Effect of Planting Density and Integrated Nutrient Management in Sesame (*Sesamum indicum* L.)

Dambera M. Sangma, L.T. Longkumer, A.P. Singh, Virosanuo Solo

**ABSTRACT**

**Background:** *Sesamum indicum* L. is a tropical and subtropical plant cultivated for seed purpose, which yields about 50% high quality edible oil with 65% of the seeds being used for oil extraction and 35% for consumption purpose. The seeds have outstanding amounts of oil and consists of extensive root system that makes it very tolerant of drought.

**Methods:** A field experiment entitled “Effect of planting density and Integrated Nutrient Management in sesame” was carried out at the Agronomy Research Farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus, during Kharif season of 2017-18. Nine treatment combinations consisting of three level of planting density i.e., *T*₁ (20cm x 10cm), *T*₂ (30cm x 10cm) and *T*₃ (40cm x 10cm) along with three levels of nutrient management practices i.e., *N*₁ (100% RDF), *N*₂ (75% RDF + 25% FYM) and *N*₃ (75% RDF + 25% poultry manure) were tried in factorial randomized block design with three replications.

**Conclusion:** Among the different planting density and nutrient management practices, combined effect of 20cm x 10cm planting density with 75% RDF + 25% FYM nutrient recorded highest growth attributes viz., plant height (cm), number of leaves plant⁻¹, number of branches plant⁻¹ and yield attributes viz., number of capsules plant⁻¹, seed yield (kg ha⁻¹) and stover yield (kg ha⁻¹). However, the highest net return (16687.66) and B:C ratio (1.13) was obtained from the treatment combination of 40cm x 10cm planting density along with combination of 75% RDF + 25% poultry manure. Hence, the combined application of manures with inorganic source of nutrients with reduced planting density recorded higher growth and yield attributes thereby resulting higher economic return than the application of RDF alone.

**Key words:** Farmyard manure, Integrated nutrient management, Poultry manure sesame.

**INTRODUCTION**

*Sesame* (*Sesamum indicum* L.) is one of the oldest oilseed crop widely grown in tropical and sub-tropical area (Wei et al. 2011, Pathak et al. 2017) and is an important oilseed (2n=26) consisting of 24 species found in tropical South Africa and Asia. It is basically a short day plant but thrives well in long day areas too and thrives best on moderately fertile, well-drained soils with a pH of 5.5 to 8.0 (Kafiriti and Mponda, 2008). Among the various oilseed crops, sesame tops as the first for its highest oil content of 46-64% and energy 884 kcal (3699 kj), the oil contains 85% unsaturated fatty acid, known for its good quality oil (Kushwaha and Hasan, 2011) and has reducing effect on cholesterol and is said to prevent heart disease, hence, known as “Queen of oilseeds” by virtue of its excellent quality and utility (Sivagamy and Rammohan, 2013).

In global scenario, total cultivation area under sesame is 9,398,770 ha, producing 4.76 million tons (Islam et al. 2016), however focusing in India, it is grown in an area of 1,778,000 ha area, with a production of 8,11,000 tonnes and yield of 4561 kg ha⁻¹ (Anonymous, FAO, 2014). The major growing states of India are West Bengal, Gujarat, Madhya Pradesh, Tamil Nadu, Maharashtra, Rajasthan and Uttar Pradesh. As North-Eastern states, the growing area and production is found to be highest in Nagaland state but in terms of productivity the highest is in Manipur state (Debnath et al. 2015). As a report during 2011-12, area and production was highest in Dimapur district (area 630 ha and production of 400 metric tonnes) followed by Mokokchung district (area 450 ha and production of 260 metric tonnes). The overall production of 2011-12 was 2100 metric tonnes from an area of 3500 ha (Wallang, 2015).

Among the various agronomic practices involved, plant density plays a major role in influencing the productivity and yield (Nantongo, 2002). Plant density manipulates micro environment of the field and thus affects growth, development and yield formation of crops (Rahman and Hossain, 2011). Various reports showed that the growth and yield attributes and yield of sesame were determined by plant density and the adoption of suitable optimum spacing would fulfill the objective of maximizing the yield of sesame (Kalaiselvan et al. 2001). The low productivity has been
attributed to the imbalance of nutritional status of plant which is mostly due to the inadequate use of nutrients which limits the full expression of sesamum potential. Plant nutrients can be supplied from several sources viz: organic manures, crop residues, bio fertilizers and chemical fertilizers. Integrated use of organic manures and chemical fertilizers in sesame helps in maintaining stability in crop production, besides improving soil physical condition (Sahu et al. 2017). Keeping the points in view, the investigation had been under taken to test the effect of planting density and integrated nutrient management on sesame.

**MATERIALS AND METHODS**

A field trial was taken at the experimental site of SASRD, NU, Medziphema campus, during kharif 2017(July-October) where the soil was well drained and equally divided into three blocks with each block further divided into eight equal plots and spacing of 0.5m was maintained between blocks and plots. The initial analysis of soil was recorded with pH 4.5, organic carbon 1.34%, available N 252 kg ha⁻¹, available P<sub>2</sub>O<sub>5</sub> 16.8 kg ha⁻¹ and available K<sub>2</sub>O 173.6 kg ha⁻¹. The trial was conducted in RBD with three replication and consisted of the following- T<sub>1</sub> = 20x10cm<sup>2</sup> (750 plants); T<sub>2</sub> = 30x10cm<sup>2</sup> (495 plants); T<sub>3</sub> = 40x10cm<sup>2</sup> (375 plants); N<sub>1</sub> = 100% RDF; N<sub>2</sub> = 75% RDF + 25% FYM; N<sub>3</sub> = 75% RDF + 25% poultry manure. The experimental field was selected from a suitable site and was prepared during the second forth night of July, 2017. Sowing was done on 28<sup>th</sup> of July, 2017 where furrows were opened using spades according to the required sowing depth of the crop and sown manually in their respective rows. The thinning was carried out with a view to maintain optimum plant population by maintaining plant to plant distance of 10cm and followed by routine monitoring of site was carried out along with hand weeding was done twice at 30 and 50-60 days after sowing and at harvest. For plant protection, implementation of chloropyrifos 20% EC @ 1.5 ml litre⁻¹ followed by spraying of Mancozeb twice at an interval of 10-15days. The observations on growth and yield attributes were manually recorded by tagging on five random plants from each plot of each replication separately respectively.

**RESULTS AND DISCUSSION**

**Effect of planting density and INM on growth attributes**

The data presented in Table 1 indicated that plant height at 50DAS and at harvest was significantly influenced due to planting density, however, plant height at 25DAS turned out to be non-significant. The various spacing, 40 cm row to row spacing recorded the highest plant height at 50DAS (70.06 cm) while at harvest recorded 84.93cm. The wider row spacing had provided sufficient rooting and moisture extraction pattern to the plant, hence allowed better absorption of nutrient and water from the soil resulting in tallest plant, this was similar finding was discovered by Caliskan et al. (2004). Table 1 also revealed that the plant height was significantly influenced due to INM treatment at 50DAS and at harvest while at 25DAS was non-significant. Plant height at 50DAS and at harvest indicated that the application of 75% RDF + 25% produced significantly taller plants (70.93cm) and (83.50cm) respectively and it was statistically at par with treatment 75% RDF + 25% poultry manure at 50DAS (65.93cm) and at harvest (82.32cm). Similar observations were also recorded by Deshmukh et al. (2002) and Mamatha et al. (2014). The interaction effect (Table 2) proved that planting density and INM had no significant difference in all the growth stages (Girdharbhai, 2016). Highest number of branches plant<sup>⁻¹</sup> recorded during 50DAS was at plant spacing of 40x10cm<sup>2</sup> while during time at harvest treatment combination of 75% RDF + 25% FYM was found superior. Number of branches plant<sup>⁻¹</sup> was found to be increasing with increased row spacing, similarly such results were recorded by Bonsu (2003), Caliskan et al. (2004), El Naim (2010), Umar et al. (2012) and Kalaiselvan et al. (2001) who also outlined that depletion in plant density significantly increased the branches plant<sup>⁻¹</sup>. Among the INM, topmost number of branches plant<sup>⁻¹</sup> at 50DAS and at harvest was recorded in 75% RDF + 25% FYM (4.68 and 6.02) which was significantly superior over treatment 100% RDF (3.77 and 4.96 respectively). Similarly Mamatha et al. (2014) stated that supplication of RDF along with FYM resulted in higher no. of branches plant<sup>⁻¹</sup>. RGR at 25-50DAS with treatment 40x10cm<sup>2</sup> showed significant over all other treatments while at 0-25DAS and 25-50DAS due to different nutrient management treatments were found non-significant.

**Effect of planting density and INM on yield attributes**

The data in Table 3 reported that the number of capsule plant<sup>⁻¹</sup> were found to be significant. The maximum number of capsule plant<sup>⁻¹</sup> was recorded in treatment 40x10cm<sup>2</sup> (89.33), while the least number of capsule plant<sup>⁻¹</sup> was observed at treatment 20x10cm<sup>2</sup> (71.61). Similar observation was reported by Bonsu (2003), Caliskan et al. (2004) and El Naim (2010) who reported that reduction in planting density increases capsule yield plant<sup>⁻¹</sup> and number of mature seeds plant<sup>⁻¹</sup>. In terms of INM, there was no significance, similarly no interaction was reported (Table 4). The data pertaining to number of seed capsule<sup>⁻¹</sup> as influenced by planting density and INM were illustrated in Table 3 revealed a non-significant effect of planting density and INM on number of seeds capsule<sup>⁻¹</sup> and weight of capsule (g) with no significant interactions also. Data presented in Table 5, reported significant effect in seed yield due to different planting density, where the treatment 40x10cm<sup>2</sup> (375kg ha⁻¹) was at par with 30x10cm<sup>2</sup> (356.67 kg ha⁻¹) while the least yield was obtained under 20x10cm<sup>2</sup> (334.44 kg ha⁻¹). Similar discovery were recorded by Caliskan et al. (2004) and Umar et al. (2012) who detected that increasing planting density decreases the seed yield of sesame, while the improvement in seed yield was due to superior growth parameters (plant height, no. of leaves plant<sup>⁻¹</sup>, no. of branches plant<sup>⁻¹</sup>) and yield attributes (no. of capsule plant<sup>⁻¹</sup>, seed capsule<sup>⁻¹</sup>). The seed yield were also found to be significant due to INM where
Effect of Planting Density and Integrated Nutrient Management in Sesame (*Sesamum indicum* L.)

### Table 1: Effect of planting density and INM on plant height, number of leaves plant\(^{-1}\) and number of branches.

| Treatment | 25 DAS | 50 DAS | At harvest | 25 DAS | 50 DAS | At harvest | 50 DAS | At harvest |
|-----------|--------|--------|------------|--------|--------|------------|--------|------------|
| T\(_1\)   | 16.17  | 63.93  | 76.43      | 8.71   | 33.11  | 48.25      | 3.22   | 4.3        |
| T\(_2\)   | 17.86  | 66.71  | 79.11      | 9.37   | 47.9   | 61.13      | 4.35   | 5.77       |
| T\(_3\)   | 18.6   | 70.06  | 84.93      | 9.15   | 51.1   | 65.81      | 4.6    | 5.92       |
| SEm ±     | 1.13   | 1.60   | 2.25       | 0.62   | 3.48   | 3.40       | 0.23   | 0.24       |
| CD (P= 0.05) | NS    | 4.80   | 6.75       | NS     | 10.44  | 10.21      | 0.69   | 0.74       |

### Table 2: Interaction effect of planting density and INM on the plant height (cm), number of leaves plant\(^{-1}\) and number of branches.

| Treatment | 25 DAS | 50 DAS | At harvest | 25 DAS | 50 DAS | At harvest | 50 DAS | At harvest |
|-----------|--------|--------|------------|--------|--------|------------|--------|------------|
| T\(_1\)N\(_1\) | 13.86  | 64.26  | 75.06      | 8.2    | 32.26  | 45.46      | 3.26   | 4.13       |
| T\(_1\)N\(_2\) | 17.93  | 65.83  | 74.24      | 10.26  | 38.53  | 52         | 3.86   | 4.93       |
| T\(_1\)N\(_3\) | 16.73  | 61.71  | 80         | 7.6    | 28.53  | 47.3       | 2.53   | 3.93       |
| T\(_2\)N\(_1\) | 16.53  | 63.06  | 72.48      | 10     | 41.36  | 57.06      | 3.86   | 5.33       |
| T\(_2\)N\(_2\) | 19.53  | 72.7   | 85.36      | 9.3    | 57.93  | 70.2       | 4.93   | 6.46       |
| T\(_2\)N\(_3\) | 17.53  | 64.36  | 79.48      | 9.2    | 44.4   | 56.13      | 4.26   | 5.53       |
| T\(_3\)N\(_1\) | 19.46  | 64.2   | 76.4       | 10.13  | 43.83  | 54.4       | 4.2    | 5.43       |
| T\(_3\)N\(_2\) | 18.73  | 74.27  | 90.9       | 9.06   | 59.06  | 74.83      | 5.26   | 6.66       |
| T\(_3\)N\(_3\) | 17.6   | 71.73  | 87.5       | 8.26   | 50.4   | 68.2       | 4.33   | 5.66       |
| SEm ±     | 1.96   | 2.77   | 3.90       | 1.08   | 6.03   | 5.8        | 0.40   | 0.43       |
| CD (P=0.05) | NS    | 4.80   | 6.75       | NS     | 10.44  | 10.21      | 0.69   | 0.74       |

### Table 3: Effect of planting density and INM on number of capsules plant\(^{-1}\), number of seeds capsule\(^{-1}\), weight of capsule (g) and test weight (g).

| Treatment | Number of capsules plant\(^{-1}\) | Number of seeds capsule\(^{-1}\) | Weight of capsule (g) | Test weight (g) |
|-----------|----------------------------------|---------------------------------|----------------------|-----------------|
| T\(_1\)   | 71.61                            | 27.407                          | 0.90                 | 2.73            |
| T\(_2\)   | 78.07                            | 31.47                           | 0.94                 | 2.74            |
| T\(_3\)   | 89.33                            | 33.50                           | 0.97                 | 2.78            |
| SEm ±     | 3.45                             | 1.81                            | 0.02                 | 0.023           |
| CD (P= 0.05) | 10.36                          | NS                              | NS                   | NS              |

### Table 4: Interaction effect of planting density and INM on number of capsules plant\(^{-1}\), number of seeds capsule\(^{-1}\), weight of capsule (g) and test weight (g).

| Treatment | Number of capsules plant\(^{-1}\) | Number of seeds capsule\(^{-1}\) | Weight of capsule (g) | Test weight (g) |
|-----------|----------------------------------|---------------------------------|----------------------|-----------------|
| T\(_1\)N\(_1\) | 73.43                           | 26.22                           | 0.92                 | 2.75            |
| T\(_1\)N\(_2\) | 69.26                           | 30.22                           | 0.91                 | 2.69            |
| T\(_1\)N\(_3\) | 72.13                           | 25.81                           | 0.89                 | 2.77            |
| T\(_2\)N\(_1\) | 75.70                           | 29.55                           | 0.92                 | 2.75            |
| T\(_2\)N\(_2\) | 82.84                           | 32.44                           | 0.96                 | 2.78            |
| T\(_2\)N\(_3\) | 75.67                           | 32.44                           | 0.94                 | 2.70            |
| T\(_3\)N\(_1\) | 78.37                           | 30.66                           | 0.94                 | 2.80            |
| T\(_3\)N\(_2\) | 95.88                           | 35.15                           | 1.01                 | 2.78            |
| T\(_3\)N\(_3\) | 93.75                           | 34.7                            | 0.97                 | 2.75            |
| SEm ±     | 5.98                             | 3.14                            | 0.042                | 0.040           |
| CD (P=0.05) | 17.95                           | NS                              | 0.13                 | NS              |
75% RDF + 25% FYM (375 kg ha\(^{-1}\)) was at par with 75% RDF + 25% poultry manure (353.66 kg ha\(^{-1}\)) while the lowest yield was obtained from 100% RDF (337.44 kg ha\(^{-1}\)). The higher seed yield in INM could be attributed to the availability of nutrients and its higher uptake by the crop, this was in conformity with the reports by Duhoon et al. (2001), Narkhede et al. (2001), Deshmukh et al. (2002). The interaction effect of planting density and INM on yield attributes viz., no. of capsule plant, no. of seed capsule, weight of capsule, test weight, seed yield and stover yield were found non-significant, similar results were reported by Girdharbhai (2016) where he commented that the combined effect of spacing and nutrient management treatments on yield attributes was found non-significant. Data presented in Table 5, reported a significant effect in stover yield due to different planting density. Significantly, stover yield under the 20x10cm\(^2\) (937.77 kg ha\(^{-1}\)) was superior over the 20x10cm\(^2\) (857.77 kg ha\(^{-1}\)) and was found to be at par with treatment 30x10cm\(^2\). Treatment combination of 75% RDF + 25% FYM gave higher stover yield (937.77 kg ha\(^{-1}\)) which was found to be at par with treatment 75% RDF + 25% poultry manure, however the lowest was reported from 100% RDF (861.11 kg ha\(^{-1}\)). Similar results were reported by Mamatha et al. (2014). There was also no significant interaction found. It is evident from table, that there was a non-significant effect of planting density on harvest index. Similar results were stated by El Naim (2010) who mentioned that there was no significant difference in harvest index between planting density. The interaction effect between different planting density and nutrient management on harvest index is presented in Table 6, was also found non-significant.

Available soil pH and organic carbon (%)

There was no significant increase in soil pH among the treatments due to different nutrient management in soil at harvest. The data in Table 7, indicated that the difference in soil organic carbon due to planting density was found not significant. There was a significantly higher organic carbon (%) content in treatment 75% RDF + 25% FYM than the 20x10cm\(^2\) and was at par with 40x10cm\(^2\) due to different nutrient management treatment in soil at harvest. The interaction effect between different planting density and nutrient management on harvest index is presented in Table 6, which was not found significant.

**Available soil NPK (kg ha\(^{-1}\))**

The interaction effect between different planting density and nutrient management on organic carbon (%) content in soil at harvest is presented in Table 8, which was not found significant.

**Available soil NPK (kg ha\(^{-1}\))**

Table 9, indicated that available N and K\(_2\)O status in soil after harvest of the crop was not significantly varied due to
different planting density and nutrient management treatments which also resulted in no interaction (Table 10). However, highest available P₂O₅ was obtained in treatment 100% RDF which was superior over other treatments.

**Economic analysis**

It is evident from the data presented in Table 11, the highest cost of cultivation was recorded in 75% RDF + 25% FYM (16,359) followed by 100% RDF (15,618) while the highest

Table 9: Effect of planting density and INM on soil available N, P and K content in soil after harvest.

| Treatment | Nitrogen   | Phosphorus | Potassium |
|-----------|------------|------------|-----------|
| T₁        | 256.35     | 27.37      | 172.06    |
| T₂        | 255.42     | 26.88      | 170.80    |
| T₃        | 254.48     | 25.76      | 170.30    |
| SEm ±     | 2.89       | 0.51       | 1.89      |
| CD (P= 0.05) | NS  | NS         | NS        |
| N₁        | 257.60     | 28.00      | 172.07    |
| N₂        | 256.04     | 26.38      | 171.73    |
| N₃        | 252.62     | 25.64      | 169.37    |
| SEm ±     | 2.89       | 0.51       | 1.89      |
| CD (P=0.05) | NS  | 1.53       | NS        |

NS- Non significant, S- Significant.

Table 10: Interaction effect of planting density and INM on soil available N, P and K content in soil after harvest.

| Treatment | Nitrogen   | Phosphorus | Potassium |
|-----------|------------|------------|-----------|
| T₁N₁      | 260.40     | 28.75      | 176.47    |
| T₁N₂      | 257.60     | 27.25      | 172.47    |
| T₁N₃      | 251.07     | 26.13      | 167.25    |
| T₁N₄      | 256.67     | 28.37      | 169.87    |
| T₂N₁      | 255.73     | 26.51      | 173.60    |
| T₂N₂      | 253.87     | 25.76      | 168.93    |
| T₂N₃      | 255.73     | 26.88      | 169.87    |
| T₂N₄      | 254.80     | 25.39      | 169.12    |
| T₃N₁      | 252.93     | 25.01      | 171.92    |
| T₃N₂      | 5.02       | 0.88       | 3.27      |
| SEm ±     |            |            |           |
| CD (P=0.05) | NS  | NS         | NS        |

gross return was obtained from the combined interaction of 40x10cm² and 75% RDF+25% FYM (32,712.8) followed by treatment combination of 30x10cm² and 75% RDF + 25% FYM (31,346.66). In terms of maximum net return, combined effect of treatment 40x10cm² and 75% RDF + 25% poultry manure (1.13) followed by 30x10cm² and 75% RDF+ 25% poultry (1.01) while the lowest B:C ratio was obtained from the treatment 30x10cm² and 100% RDF (0.73).

**REFERENCES**

Anonymous (2014). FAO. Source: http://faostat.fao.org/site. Dated 17/07/2017.

Bonsu, O.K. (2003). Effect of spacing and fertilizer application on the growth, yield and yield components of sesame (Sesamum indicum L.). Journal of Sustainable Agriculture. 23(1): 40-49.

Caliskan, S., Arslan, M., Arioglu, H. and Isler, N. (2004). Effect of planting method and plant population on growth and yield of sesame (Sesamum indicum L.) in a Mediterranean type of environment. Asian Journal of Plant Sciences. 3(5): 610-13.

Debnath, P., Singh, R., Ferroze, S.M. and Sarkar, A. (2015). Study on growth and instability of sesame in North-Eastern Hill Region of India. Economic in Affairs. 60(2): 193-6.

Deshmukh, M.R., Jain, H.C., Duhoon, S.S. and Goswami, U. (2002). Integrated Nutrient Management in sesame for Kymore plateau zone of Madhya Pradesh. Journal of Oilseeds Research. 19(1): 73-75.

Duhoon, S.S., Jain, H.C., Deshmukh, M.R. and Goswami, U. (2001). Effect of organic and inorganic fertilizers along with biofertilizers on kharif sesame under different soils and locations in India. Journal of Oilseeds Research. 18(2): 178-180.

El Naim, A.M. (2010). Effect of plant density on the performance of some sesame (Sesamum indicum L.) cultivars under rainfed. Research Journal of Agriculture and Biological Sciences. 6(4): 498-504.

Girdharbhai P.S. (2016). Effect of spacing and nutrient management on summer sesame (Sesamum indicum L.) under South Gujarat condition. Thesis submitted to Navsari Agricultural University.

Islam, F., Gill, R.A., Ali, B., Farooq, M.A., Xu, L., Najeeb, U. et al. (2016). Sesame. In: Breeding Oilseed Crop for Sustainable Production: Opportunities and Constraints. [ed.] S.K. Gupta (Cambridge, MA: Academic Press), 135-147.

Kafiriti, E. and Mponda, O. (2008). Soils, Plant Growth and Crop Production. Longman Press, London.

Kushwaha, D. and Hasan, Z. (2011). Growth and yield of different sesame (Sesamum indicum L.) cultivars under different planting density and nutrient management in a Mediterranean type of environment. Indian Journal of Plant Sciences. 6(4): 498-504.

Khalil, A. and Mponda, O. (2007). Growth and yield of sesame (Sesamum indicum L.) as influenced by different planting densities and nutrients. Research Journal of Agriculture and Biological Sciences. 13(10): 74-76.
by seed applied azotobacter and phosphate solubilizing bacteria. Indian Journal of Agricultural Research. 45(4): 326-330.

Mamatha, K., VidyaSagar, G. E. Ch, Laxmi, N. P. and Padmaja, G. (2014). Growth, yield attributes and yield of sesame (Sesamum indicum L.) as influence by the application of Sulphur with FYM. International Journal of Current Research. ISSN-0975-833X.

Nantongo, S. (2002). Effect of spatial arrangement and plant population on growth and yield of sesame (Sesamum indicum L.) in pure stands and in mixtures with finger millet (Eleusine coracana). M. Sc. Thesis. Makerere University.

Narkhede, T.N., Wadile, S.C., Attarde, D.R., Suryawanshi, R.T. and Deshmukh, A.S. (2001). Response of macro and micro nutrients in combination with organic matter (FYM) on yield of sesame (Sesamum indicum L.). Journal of Soils and Crops. 11(2): 203-205.

Pathak, K., Rahman, S., Bhagawati, S. and Gogoi, B. (2017). Sesame (Sesamum indicum L.), an underexploited oil seed crop: Current status, features and importance-A review. Agricultural Reviews. 38(3): 223-227.

Rahman, M.M. and Hossain, M.M. (2011). Plant density effects on growth, yield and yield components of two soybean varieties under equidistant planting arrangement. Asian Journal of Plant Sciences. 10: 278-86.

Sahu, G., Chatterjee, N., Bera, M., Ghosh, G.K., Mandal, S., Biswas, P.K. and Kundu, M.G. (2017). Integrated nutrient management in sesame (Sesamum indicum) in red and lateritic soils of West Bengal. International Journal of Plant, Animal and Environmental Science. 7(1): 137-46.

Sivagamy, K. and Rammohan, J. (2013). Effect of sowing date and crop spacing on growth, yield attributes and quality of sesame. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 5(2): 38-40.

Umar, U.A, Mahmud, M., Abubakar, I.U., Babaji, B.A. and Idris, U.D. (2012). Performance of sesame (Sesamum indicum L.) varieties as influenced by nitrogen fertilizer level and intra row spacing. The Pacific Journal of Science and Technology. 13: 364-9.

Walling, I. (2015). Sesamum (Sesamum indicum L.) a promising oilseed crop. The Morung Express. Dated: 16/7/2017. (morungexpress.com/sesamum-sesamum-indicum-l-a-promising-oilseed-crop/).

Wei, W., Qi X., Wang, L., Zhang, Y., Hua, W., Li, D., Lv, H. and Zhang, X. (2011). Characterization of the sesame (Sesamum indicum L.) global transcriptome using illumine period-end sequencing and development of EST-SSR markers. BMC Genomics. 12(451): 1-13.