marg, Jaipur - 302 004, Rajasthan, India

Received: 05 July 2020; Revised accepted: 14 August 2020

ABSTRACT

The present study was carried out to analyze biochemical parameters of *Sesamum indicum* L. by treating the plants with fertilizers and manures at University of Rajasthan, Jaipur. The experiment consisted of five treatments named as T_1- control (without any manure or fertilizer), T_2- urea as nitrogen fertilizer, T_3- urea + diammonium phosphate as N+P fertilizer, T_4- vermicompost, and T_5- a combination of vermicompost + biofertilizer. These were evaluated in a complete randomized design with four replications. Biochemical parameters taken for the study were- lipids, proteins, total soluble sugars, starch, phenols, and two antioxidant enzymes: peroxidase and catalase. Experimental results showed that chlorophyll-a, b, total chlorophyll, protein content, lipids, and peroxidase were observed maximum in vermicompost treated plants. Total phenols were observed increased in vermicompost + biofertilizer treatment. Therefore, they can be used to enhance the above parameters as an alternative of inorganic fertilizers under the arid conditions of Rajasthan. However, carotenoids, TSS, starch, and catalase were found higher in control plants. These parameters were not influenced significantly by fertilizer and manure treatments. It suggests that an optimized fertilizer rate is necessary to ensure agricultural sustainability in respect of synthesized food and antioxidants.

Key words: *Sesamum indicum* L., Fertilizers, Manures, Biochemical characteristics

Sesame (*Sesamum indicum* L.) is an important oilseed crop of the warm region of the tropics and sub-tropics and considered the most ancient oilseed crop grown in India (Wayase *et al*. 2014). It belongs to the family Pedaliaceae. Sesame has antioxidant value due to the presence of lignans (sesamin, sesamolin) and tocopherol. Sesame seeds are rich in fatty acids like oleic, linoleic, palmitic, and stearic acids, also contains vitamins (vitamin E, vitamin A and B complex, niacin) and some other minerals (Choudhary *et al*. 2017).

For proper growth and optimal yield of any crop, nutrients must be required to plants in correct quantity and proportion. To fulfill these requirements, chemical fertilizers or organic manures are required (Sheikh and Ishaq 2016). Chemical fertilizers have been used to increase the productivity of food crops by promoting plant growth but high inputs of agrochemicals can cause adverse environmental effects such as pollution, death of beneficial micro-organisms, residue accumulation in soil, and finally affect soil fertility. All these adverse effects of synthetic fertilizers lead to the search for more sustainable and eco-friendly agricultural methods. Organic manure provides soil organic matter and beneficial soil microbes, have importance as key factors in maintaining soil quality and crop production (Subash and Raftah 2016, Kurdiya *et al*. 2019). A new approach is biofertilizers are non-hazardous, environmentally friendly products. These have been used in sustainable agriculture to improve the plant nutrients present in soil (Youssef *et al*. 2010).

In Rajasthan, farmers face the low nutrient status of soil due to drought, lack of proper rain, excess use of fertilizers, and many other reasons. It affects the growth, quality and, productivity of crops and also soil properties. Considering all these factors, the present study was done to evaluate the

***Corresponding author:** Kusum Kurdiya, Research Scholar, University of Rajasthan, JLN Marg, Jaipur - 302 004, Rajasthan
e-mail: kusumkurdiya85@gmail.com

effect of fertilizers and manures on biochemical quality parameters of sesame.

MATERIALS AND METHODS

The present study was conducted in the department of botany, University of Rajasthan, Jaipur. A complete randomized design (CRD) was adopted for the experiment. The seeds were sown in experimental pots (10 kg) in July 2017. The minimum and maximum temperatures during growing crops ranged from 20-30ºC and 28-35ºC respectively. The pots were irrigated thrice in a week and watering schedules same in all treatments. The experiments consist of five treatments named T_1, T_2, T_3, T_4 and T_5, each replicated four times. Treatments were: T_1- control (without any fertilizer or manure), T_2- 40 kg N ha^{-1} (0.392 gm urea in 10 kg soil), T_3- 40 kg. N + 25 kg. P_2O_5 ha^{-1}, (0.392 gm urea + 0.247 gm DAP in 10 kg soil), T_4-Vermicompost 10t ha^{-1} (45.45 gm in 10 kg soil), T_5- Biofertilizer + vermicompost. A double dose of recommended urea fertilizer was applied in two splits: one split at sowing time and another at flowering time. Ten-day old seedlings were used for estimation of two antioxidative enzymes viz. peroxidase, and catalase. After two months, fresh plant leaves were used for chlorophyll estimation. After completing the life-cycle of sesame plants, leaves were shade dried and powdered. This dry material was used for protein, phenol, carbohydrate, and starch estimation. Chlorophyll a, chlorophyll b, carotenoids, and total chlorophyll were estimated by Arnon's method (1949). Protein content in leaves was measured by a method described by Lowry *et al.* (1951). Phenol content in leaf was measured by a method described by Bray and Thorpe (1954). Carbohydrate was estimated in leaf by phenol-sulphuric acid method (Dubois *et al.* 1951). Peroxidase and catalase were estimated by methods used by Putter and Aebi (1974) respectively.

The statistical analysis was done using R language version 3.5. One-way ANOVA was used to check the significant difference between the treatments at $p<0.05$ significant level. T-tests were employed to test the difference between the different variables in multiple treatments. SEm± and critical difference (CD) values were also calculated at 0.05 probability level.

RESULTS AND DISCUSSION

Biochemical parameters studied in the sesame plant were chlorophyll-a, chlorophyll-b, carotenoids, total chlorophyll, protein, total soluble sugars (TSS), starch, total phenols and two antioxidant enzymes: catalase and peroxidase. These parameters were studied in different fertilizer treated plants such as control (T_1), nitrogen fertilizer (T_2), N+P (T_3), vermicompost (T_4) and vermicompost + biofertilizer (T_5) (Table 1).

In sesame plants studied, the amount of chlorophyll-a was found higher in T_4 treatment (1.31±0.02 mg/gm) followed by T_2 (1.19±0.03 mg/gm) and least observed in T_3 treatment (1.04±0.03 mg/gm). Chlorophyll-b amount was observed maximum in T_4 treatment (0.46±0.01 mg/gm) followed by T_5 (0.40±0.03 mg/gm) as compared to other treatments (Fig 1). Similarly, total chlorophyll was maximum in T_4 (1.79±0.02 mg/gm) and minimum in T_3 (1.41±0.02 mg/gm). From these experiments, chlorophyll a, chlorophyll b and total chlorophyll were observed maximum in vermicompost treated plants (1.31, 0.46 and 1.79 mg/gm fresh weight respectively) in comparison to other treatments. Similar observations were found by Manikandan and Thamizhiniyan (2016). They observed that chlorophyll content was observed maximum in compost treatment in the *Helianthus annuus* L. plant. The reason for increased chlorophyll content may be that availability of N, P, and K content was higher in compost treatment which might be due to rapid decomposition and mineralization in compost as compared to inorganic fertilizers.

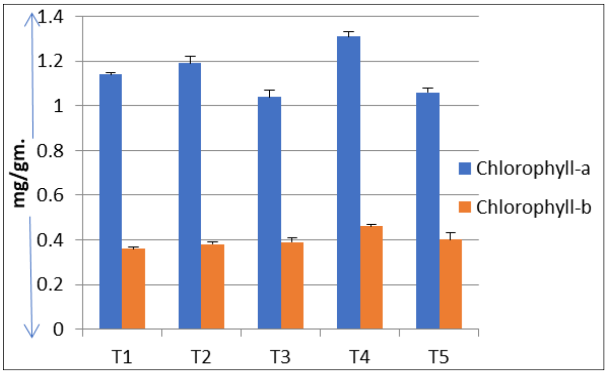

Fig 1 Histogram depicting chlorophyll-a and chlorophyll-b amount from different fertilizer treatments

The amount of carotenoid was observed higher in T_1 treatment (0.604±0.005 mg/gm) and lowest in T_3 treatment (0.418±0.001 mg/gm) (Fig 2). Carotenoids help plants to absorb light energy for use in photosynthesis. They also have an important antioxidant function of deactivating free radicals-single oxygen atom that can damage cells by reacting with other molecules (Sazalay 2015) Carotenoid was observed higher in T_1 treatment where no fertilizer or manure added. It may be due to nutrient deficiency stress.

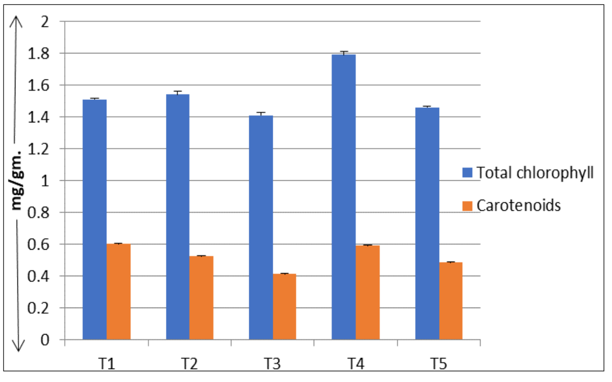

Fig 2 Histogram represents total chlorophyll and carotenoids amount from different fertilizer treatments

Protein content was analyzed 85.05±3.33, 98.06±1.71, 111.16±1.84, 129.94±14.80, 120.93±2.51 in T_1, T_2, T_3, T_4, and T_5 treatments respectively (Fig 3). These results show that higher protein content was found in T_4 treatment and least was found in T_1 treatment. Protein content was observed higher in vermicompost treatment followed by the combined application of vermicompost + biofertilizer treatment. These results are in accord with Mathivanan *et al.* (2013) who concluded that vermicompost consist of macronutrients and micronutrients and the uptake of these nutrients have a positive effect on plant nutrition, photosynthesis, and chlorophyll content of the leaves. An increase in protein content was also reported by Gowda *et al.* (2008) in the wheat crop grown under vermicompost application.

Total soluble sugars (TSS) were found maximum in T_1 (12.86±0.90 mg/gm) followed by T_4 treatment (12.66±0.41 mg/gm) and minimum was observed in T_2 treatment (10.33±1.40 mg/gm) (Fig 4). Elhanafi *et al.* (2019) found in their study that increased nitrogen fertilizer had an adverse effect on the oil and sugars in sesame seeds. TSS content was negatively influenced by nitrogen supply. In our study, in T_2 treatment, double dose RDF of nitrogen fertilizer was added; it may have an adverse effect on TSS content in sesame leaves and observed the least value as compared to others. But in T_4 treatment, vermicompost releases nitrogen slowly in soil, so it may be possible that nitrogen not available in readily form, may not have an adverse effect on TSS and its value was found higher in T_4 than other inorganic treatments, similarly, in T_1 treatment (control) where no fertilizer or manure added, has maximum TSS value followed by T_4 treatment. Other findings suggest that nitrogen is a direct factor that regulates carbon balance that is the basic element for sugar conservation. Sugar content was found to decrease with increasing nitrogen levels. Sugar is involved in many chemical reactions to produce energy (Xia and Cheng 2004).

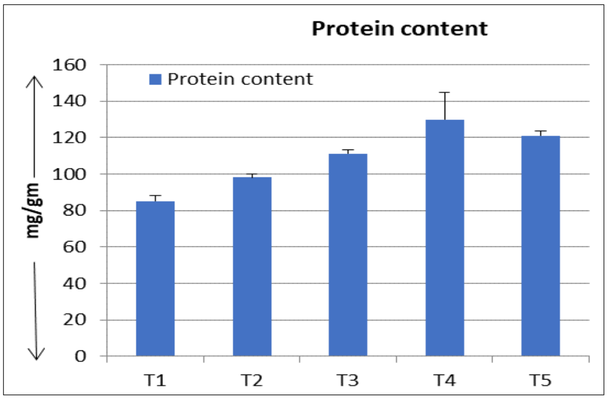

Fig 3 Histogram depicting protein amount from different fertilizer treatments

Table 1 Showing comparative studies on biochemical characteristics of sesame plant

Treatment	Chlorophyll-a (mg/gm)	Chlorophyll-b (mg/ gm)	Total chlorophyll (mg/ gm)	Carotenoids (mg/gm)	Protein (mg/gm)
T_1	1.14± 0.01	0.36± 0.01	1.51±0.01	0.604±0.005	85.05± 3.33
T_2	1.19± 0.03*	0.37± 0.01^{NS}	1.54±0.02 ^{NS}	0.525±0.004***	98.06± 1.71**
T_3	1.04± 0.03^{NS}	0.39± 0.02^{NS}	1.41±0.02**	0.418±0.001**	111.16±1.84***
T_4	1.31± 0.02***	0.46± 0.01**	1.79±0.02***	0.591±0.03*	129.94±14.80***
T_5	1.06± 0.02*	0.40± 0.03*	1.46±0.01**	0.489±0.003***	120.93±2.51***
SEm±	0.04	0.01	0.01	0.002	4.02
CD (0.05)	0.13	0.03	0.04	0.006	12.84

……Table 1 Continued……

Treatment	TSS (mg/gm)	Starch (mg/gm)	Total phenols (mg/gm)	Lipids (mg/gm)	Catalase (µml/l/g/fw)	Peroxidase (µml/l/g/fw)
T_1	12.86± 0.90	6.96±0.68	1.45±0.01	35± 6.24	1.54±0.48	1.82±0.66
T_2	10.33± 1.40^{NS}	5.3±0.1*	1.07± 0.02***	37.6±7.31 ^{NS}	1.0±0.22 ^{NS}	1.52±0.59^{NS}
T_3	12.01± 1.58^{NS}	5.63± 0.15*	1.22±0.02***	28.3±5.66^{NS}	0.82±0.12^{NS}	1.90±0.43^{NS}
T_4	12.66± 0.41^{NS}	5.56± 1.80^{NS}	1.21± 0.02***	46.0±6^{NS}	0.78±0.08^{NS}	2.24±0.44^{NS}
T_5	10.93±2.38^{NS}	4.6±0.7*	1.5±0.01*	42.0±11.13^{NS}	0.93±0.24^{NS}	1.60±0.77^{NS}
SEm±	0.86	0.53	0.01	4.35	0.22	0.39
CD (0.05)	NS	NS	0.039	NS	NS	NS

***=p 0.001, **=p 0.01, *=p 0.05, NS=Non significant

Starch content was estimated 6.96±0.68, 5.3±0.1, 5.63±0.15, 5.56±1.80, and 4.6±0.7 mg/gm. dry weight in T_1, T_2, T_3, T_4, and T_5 treatments respectively (Fig 4). A higher amount of starch was found in T_1 treatment and least in T_5 treatment. Experiments showed that total soluble sugars and starch were observed maximum in T_1 treatment as compared to treated plants. Similar results were also found by Hirano *et al.* (2005), Wang *et al.* (2006) who worked on rice plants and Chen and Cheng (2003) in grapes (*Vitis labrusca* L.). They observed from their studies that starch and soluble sugars can accumulate with low nitrogen supply. Braun *et al.* (2017) analyzed starch accumulation in potato leaves, at conditions of low nitrogen. The relationship starch/NRS is indicative of carbon partitioning in plants, which has increased as doses of nitrogen were reduced. They stated from their experiments that at poor conditions of nitrogen (N) in the soil, potato plants may accumulate starch in leaves and be indicative of nitrogen nutritional stress. Cruz *et al*. (2003) reported that this behaviour is due to a deficiency in the capacity of exporting sugar simultaneously to the stimulus for the formation of starch in cassava. They found that total soluble sugars and non-reducing sugars had their contents increased and reducing sugars as well as starch decreased as nitrate supply increased in the solution. The reason may behind that the accumulation of soluble sugar under low nitrogen fertilizer might be due to a reduction in the sink size of the plant when nitrogen is limited; hence reducing the translocation of carbohydrate to the other plant parts (Meyer *et al*. 2006).

The amount of total phenols was observed maximum in T5 treatment (1.50±0.015 mg/gm) and observed minimum in T_2 treatment (1.07±0.02 mg/gm) (Fig 4). Phenolic compounds are secondary plant metabolites and naturally present in almost all plant materials. These compounds can delay or inhibit the oxidative damage caused by free radicals such as superoxide anion radicals and non free-radical species such as H_2O_2 and singled oxygen, by inhibiting the initiation or propagation of oxidative chain reactions (Alizadeh *et al*. 2010). Asami *et al*. (2003) reported that organic fertilizer alone did not stimulate the biosynthesis of phytochemicals as phenolics in strawberries and lettuce. These results are in accord with our results. Our results also agree with Banerjee *et al*. (2012), who found in their study the maximum accumulation of phenol in leaves in biofertilizer and cycocel treated plots. Higher phenol content in leaves of biofertilizer treated plots might be attributed to the use of accumulated nitrate in plants thus enabling it to use more carbohydrates for structural growth under the influence of biofertilizer application (Hanafy *et al*. 2000). In other studies, it was considered that the concentration of phenol and proteins are negatively co-related (Jones and Hartley 1999). The reason may behind that phenylalanine which is a key substance in the synthesis of phenols, is preferentially applied to protein chain synthesis rather than phenols (Li *et al*. 2008).

Lipid content was found maximum in T_4 treatment (46.0±6) followed by T_5 treatment (42.0±11.13) and observed minimum in T_3 treatment (28.3±5.66) (Fig 5). Lipid content was not significantly affected (p>0.05). The positive effect of nitrogen supply on the formation of chloroplasts during leaf growth also increases the chlorophyll content of leaves (Singh *et al*. 2016). In turn, the chloroplast formation leads to an increase in the lipid content of leaves and chloroplast constituents such as chlorophyll and carotene (Mondal *et al*. 2017).

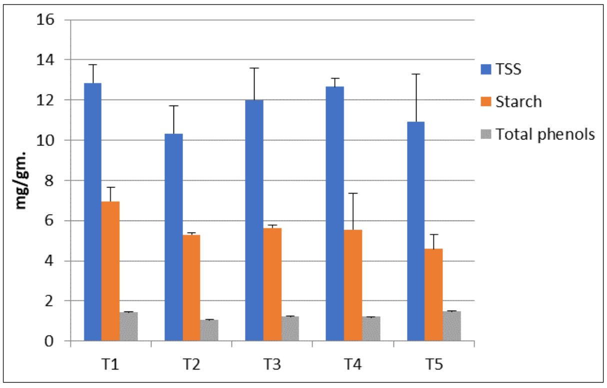

Fig 4 Histogram representing TSS, Starch and total phenols from different fertilizer treatments

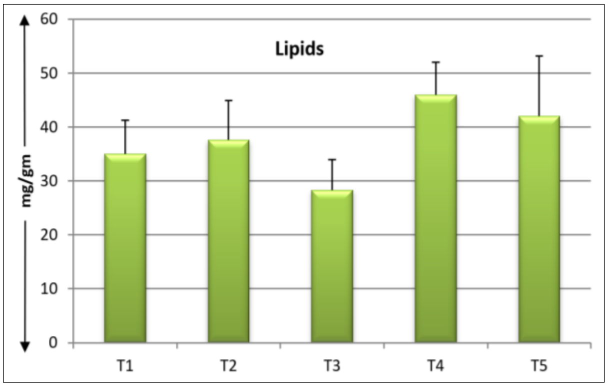

Fig 5 Histogram showing lipids amount from different fertilizer treatments

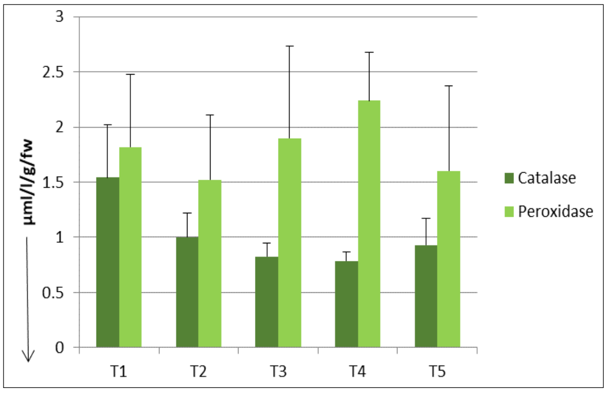

Fig 6 Histogram showing catalase and peroxidase concentration from different fertilizer treatments

Antioxidant enzymes (catalase and peroxidase) were estimated 1.54±0.48 and 1.82±0.66 in T_1 treatment, 1±0.22 and 1.52±0.59 in T_2 treatment, 0.826±0.12 and 1.9±0.43 in T_3 treatment, 0.786±0.08 and 2.24±0.44 in T_4 treatment, and 0.93±0.24 and 1.60±0.77 µml/l/g/fw in T_5 treatment. The amount of catalase was more in T_1 treatment and a decreased amount was observed in T_4 treatment. Peroxidase enzyme was found maximum in T_4 treatment and minimum observed in T_2 treatment. Catalase and peroxidase both were not significantly (p>0.05) affected. Ahmed *et al*. (2010) reported that the application of organic manures and biofertilizers increase catalase and peroxidase activities in sorghum. They concluded in their study that this might be due to mineral fertilization can supply control plants greater amounts of nitrogen in a brief period to improve metabolism with no need of additional antioxidant enzymes, whereas in case of plants that receive the organic fertilizers face a condition of slow release of available nitrogen. That might be considered as adverse environmental conditions due to nutrient deficiency where the role of the antioxidant enzymes support plants to become more tolerant against the proposed disturbances in different plant physiological process (Siavoshi and Laware 2013). In our study, catalase activity was more in T_1 (control) treatment, maybe nutrient deficiency stress, due to which plant accumulates high catalase when plant faces nutrient deficiency as seen in control.

Antioxidant levels in *Brassica rapa* seemed to decrease as the fertilizer rate increased, especially under conventional fertilization **(**Zhao *et al*. 2006, Sheikh and Ishak 2016). It was observed that the use of chicken dung (organic fertilizer) resulted in higher production of secondary metabolites and increased antioxidant activity compared to the use of NPK (inorganic fertilizer) (Ibrahim *et al*. 2013).

From our study, it was concluded that vermicompost help to enhance chlorophyll content, proteins, lipids, and peroxidase in sesame plant under arid conditions of Rajasthan. The combined application of vermicompost and biofertilizer is beneficial for total phenols elevation, that has a major role in the prevention of oxidative damage. Whereas carotenoids, TSS, starch, and catalase were not influenced by fertilizer treatments may be due to nutritional stress. It suggests that an optimized fertilizer rate is necessary to ensure agricultural sustainability with respect to synthesized food and antioxidants.

Acknowledgement

We are highly thankful to CSIR-UGC for providing financial support to one of the authors in the form of fellowship.

LITERATURE CITED

Aebi H. 1974. Catalases. *In*: (Eds) Bergmeyer H.U. Methods of enzymatic analysis. Academic Press, NY. **2**: 673-684.

Ahmed A G, Orabi S and Gomaa A M. 2010. Bio-organic farming of grain sorghum and its effect on growth, physiological and yield parameters and antioxidant enzymes activity. *Research Journal of Agriculture and Biological Sciences* **6**(3): 270-279.

Alizadeh A, Khoshkhui M, Javidnia K, Firuzi O, Tafazoli E and Khalighi A. 2010. Effects of fertilizer on yield, essential oil composition, total phenolic content and antioxidant activity in *Satureja hortensis* L. (Lamiaceae) cultivated in Iran. *Journal of Medicinal Plants Research* **4**(1): 33-40.

Arnon D I. 1949. Copper enzymes in isolated chloroplasts, polyphenoxidase in *Beta vulgaris. Plant physiology* **24**: 1-15.

Asami D K, Hong Y J, Barrett D M and Mitchell A E. 2003. Comparison of the total phenolic and ascorbic acid content of freeze-dried and air-dried marionberry, strawberry, and corn grown using conventional, organic, and sustainable agricultural practices. *Journal of Agriculture and Food Chemistry* **51**: 1237-1241.

Banerjee A, Datta J K and Mondal N K. 2012. Biochemical changes in leaves of mustard under the influence of different fertilizers and cycocel. *Journal of Agricultural Technology* **8**(4): 1397-1411.

Braun H, Fontes P C R, Silva T P, Finger F L, Cecon P R and Ferreira A P S. 2017. Carbohydrates concentration in leaves of potato plants affected by nitrogen fertilization rates. *Rev. Ceres, Viçosa* **63**(2): 241-248.

Bray H G and Thorpe W V. 1954. Analysis of phenolic compounds of interest in metabolism. *Methods of Biochemical Analysis* **52**: 1-27.

Chen L S and Cheng L. 2003. Carbon assimilation and carbohydrate metabolism of 'Concord' grape (*Vitis labrusca* L.) leaves in response to nitrogen supply. *Journal American Horticulture Science* **128**: 754-760.

Choudhary K, Sharma S R, Jat R and Didal V K. 2017. Effect of organic manures and mineral nutrients on quality parameters and economics of sesame (*Sesamum indicum* L.). *Journal of Pharmacognosy and Phytochemistry* **6**(3): 263-265.

Cruz J L, Mosquim P R, Pelacani C R, Araújo W L and Damatta F M. 2003. Carbon partitioning and assimilation as affected by nitrogen deficiency in cassava. *Photosynthetica* **41**: 201-207.

Dubois M K, Gilles J K, Robers P A and Smith F. 1951. Calorimetric determination of sugar and related substance. *Analytical Chemistry* **26**: 351-356.

Elhanafi L, Houhou M, Rais C, Mansouri I, Elghadraoui L and Greche H. 2019. Impact of excessive nitrogen fertilization on the biochemical quality, phenolic compounds, and antioxidant power of *Sesamum indicum* L. seeds. *Journal of Food Quality* **2019**: 1-6.

Gowda C, Patil N K B, Patil B N, Awaknavar J S, Ninganur B T and Hunje R. 2008. Effect of organic manures on growth, seed yield and quality of wheat. *Journal of Agricultural Sciences* **21**(3): 366-368.

Hanafy A H, Mishriky J F and Khalil M K. 2000. Reducing nitrate accumulation in lettuce (*Lactica saliva* L.) plants by using different biofertilizers. ICEHM, Cairo University, Egypt. pp 509-517.

Hirano T, Saito Y, Ushimaru H and Michiyama H. 2005. The effect of the amount of nitrogen fertilizer on starch metabolism in leaf sheath of japonica and indica rice varieties during the heading period. *Plant Production Science* **8**: 122-130.

Ibrahim M, Hussain M, Khan A, Jamal Y, Ali M and Malik M F A. 2013. Effect of nitrogen and phosphorus on yield and yield components of sesame (*Sesamum indicum* L.). *International Journal of Sciences: Basic and Applied Research* **18**(1): 95-101.

Jones C G and Hartley S E. 1999. A protein competition model of phenolic Allocation. *Oikos* **86**(1): 27-44.

Kurdiya K, Meena J K, Meena G N and Sharma M. 2019. Impact of fertilizers and manures on morphological and growth characters of sesame (*Sesamum indicum* L.). *Annals of Plant and Soil Research* **21**(4): 337-340.

Li J, Zhu Z and Gerend J. 2008. Effects of nitrogen and sulphur on total phenolics and antioxidant activity in two genotypes of leaf mustard. *Journal of Plant Nutrition* **31**(9): 1642-1655.

Lowry O H, Rogebrough N J, Farr A L and Randall R J. 1951. Protein measurement with the folin phenol reagent. *Journal of Biological Chemistry* **193**: 265-275.

Manikandan S and Thamizhiniyan P. 2016. Effect of organic and inorganic fertilizer on phytochemical constituents in sunflower. *Journal of Applied Advanced Research* **1**(4): 18-20.

Mathivanan S, Kalaikandhan R, Chidambaram A L A and Sundramoorthy P. 2013. Effect of vermicompost on the growth and nutrient status in groundnut (*Arachis hypogaea*. L.). *Asian Journal of Plant Science and Research* **3**(2): 15-22.

Meyer S, Cerovic Z G, Goulas Y, Montpied P, Demotes S, Bidel L P R, Moya I and Dreyer E. 2006. Relationship between assessed polyphenols and chlorophyll contents and leaf mass per area ratio in woody plants. *Plant Cell Environment* **29**: 1338-1348.

Mondal T, Datta J K and Mondal N K. 2017. Chemical fertilizer in conjunction with biofertilizer and vermicompost induced changes in morpho-physiological and bio-chemical traits of mustard crop. *Journal of the Saudi Society of Agricultural Sciences* **16**: 135-144.

Putter J. 1974. *Peroxidases*. *In*: (Eds) Bergmeyer H. U. Methods of Enzymatic Analysis: Academic Press, NY 2. pp 685-690.

Sazalay J. 2015. What are carotenoids? https://www.livescience.com/52487-carotenoids.html

Sheikh S and Ishak C F. 2016. Effect of nitrogen fertilization on antioxidant activity of Mas cotek (*Ficus deltoidea* Jack). *Journal of Medicinal Plants Studies* **4**(4): 208-214.

Siavoshi M and Laware S. 2013. Organic fertilizers role on antioxidant enzymes in rice (*Oryza sativa* L.). *International Journal of Farm and Allied Science* **2**(S2): 1337-1342.

Singh M, Khan, M M A and Naeem M. 2016. Effect of nitrogen on growth, nutrient assimilation, essential oil content, yield and quality attributes in *Zingiber officinale* Rosc. *Journal of Saudi Society of Agricultural Sciences* **15**(2): 171-178.

Subash M and Rafath H. 2016. Effect of biofertilizer and some plant growth hormones on germination and seedling character of Sesame (*Sesamum indicum* (L.). *Journal of Applied and Advanced Research* **1**(1): 46-48.

Wang S, Zhu Y, Jiang H and Cao W. 2006. Positional differences in nitrogen and sugar concentrations of upper leaves relate to plant N status in rice under different N rates. *Field Crops Research* **96**: 224-234.

Wayase K P, Thakur B D and Bhalekar M D. 2014. Influence of chemical fertilizer and biofertilizer application on yield contributing characters of sesame. *World Journal of Agricultural Sciences* **10**(3): 91-94.

Xia G and Cheng L. 2004. Foliar urea application in the fall affects both nitrogen and carbon storage in young ‘concord’ grapevines grown under a wide range of nitrogen supply. *Journal of American Society of Horticultural Science* **129**(5): 653-659.

Youssef G H, Seddik W M A and Osman M A. 2010. Efficiency of natural minerals in presence of different nitrogen forms and potassium dissolving bacteria on peanut and sesame yields. *Journal of American Science* **6**: 11.

Zhao X, Carey E E and Iwamoto T. 2006. Fertilizer source and high tunnel production environment affect antioxidant levels of Pac choi. *Horticultural Sciences* **41**(4): 1000-1001.