



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

© Agronomy

www.agronomyjournals.com

2019; 2(1): 42-47

Received: 24-01-2019

Accepted: 26-03-2019

Taminaw Zewdie

Department of Plant Science,
College of Agriculture, Mekdela
Amba University, Ethiopia

Nuru Seid Tehulie

Department of Plant Science,
College of Agriculture, Mekdela
Amba University, Ethiopia

Review on effects of plant densities and nitrogen fertilization on sesame (*Sesamum indicum* L.) Yield and yield components

Taminaw Zewdie and Nuru Seid Tehulie

Abstract

Sesame is the most ancient oil seed used by man and it is considered as one of the most important oil crop. Sesame is an erect annual plant of numerous types and varieties two basic sesame types are usually distinguished; long-season, occasionally treated as perennials. Seeds are rich source of edible oil (48-55%) and protein (20-28%). The optimum soil condition for sesame is well-drained, loose, fertile and sandy alluvial soils that have a pH value between 5.4 and 6.7. This review is required to review the effects of plant density and nitrogen fertilization on yield and yield components of sesame. Nitrogen is the most important essential nutrient in plant nutrition. When rate of nitrogen fertilizer increased, yield and yield components of sesame also increased in some extent except oil contents. Oil contents of crops are decreased when nitrogen rate is increased. Maximum yield of sesame is achieved from the best spatial arrangement of plants for effective canopy development, water and nutrient utilization and pest control increasing plant density by decreasing planting distance b/n plants increased plant height, height of the first fruiting branch. These results are due to higher competition among plants for light and results the elongation of internodes. Decreasing plant population by increasing distance b/n plants increased number of branches, capsules/plant, 1000-seed weight and seed weight/plant. Increasing plant population density decreases seed yield and oil content of seed per plants and increases seed yield and oil yield/ha, due to the greater number of sesame plants per unit area.

Keywords: Sesame, nitrogen, spacing, yield

1. Introduction

Sesame (*Sesamum indicum* L.) belongs to the double-cotyledon pedaliaceae family. It is probably the most ancient oil seed used by man and its domestication lost in the mists of antiquity. It is considered as one of the most important oil crop “Queen of oil seeds” in the world because its seeds have high contents of oil and protein (Weiss, 2000) [38]. The origin of sesame is still controversial. Kobayashi (1985) [19] suggested that sesame originated in Africa, but Bedigian and Harland (1986) [8] concluded that sesame originated on the Indian sub-continent. According to (Franz Augstburger, *et al.*, 2002) [14] Africa is considered as the primary centre of origin of this crop because of the presence of its diverse wild species in that continent and India and Japan are the secondary centre of origin.

Sesame is an erect annual plant of numerous types and varieties, which grow from about 0.5 to 2.5 m tall; some have branches and others do not. Two basic sesame types are usually distinguished; long-season, occasionally treated as perennials, with an extensive and penetrating root system; and short-season, with less extensive, shallower roots (Weiss, 2000) [38]. It has single or multiple flowers per leaf axel. Flowers develop to capsule that contains a number of small oleaginous seed (Weiss, 1971) [37]. The seeds can be either white, yellow, red, brown or black. The vegetation period is only 80-130 days short. The blossoming and ripening phases take place over several weeks, starting at the bottom of the plant and progressing upwards (Franz Augstburger *et al*, 2002) [14]. Sesame is used as a source of food; eaten as raw, either roasted or parched or as blended oil in the form of different sweet (Weiss, 1971) [37]. It has high quality polyunsaturated stable fatty acids in seeds, which offer resistance to rancidity. Moreover, seeds are rich source of edible oil (48-55%) and protein (20-28%) (Nagaraj, 1995) [27], consisting both methionine and tryptophane, vitamin (niacine) and minerals (Ca and P).

Corresponding Author:

Taminaw Zewdie

Department of Plant Science,
College of Agriculture, Mekdela
Amba University, Ethiopia

Sesame seeds have two compounds sesamine and sesamol. Sesamol on hydrolysis yields sesmol, which has pronounced antioxidant activity there by offer higher shelf life and called as "Seeds of immortality". The expeller cake not only serves as good feed concentrate for livestock and poultry and also used as organic manure. Among the oilseed crops, sesame is the only crop having importance in religious rituals. Apart from these, sesame is a good catch crop and performs well in pure and mixed stand in residual soil moisture. It also used for anointing the body, for manufacturing perfumed oils and for medicinal purposes (Anonymous, 2005). In Ethiopia, sesame is used as cash crop, export commodity, raw materials for industries and as source of employment opportunity (Getinet and Negusse, 1997) [16].

The cotton cultivation zone at the crossover between the tropics and the sub tropics also provides the best growing conditions for sesame. The main cultivation region lies between the 25° northerly and 25° southerly latitudes but it can be found up to 40° N and 35° S (Weiss, 1971) [37]. Sesame needs a constant high temperature, the optimum range or growth, blossoms and fruit ripeness is 26-30 °C. The minimum temperature for germination is around 12 °C, yet even temperatures below 18°C can have a negative effect during germination. Pollination and the formation of capsules are inhibited during heat-wave periods above 40 °C. In regions visited by strong winds and hots the plants only form smaller seeds with lower oil content. For these reasons, sesame is cultivated in cooler regions as a summer crop and in warmer climes during the cooler season. Sesame is frost-susceptible. Depending on the climate, sesame can be cultivated at altitudes up to 1600 m (Franz Augstburger *et al.*, 2002) [14].

Good harvests can be expected when rainfall of 300-600 mm is optimally spread throughout the vegetation period. Optimum distribution means: 35% before the first cusps are formed, 45% during the main blossoming period, 20% during the ripening period and drought, if possible, during harvesting. During each of its development stages, the plant is highly susceptible to water-logging and can therefore only thrive during moderate rainfall, or when irrigation is carefully controlled in drier regions. Due to its tap roots, the plant is highly resistant to drought, and can provide good harvests even when only stored soil water is available (Franz Augstburger *et al.*, 2002) [14].

A wide range of soils is suitable for sesame cultivation; optimum is well-drained, loose, fertile and sandy alluvial soils that have a pH value between 5.4 and 6.7. Very low PH values have a drastic effect on growth, whereas some varieties can tolerate a PH value up to 8. When irrigated, or during summer rain spells, sesame grows better in sandy than in heavy soils. This is due to its sensitivity to high soil moisture contents. Heavy, water-logged soils, as well as soils with high salt contents are not suitable; salt contents which would hardly affect cotton or safflower can already kill off sesame plants (Franz Augstburger *et al.*, 2002) [14].

Sesame needs long periods of sunshine, and is generally a short-day plant whereby varieties exist which are unaffected by the length of the day. Sesame is sensitive to strong winds when the main stem is fully-grown. Tall varieties should not be planted in regions, which have strong winds during the harvesting season (and, if necessary, hedges to protect against the wind should be planted) (Franz Augstburger *et al.*, 2002) [14].

Use of proper agronomic practices is very important to increase yield of sesame per unit area.

Many agronomic researches like effects of fertilizer, plant density, irrigation interval, planting pattern, etc on yield and

yield components of sesame have been done by many researchers in order to increase the yield and yield components of sesame per unit area. However, mostly in the world as well as in the Ethiopia, sesame crop is considered as none responsive to fertilizers and this consequence is decreases the yield of sesame per unit area. Another way of sesame yield reduction is use of only 40 x10cm of plant spacing as blank recommendations for all types of sesame varieties. Therefore, the objective of this paper is:

- To review the effects of plant density and nitrogen fertilization on yield and yield components of sesame

2. Literature Review

2.1 Production of sesame

2.1.1 World production

Sesame is considered as one of the most important oil crop in the world because its seeds have high contents of oil and protein. It is widely cultivated in tropical and sub-tropical parts of the world. Recently, India and china are the world's largest producers of sesame, followed by Burma, Sudan, Mexico, Nigeria, Venezuela, Turkey, Uganda and Ethiopia. Of the world's sesame production, 60% is produced in Asia, but less than 2% of this total is exported. Africa too has large internal market, but supplies about 80% of the world exports (Seegeler, 1983) [34].

World production of sesame seed gradually increased from 1.5 million tons per year in the 1960s to 3.2 million tons per year (from 2.7 million ha) in 2005, due to an increasing demand for sesame oil worldwide (Mkamilo and Bedigian, 2007) [23]. During the year of 2007, India leads world in sesame production. In that year India was contributed 18.8% of the production of sesame in the world while China (19.9%), Myanmar (17.3%), Sudan (5.9%), Uganda (4.9%), Nigeria (2.9%), Pakistan (0.8%), Ethiopia (4.7%) and Bangladesh (1.4%). The productivity of sesame in India was 0.33 tons/ha compared to world average of 0.44 tons/ha in the year 2006-07 (Lagaham, 2008). In 2010, the world harvested sesame seeds was about 3.84 million metric tonnes. During that time the largest producer of sesame was Myanmar and the world's largest exporter was India while Japan was the largest importer (FAO, 2012) [12].

2.1.2 Ethiopian Production

Sesame production trend shows that in 1960s Ethiopia was one of the few leading producers and exporters in the world. Weiss (1971) [37] indicated that in 1964, the area allocated and yield produced were 77,000 hectares and 31,570 ton, respectively. However, after ten years, in 1974, Getinet and Adugna (1995) [16] reported that the crop was produce at 153,900 hectares with 73,000 tons of yield and in the next ten years, the figure declined to 4800 hectares of land and 528 tons of production in 1984. As Elias (1988) [11] reported that the major reasons of sesame yield reduction is the areas under large scale sesame production was dramatically decreased as the state and private farms specialized on this crop become nonfunctional or operating at minimum scale primarily due to the lack of labor at harvest, drought and other management and social problems specially in 1980s. However, CACC (2004) reported that in Ethiopia area covered by sesame during 2001 to 2003 was from 58,780.38 ha to 89,412.2 ha. The country's annual production was increased from 18,878 tons in 2001 to 148,861 tons in 2006 (MoARD, 2007b) [24]. According to CSA (2011) [10] data, Ethiopia's sesame production in 2007, 2008 and 2009 were 186773, 216741 and 260534 tons, respectively.

2.2 Effects of Nitrogen fertilization

Nitrogen is the most important essential nutrient in plant nutrition. It is a constituent of a large number of necessary organic compounds such as amino acids, proteins, coenzymes, nucleic acids, ribosome, chlorophyll, cytochrome and some vitamins Marschner (1986) [22] and Noorka *et al.* (2009) [28]. Several investigators reported the positive effects of applying nitrogen fertilization on growth, yield attributes, seed yield and quality of sesame. Basha (1994) [6] reported that number of capsules/plant, seed index, seed weight/plant and seed yields/ha were increased by raising N fertilizer from 35.70 to 178.50 kg/ha, but the oil content percentage was decreased. Bassiem & Anton (1998) [7] observed that yield components were increased by escalating N doses from 71 to 142Kg/ha while seed yield/ha was augmented up to 214 Kg/ha. Nevertheless, the low level of N (71 Kg /ha) produced the highest seed oil content percentage. Fayed *et al.* (2000) [13] detected that plant height, height of first capsule, number of capsules/plant, seed weight/plant and seed yield/ha were increased by raising N fertilization from 71 to 142Kg/ha. In addition, Ashfaq *et al.*, (2001) [4] demonstrated that plant height, number of branches and capsules/plant, seed index and seed yield/ha were increased by increment N up to 120 Kg/ha.

Similarly, nitrogen fertilization has also been reported to have profound effect on oilseed crops. Application of 45 kg N ha⁻¹ increased the number of branches and capsules plant⁻¹ and seeds capsule⁻¹ in sesame (Subramanian *et al.*, 1979) [5]. Parwar *et al.* (1993) [29] reported that seed yield in sesame was increased with 120 kg N ha⁻¹ while Sumathi and Jaganadham (1994) [36] obtained maximum sesame yield with 60 kg N ha⁻¹. Seed oil contents were increased by N application except at the highest rate (90 kg N ha⁻¹) which slightly reduced oil content compared with the control (Ramakrishnan *et al.*, 1994) [31]. The tallest plants, highest number of capsules plant⁻¹ and highest seed yield were obtained with an application of nitrogen 45 kg ha⁻¹ (Saharia & Bayan, 1996).

As reported by Sghar Malik *et al.* (2003) plant height was significantly affected by nitrogen levels. 80 kg ha⁻¹ treatment was produced the tallest plants with 136.34 cm height, followed by nitrogen 40 kg ha⁻¹ with 131.66 cm tall plants. The minimum plant height (127.48 cm) was recorded in control nitrogen treatment. Maximum number of capsules plant⁻¹ (97.88) was produced at the nitrogen level of 80 kg ha⁻¹ followed by 40 kg N ha⁻¹ which produced 92.50 capsules per plant. Minimum

number of capsules plant⁻¹ (88.55) was recorded in control treatment. Maximum number of seeds capsule⁻¹ (62.83) was produced when nitrogen was applied at the rate of 80 kg ha⁻¹. While minimum number of seeds capsule⁻¹ (61.42) was produced in N0 (control) treatment. The treatment N2 (80 kg ha⁻¹) produced maximum seed yield (0.794 t ha⁻¹) followed by N1 (40 kg ha⁻¹) treatment that gave 0.716 t ha⁻¹. Minimum seed yield (0.572 t ha⁻¹) was noted in case of N0 (control) treatment. The treatment N2 (80 kg ha⁻¹) resulted in the highest oil content (45.88%), followed by N1 (40 kg ha⁻¹) that gave 44.33% oil content

As reported by Hafiz S.I and M. A. S. El-Bramawy (2011) [17], the effect of nitrogen fertilization on sesame yields under reclaimed sandy soils showed that increasing nitrogen fertilizer level up to 205kg N/ha consistently and significantly increased plant height, height of the first fruiting branch and fruiting zone length (table 1). The differences between the four levels of N were significant and that was true in 2008 and 2009 seasons. Number of branches per plant was increased significantly by increasing N rate from 55 to 205 kg/ha in the two growing seasons. Applying nitrogen fertilizer produced more number of capsules/plant of sesame and the differences between the four levels of N (55, 105, 155 and 205 kg N/ ha) were significant in 2008 and 2009 seasons.

Table 1: Effect of nitrogen fertilization on plant height, height of the first fruiting branch and fruiting zone length of sesame through 2008 and 2009 seasons

Treatments	Plant height (cm)		Height of the first fruiting Branch (cm)		Fruiting zone length (cm)	
	2008	2009	2008	2009	2008	2009
55 N kg/ha	133.67	153.33	36	37.41	57	60.34
105 N kg/ha	151.67	164.66	42.56	43.9	60.73	64.13
155 N kg/ha	168.67	180.33	46.67	48.95	65.77	69.74
205 N kg/ha	177	192	51.33	52.85	67.21	71.80

He reported that the seed yield/ha increased significantly and consistently as N fertilizer rate was increased up to 205 Kg N/ha in both seasons (2008 and 2009) (table 2). The positive effect of increasing N fertilizer level on seed yield/ha of sesame might be attributed to the beneficial role of nitrogen on stimulating plant growth. Plant traits plant height, number of branches/plant and fruiting zone length, which reflects favor on yield attributes i.e. capsules number/plant, 1000-seed weight and seed weight/plant in turn increased seed yield/ha.

Table 2: Effect of nitrogen fertilization on seed weight/ plant, seed yield/ha, seed oil content (%) and oil yield /ha of sesame through 2008 and 2009 seasons.

Treatments	Seed weight/ plant(g)		Seed yield/ha (ton)		Seed oil content (%)		Oil yield /ha (ton)	
	2008	2009	2008	2009	2008	2009	2008	2009
55 Kg N/ha	9.23	11.18	1.285	1.628	58.19	58.98	0.747	0.950
105 Kg N/ha	11.51	13.60	1.622	1.974	53.92	54.83	0.866	1.073
155 Kg N/ha	14.19	16.51	2.008	2.334	52.57	53.30	1.044	1.228
205 Kg N/ha	17.19	18.69	2.442	2.691	52.20	52.86	1.264	1.406

Sources: Hafiz S.I and M. A. S. El-Bramawy, 2011 [17]

Seed oil content (%) was negatively and significantly affected by increasing N rate up to 205 kg N/ha and that held true in both seasons (Table 2). These results were expected since the low nitrogen rates resulted in smaller seeds (1000-seed weight) and this might be on the expense of carbohydrate storage rather than oils, which resulted in increasing percentage of the later. Table 3 shows that increasing nitrogen fertilizer level up to 205 kg N/ ha significantly increased oil yield/ha in 2008 and 2009 seasons. The increase in oil yield/ha by increasing nitrogen rate might be

mainly due to the increase in seed yield/ha regardless the negative effect of that on seed oil percentage.

2.3 Effects of plant density

Plant population is defined as the number of plants per unit area. Optimum number of plants is required per unit area to utilize efficiency the available production resources such as water, nutrients, light and carbon dioxide. Normally maximum productions are obtained from plant populations, which do not

allow plants to achieve their individual maximum potential. Thus, the entire community of plants is considered for higher production rather than the individual plant performance (Balasubramaniyan and Palaniappan, 2007) [5].

The full yield potential of an individual plant is fully exploited when sown at wider spacing. Yield per plant decreases gradually as plant population per unit area increases. As plant density increases the amount of dry matter in vegetative parts also increases. Both the biological and economical yield increases with increasing plant population up to certain point and subsequently no addition in biological yield can be obtained and economic yield decreases. Therefore, the optimum plant population of individual crop should be worked out under suitable environment conditions (Singh and Singh, 2002) [35].

In agronomy it is important to realize that plant population should be seen not only in terms of plant per unit area (i.e plant density) but also in terms arrangements of these exposing larger area of bare soil to sun radiation, would increase moisture losses due to evaporation thereby defeating the purpose of the wide spacing (Arnon, 1975) [3]. Maximum yield of sesame is achieved from the best spatial arrangement of plants for effective canopy development, water and nutrient utilization and pest control (Caliskan *et al.*, 2004) [9]. These relationships are also important for optimal physiological function of the crop. Many factors influence the optimum plant density for a crop. The most important factors are like availability of water, nutrient and sunlight, length of growing seasons, potential plant size, planting pattern and the plant's capacity to change its form in response to varying environmental conditions (morphological plasticity

(Lyon, 2009) [21].

As Franz Augstburger, *et al.* (2002) [14] reported that when using dry-land farming, the distance between the rows should be expanded to 75-100 cm, and the distance within the rows to 10-15 cm, each time, depending on the available moisture in the soil. Under normal condition high yield of sesame was observed at 30-45 cm x 7.5 cm for non-branching and 50-60 cm x 10-15 for branching cultivars. Ahmad *et al.*, (2002) reported that sesame when sown at spaces 30, 45 and 60 cm between plants, the plant height and seed yield /ha were increased by raising planting space at 45cm. Rahnama & Bakhshandeh (2006) reported that number of capsules/plant, seed index, seed weight/plant and oil concentration were increased by increment of row spacing from 37.5cm to 60cm.

Hafiz S.I and M. A. S. El-Bramawy (2011) [17] revealed that increasing plant population density from 200000 to 266666 and 400000 plants/ha by decreasing planting distance between hills from 20 to 15 and 10 cm significantly increased plant height, height of the first fruiting branch. These results might be due to the higher competition among plants, for light in dense plant population, which may results elongation of internodes and in turn gave taller plants. Ahmad *et al.*, (2002), obtained similar results with 30 cm between hills. Hafiz S.I and M. A. S. El-Bramawy (2011) [17] also reported increasing planting distance between hills up to 20 cm significantly increased fruiting zone length. These results were expected because of low competition among plants for moisture, nutrients and light in wide planting distance, which increased potentiality of plants in increasing fruiting zone length.

Table 3: Effect of planting distance on plant height, height of the first fruiting branch and fruiting zone length of sesame through 2008 and 2009 seasons

Treatments Seasons	Plant height (cm)		Height of the first fruiting branch (cm)		Fruiting zone length (cm)	
	2008	2009	2008	2009	2008	2009
10 cm (400000 plants/ha)	163.25	181	47.5	49.52	58.32	61.79
15 cm (266666 plants/ha)	158.50	172.25	44	45.76	63.20	67.15
20 cm (200000 plants/ha)	151.50	164.5	40.92	42.05	66.50	70.57

In (Table 2) Hafiz S.I and M. A. S. El-Bramawy (2011) [17] showed that distances between hills exhibited significant effects on number of branches and capsules /plant as well as 1000-seed weight of sesame. There were consistent and remarkable increases in the aforementioned characters as planting distance was increased from 10 to 15 and 20 cm. These results were expected since that in wide planting distance there was a low competition among plants for growth factors such as moisture, nutrients, space and light, which in turn increased potentiality of sesame plants in producing more branches and capsules per plant as well as heavier 1000-seed weight. Moreover, Karaaslan

et al., (2007) [18] found that increasing row width from 50-30 to 80-40 cm increased the mentioned characters.

Decreasing plant population density by increasing planting distance between hills from 10 to 15 and 20 cm gave significant increases in seed weight/plant of sesame in 2008 and 2009 seasons (Table 3). Such effect might be due to the increase in capsules number/plant and 1000-seed weight with wide distance between hills. Similar results were reported by Rahnama & Bakhshandeh (2006), who observed that seed weight/plant was increased by increasing plant distance up to 60 cm.

Table 4: Effect of nitrogen fertilization and planting distance on seed weight/ plant, seed yield/ha, seed oil content (%) and oil yield /ha of sesame through 2008 and 2009 seasons.

Treatments Seasons	Seed weight/ plant (g)		Seed yield/ha (ton)		Seed oil content (%)		Oil yield /ha (Ton)	
	2008	2009	2008	2009	2008	2009	2008	2009
10 cm (400000plants/ha)	12.11	14.04	2.419	2.728	50.70	51.08	1.214	1.382
15 cm (266666 plants/ha)	13.03	15.04	1.699	2.108	55.13	55.93	0.934	1.171
20 cm (200000 plants/ha)	13.96	15.90	1.405	1.631	56.82	57.97	0.792	0.939

Data in (Table 4) shows that increasing plant population density up to 400000 plants/ha via decreasing planting distance up to 10cm increased seed yield/ha significantly and consistently in the two growing seasons. Sowing sesame plants at close distance of 10cm out yielded 15 and 20 cm in seed yield/ha by 42.35% and 72.15% in the first season and 29.40% and 67.25% in the

second one, respectively. It is worthy to mention that increases in seed yield per ha at highest plant population density might be due to that the greater number of sesame plants per unit area in narrow distance between hills could compensate that reduction in yield attributes of the individual plants such as number of capsules/plants, 1000-seed weight and seed weight/ plant. It is

important that the unit land area not the individual plant produce its maximum yield. These results are in harmony with those reported by Ahmad *et al.*, (2002), Rahnama & Bakhshandeh (2006), who found that the highest seed yield/ha was produced with planting distance of 45 cm and 30 cm between hills, respectively.

Seed oil content (%) of sesame was inversely related to increasing plant density as shown in (Table 4). There was significant increase in seed oil percentage by decreasing plant density up to 200000 plants/ha. May be the lack of the number of plants per unit area helps the growth of plants that are good for the availability of fertilizer nutrients, water and air, thereby increasing the accumulation of food ingredients in seeds as part of the economic yield and oil content of seeds. These results are in agreement with those recorded by Rahnama & Bakhshandeh (2006) who found that seed oil percentage increased by increment in planting distance up to 60 cm. Table 4 illustrates that increasing plant density up to 400000 plants/ha through decreasing planting distance up to 10 cm gave significant increase in oil yield/ha in 2008 and 2009 seasons. The increase in oil yield/ha with higher plant population density are mainly due to the increase in seed yield per ha confirming results reported by Rahnama & Bakhshandeh (2006).

3. Conclusion

Sesame is considered as one of the most important oil crop in the world because its seeds have high contents of oil and protein. It is widely cultivated in tropical and sub-tropical parts of the world. In order to increase the yield of sesame per unit areas, different agronomic researches have been done by different researchers. From those several investigators reported that the effects of applying nitrogen fertilization and plant population on growth, yield attributes, seed yield and quality of sesame. Nitrogen is the most important essential nutrient in plant nutrition. It is a constituent of a large number of necessary organic compounds such as amino acids, proteins, coenzymes, nucleic acids, ribosome, chlorophyll, cytochrome and some vitamins. As reported by many researcher when rate of nitrogen fertilizer increased, yield and yield components of sesame also increased in some extent except oil contents. Oil contents of crops are decreased when nitrogen rate is increased. Maximum yield of sesame is achieved from the best spatial arrangement of plants for effective canopy development, water and nutrient utilization and pest control. Many factors influence the optimum plant density for a crop. Therefore, mostly density of sesame crops based on availability of water, nutrient and sunlight, length of growing seasons, potential plant size, planting pattern and the plant's capacity to change its form in response to varying environmental conditions (morphological plasticity). Both the biological and economical yield increases with increasing plant population up to certain point and subsequently no addition in biological yield can be obtained and economic yield decreases. Increasing plant density by decreasing planting distance b/n plants increased plant height, height of the first fruiting branch. These results are due to higher competition among plants for light and results the elongation of internodes. Decreasing plant population by increasing distance b/n plants increased number of branches, capsules /plant, 1000-seed weight and seed weight/plant. This is due to low competition among plants for growth. Increasing plant population density decreases seed yield and oil content of seed per plants and increases seed yield and oil yield/ha, due to the greater number of sesame plants per unit area in narrow distance compensate that reduction in yield attributes of the individuals.

4. References

- Ahmad R, Tariq M, Seleem MF, Ahmad S. Comparative performance of two sesame (*Sesamum indicum* L.) varieties under different row spacing. *Asian Journal of Plant Sciences* 2002;1:546-547.
- Anonymous. Survey of Indian Agriculture by Hindu. The Hindu, 2005, 58-64.
- Arnon I. Physiological principles on dry land crop production. In: S.S. Gupta (Ed) *Physiological aspects of dry land farming*. Oxford and IBH publishing co. New Delhi. 1975.
- Ashfaq A, Akhtar M, Hussain A, Ehsanullah A, Musaddique M. Genotypic response of sesame to nitrogen and phosphorus application. *Pak. J Agric. Sci* 2001;38(1-2):12-15.
- Balasubramanian, Palaniappan. *Principles and practices of Agronomy*. 2nd edition, Agrobios (India), 2007.
- Basha HA. Response of two sesame cultivars to nitrogen level in newly reclaimed sandy soil. *Zagazig J Agric. Res* 1994;21(3A):603-616.
- Bassiem MM, Anton NA. Effect of nitrogen and potassium fertilizers and foliar spray with ascorbic acid on sesame plant in sandy soil. *Ann. Agric. Sci., Moshtohr* 1998;36(1):95-103.
- Bedigian D, Harland JR. Evidence for cultivation of sesame in the ancient world. *Econ. Bot* 1986;40:137-154.
- Caliskan S, Arslan M, Arioglu H, Isler N. 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 Science* 2004;3(5)610-613.
- CSA (Central Statistical Agency of Ethiopia), 2011. Country STAT Ethiopia. www.csa.gov.et/index. accessed on August 11, 2012.
- Elias Urage. The status and future trends of sesame research in Ethiopia. In: Abbas Omran (ed). *Oil Crops: Safflower, Linseed, and sesame*. Proceedings of the fourth oil crops network work shop held at Nejaro, Kenya, 1988, 25-29.
- FAO (Food and Agriculture Organization of the United Nations), 2012. 'Production Crops: sesame seeds' (<http://faostat.fao.org/site/567>). accessed on August 11, 2012.
- Fayed EHM, Hassan AA, Hussain SMA. Sesame performance as affected by seeding rate and nitrogen levels under drip irrigation system in newly cultivated sandy soil. I. Yield and yield attributes. *Ann. Agric. Sci., Moshtohr* 2000;38(1):65-73.
- Franz Augstburger, Jörn Berger, Udo Censkowsky, Petra Heid, Joachim Milz, Christine Streit. *Organic Farming in the Tropics and Subtropics Exemplary Description of 20 Crops Sesame*, 1st edition, Naturland, 2002.
- Getinet Alemaw, Adugna Wakjira. The impact of IDRC support on Ethiopian oilseeds research and production. In: Luis A. Navarro (ed). *Oil crops Research Network*. Proceedings of the steering committee meeting and work shop held I Nairobi, Kenya, 1992.
- Getinet Alemaw, Negusse Alemayehu. Highland oil crops: A three-decade research experiences in Ethiopia. Research report No. 30. IAR, Addis Ababa, Ethiopia, 1997.
- Hafiz SI, EL-Bramawy MAS. Response of sesame to population densities and nitrogen fertilization on newly reclaimed sandy soils. Department of Plant Breeding and Genetics, University of Sargodha, Pakistan, 2011.
- Karaaslan D, Boydak E, Gercek S, Simsek M. Influence of

- irrigation intervals and row spacing on some yield components of sesame growth in Harran region. *Asian Journal of Plant Science* 2007;6(4):623-627.
19. Kobayashi T. The type classification of cultivated sesame based on genetic character,. In: *Sesame and safflower: status and potentials*, FAO Plant Prod. Prot. Paper No. 66. Food and Agriculture Organization of the United Nation, Roma 1985, 86-89.
 20. Langham RD. Growth and Development of sesame, 2008, 13.
 21. Lyon. How do plant populations affect yield? University of Nebraska Lincoln, 2009.
 22. Marschner H. Mineral nutrition of higher plants. Academic Press INC, U.S.A, 1986, 674.
 23. Mkamilo GS, Bedigian D. *Sesame indicum* L. In: van der Vossen, HAM, Mkalimo GS. (Eds). PROTA 14: *Vegetable oils/Oleagineux*. Wageningen, Netherlands, 2007.
 24. MoARD (Ministry of Agriculture and Rural Development), study on sesame production and marketing improvement, 44 pp, Addis Ababa, 2007b.
 25. Muhamman MA, Gungula DT. Growth parameters of sesame (*Sesamum indicum* L.) as affected by nitrogen and phosphorous levels in Mubi. Nigeria. *J of Sustainable Development in Agriculture & Environment* 2008;3(2):80-86.
 26. Muhamman MA, Gungula DT, Sajo AA. Phenological and yield characteristics of sesame (*Sesamum indicum* L.) as affected by nitrogen and phosphorous rates in Mubi, Northern Guinea Savanna Ecological Zone of Nigeria. *Emir. J Food Agric* 2009;21(1):01-09.
 27. Nagaraj, 1995. Quality and Utility of Oilseeds, Directorate of Oilseeds, Hyderabad, India.
 28. Noorka IR, Rehman S, Haidry JR, Khaliq I, Tabassamand S, Din M. Effect of water stress on physico-chemical properties of wheat (*Triticum aestivum* L.). *Pak. J Bot* 2009;41(6):2917-2924.
 29. Parwar PR, Pathi RA, Khanvilkar SA, Mahadkar UN, Bhagat SB. Effect of different levels of nitrogen and phosphorous on yield and quality of Sesamum. *J Maharashtra Agric. Univ* 1993;18:310-1.
 30. Rahnama A, Bakhshandeh A. Determination of optimum row-spacing and plant density for uni-branched sesame in Khuzestan province. *J Agric. Sci. Technol* 2006;8:25-33.
 31. Ramakrishnan A, Sundaramand A, Appavoo K. Influence of fertilization on yield and components of sesame (*Sesamum indicum* L.). *Madras. Agric J* 1994;81:696-8.
 32. Saharia P, Bayan NC. Production potential of Sesamum (*Sesamum indicum* L.) as influenced by weeds management and nitrogen level. *J Agric. Sci. Society of N.E* 1996;9:199-01.
 33. Sghar Malik M, Farrukh Saleem, Mumtaz Akhtar Cheema, Shamim Ahmed. Influence of Different Nitrogen Levels on Productivity of Sesame (*Sesamum indicum* L.) under Varying Planting Patterns. Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan, 2003.
 34. Seegeler CJP. Oil seeds in Ethiopia, their taxonomy and agricultural significance. Center for agricultural publishing and documentation (pudoc), Wageningen, the Netherlands, 1983.
 35. Singh VP, Singh RA. Scientific crop production. 1st ed. X-press Graphics, Delhi-28, India, 2002.
 36. Sumathi V, Jaganadham A. Effect of nitrogen levels on yield, dry matter and nitrogen uptake by sesame (*Sesamum indicum* L.) varieties. *J Res. Agron* 1994;27:63-68.
 37. Weiss EA. Castor, Sesame and Safflower. Barnes & Noble Inc., New York 1971, 901.
 38. Weiss EA. Oilseed Crops. 2nd ed. Blackwell Science, Inc., Malden MA. 2000.