The optimization of oil quality in sunflower seeds (*Helianthus annuus* L.) by giving cow manure and EM4

T Rahayu*, M Ihsan and S M Prabowo
Department of Agrotechnology, Agriculture Faculty UNIBA Surakarta, Indonesia

* Email: rahayu@uniba.ac.id

Abstract. Sunflower as a source of oil that is consumed as a provider of high quality protein. Sunflowers play an important role in nutrition for humans. This study aims to examine the optimization of oil quality in sunflower seeds (*Helianthus annuus* L.) by providing cow manure and EM4 to obtain recommendations for developing cultivation technology engineering formulas to improve oil quality. This study used a Randomized Completely Block Design method consisting of 2 treatments and each treatment was repeated 3 times. The first factor for manure dosing, consists of 4 levels, there are: N0: 0 ton ha⁻¹; N1: 10 ton ha⁻¹; N2: 15 ton ha⁻¹; N3: 20 ton ha⁻¹. The second factor is concentration of EM4, consists of 4 levels, there are: D0: EM4 0 cc / lt⁻¹; D1: EM4 15 cc / lt⁻¹; D2: EM4 30 cc lt⁻¹; D3: EM4 45 cc lt⁻¹. The variables of this research were: seed weight per plant and per plot, and quality of oil content of sunflower seeds. The results of analysis of variance on the variable seed weight of each plant and per plot showed the interaction between treatments with the best treatment combination was N1D2 (manure dosage of 10 tons ha⁻¹, EM4 concentration of 30 cc lt⁻¹). In the observation parameters, the sunflower seed oil content also has interactions between treatments with the best treatment combination is N2D3 (manure dosage of 20 tons ha⁻¹, EM4 concentration of 45 cc lt⁻¹).

1. Introduction

(*Helianthus annuus*, L.) is one of the important oil-producing plants and is ranked third in its production in the world after peanuts and soybeans [1]. In Indonesia, the temporary sunflower is cultivated in East Java in the Sengkaling area, Malang or in the Blitar area. Sunflower seed production in Blitar is quite high, which is 3 tons of seeds/hectare. To get 1 liter of oil, about 4 - 5 kg of sunflower seeds are needed. Sunflower is a source of consumable oil and a provider of high quality protein. Sunflowers play an important role in nutrition for humans. According to data from the Central Statistics Agency (BPS), hundreds of tons of sunflower seeds must be imported annually to meet domestic needs. There were 280 tons of seeds worth nearly US $ 328,382 were imported from China in 1999, Australia, the United States and Belgium. This shows that there are serious problems regarding the supply of sunflower seeds from within the country. Besides being caused by a lack of domestic supply, domestic production also has inadequate quality, as well as the continuity of unreliable results [2].

The number of seeds produced by sunflowers and their oil content and quality is influenced by the comparison of certain nutrient adequacy. Phosphorus has an influence on growth and development, stem height and diameter of sunflower [3]. Potassium plays an important role in increasing the number of seeds, flower weight and height of sunflower stems [4].

Sunflower seed oil is the main source of industrial and food products. Applications in the industrial world of sunflower seeds depend on the nutrients contained in them and their usefulness [5]. Industrial
products from sunflower seed oil that have been commercialized in the world include raw materials for vegetable oils, margarine, cosmetics, pharmaceuticals and for various food needs [1].

Sunflower plants have many benefits while in Indonesia there are still few farmers who cultivate sunflower plants, this can be a good opportunity for the future considering the oil needs of sunflower seeds are quite high. Therefore our research team has the idea of developing the potential of marginal land such as acid plant to increase the productivity of sunflower plants so that the production of sunflower seed oil will increase. Application of organic matter on that soil which has low organic content, will change the soil properties better than before. The organic matter increase soil aggregation on fine soil, make good aeration and soil porosity.

This study aims to examine the optimization of quality oil of sunflower seeds (Helianthus annuus L.) by providing cow manure and bioactivators to obtain recommendations for developing cultivation technology engineering formulas to increase the content and quality of sunflower seed oil.

2. Materials and Methods
This research was conducted in April-October 2018, in Jatipuro Subdistrict, Karanganyar Regency with altitude ± 500 above sea level with latosol soil types. Laboratory tests are carried out at the UNIBA Agriculture Faculty, at the Surakarta UNS Central Laboratory and at the UGM LPPT.

2.1. Materials
Materials used: Seed of sunflower plants of local variety, Cow manure, EM4. Tools used: Land processing equipment, stationery, nameplate, pH meter, spectrophotometer and camera.

2.2. Methods
This study used a Randomized Completely Block Design method consisting of 2 treatments and each treatment was repeated 3 times. The first factor for manure dosing, consists of 4 levels, there are: N0: 0 ton ha⁻¹; N1: 10 ton ha⁻¹; N2: 15 ton ha⁻¹; N3: 20 ton ha⁻¹, the second factor is concentration of EM4, consists of 4 levels, there are: D0: EM4 0 cc lt⁻¹; D1: EM4 15 cc lt⁻¹; D2: EM4 30 cc lt⁻¹; D3: EM4 45 cc lt⁻¹. Observation variables observed were seed weight per plant, sunflower seed oil content. Analysis of saturated and unsaturated fatty acids was carried out by hydrolysis using the method: Methylester 37 New 3032017 Kal, gcm. The data obtained were analyzed by Analysis of Variance at the 5% and 1% levels, while the follow-up test on the treatment results using the Duncan Multiple Range Test (DMRT) multiple distance test at level of 5%.

3. Results and Discussion

3.1. Soil Analysis
The soil chemical properties of the research are relatively poor. Provision of manure is expected to improve soil fertility. Analysis of soil at the beginning / native soil and after being given manure was carried out to determine changes in some soil chemical properties. Soil analysis was carried out in the chemical lab and soil fertility of the Faculty of Agriculture, UNS Surakarta.

| No | Kode   | pH | Available N | Total N | CEC | Org.C | Organic matter |
|----|--------|----|-------------|---------|-----|-------|----------------|
|    | Soil sample | 5.5 | 59.50       | 0.13    | 3.36| 0.85  | 1.47           |

Source: Lab. Soil Chemistry and Soil Fertility Agriculture Faculty of UNS
Table 1 shows the soil content before being treated, it is seen that the soil fertility level is low, then after being given cow manure the soil is incubated for 30 days, according to the treatment there is a change in some of the selected chemical properties of the soil (Table 2).

| No | code  | pH  | Available N Ppm | Total N % | CEC me % | Org. C % | Organic matter % |
|----|-------|-----|-----------------|-----------|----------|----------|-----------------|
| 1  | N₀D₀  | 5.89| 59.50           | 0.13      | 19.60    | 2.09     | 3.61            |
| 2  | N₀D₁  | 5.92| 63.00           | 0.14      | 20.00    | 2.25     | 3.88            |
| 3  | N₀D₂  | 5.95| 63.00           | 0.15      | 21.60    | 2.46     | 4.24            |
| 4  | N₀D₃  | 5.93| 66.50           | 0.15      | 21.20    | 2.61     | 4.50            |
| 5  | N₁D₀  | 5.97| 63.00           | 0.15      | 22.40    | 2.22     | 3.82            |
| 6  | N₁D₁  | 5.90| 66.50           | 0.17      | 21.60    | 2.34     | 4.03            |
| 7  | N₁D₂  | 5.98| 80.50           | 0.20      | 21.60    | 2.48     | 4.28            |
| 8  | N₁D₃  | 6.06| 94.50           | 0.21      | 22.08    | 2.61     | 4.50            |
| 9  | N₂D₀  | 5.77| 70.00           | 0.10      | 22.72    | 2.44     | 4.21            |
| 10 | N₂D₁  | 5.91| 73.50           | 0.14      | 23.20    | 2.45     | 4.22            |
| 11 | N₂D₂  | 5.93| 80.50           | 0.12      | 23.84    | 2.51     | 4.33            |
| 12 | N₂D₃  | 5.99| 94.50           | 0.15      | 24.00    | 2.59     | 4.47            |
| 13 | N₃D₀  | 5.81| 70.00           | 0.15      | 23.60    | 1.72     | 2.97            |
| 14 | N₃D₁  | 5.97| 101.50          | 0.14      | 24.00    | 1.55     | 2.67            |
| 15 | N₃D₂  | 5.90| 148.40          | 0.15      | 24.00    | 1.84     | 3.16            |
| 16 | N₃D₃  | 6.22| 224.00          | 0.15      | 25.20    | 1.76     | 3.03            |

Source: Lab. Soil Chemistry and Soil Fertility Agriculture Faculty of UNS

In general, in the soil treated with cow manure there was an increase in nitrogen content both in available N and in total N. The highest available N increase was obtained in the treatment with the highest dose of manure (N₃). Soils incubated after being treated with manure also experienced an increase in pH as well as an increase in the CEC. This shows that the active groups in organic matter are able to neutralize free hydrogen present in soil solutions, and simultaneously contribute organic colloids to increase soil cation exchange capacity. Giving manure certainly increases the content of organic matter and organic C in the soil.

3.2. Seed weight
In Figure 1, it appears that the treatment of manure doses significantly affects to dry seeds weight per plant. The highest yield of dry seeds was obtained at the N₁ dose treatment (10 tons ha⁻¹ manure dose) which was 158.67 grams, while the lowest was 138.58 grams obtained at the N₃ dose (20 tons ha⁻¹ manure dose). The higher the dose of manure given, the lower the yield of dry seeds per plant obtained. This data shows that the highest amount of organic matter provides a good vegetative growth in plants, but the presence of high nitrogen in the fertilizer will actually suppress crop seed production. This is because the abundance of nitrogen originating from manure in the phase of seed formation, is not balanced with other nutrient availability, especially phosphorus and potassium. The needs of P and K plants which are only supplied from organic fertilizers do not meet the needs of plants to produce higher seeds.

From the results of testing on the data obtained, the application of EM4 did not significantly affect to the weight of dry seeds per plant. It was also found that giving EM4 at a rate of 30 cc lit⁻¹ water gave the highest dry seed weight per plant, although it was not significant different from the others (Figure 2). This shows that the colonies of microorganisms contained in EM4 are able to help plant roots grow better so that their seed production also increases.
Figure 1. Effect of giving manure doses to dry seed weight each plant. $N_0$ (manure dose 0 tons ha$^{-1}$); $N_1$ (10 tons ha$^{-1}$ manure dose); $N_2$ (fertilizer dosage 15 ton ha$^{-1}$ cage); $N_3$ (manure dose 20 tons ha$^{-1}$). The average treatment followed by the same letter is not significantly different

Figure 2. Effect of concentration of giving EM4 on dry seed weight per plant. $D_0$: 0 cc lt$^{-1}$; $D_1$: 15 cc lt$^{-1}$; $D_2$: 30 cc lt$^{-1}$; $D_3$: 45 cc lt$^{-1}$. The average treatment followed by same letters is not significantly different

The analysis of variance data processing showed an interaction between the treatments tested, namely between the doses of manure and EM4 concentration. The treatment combination that yields the highest dry seed weight per plant is $N_1D_3$ (10 tons ha$^{-1}$ manure dose, 30 cc lt$^{-1}$ bioactivator concentration) which is 178.67 grams, while the treatment combination is $N_3D_0$ (manure dose 20 tons ha$^{-1}$ the 0 cc lt$^{-1}$ bioactivator concentration gave the lowest yield of 118.67 grams (Table 3).
Nutrients such as P are available and total N is a nutrient that must be fulfilled where the physiological activity of plants, namely the generative phase begins the flowering process until fertilization. The increase in the chemical properties of total N and P soil is caused by the provision of manure and EM4 (Table 2), this is in accordance with the results of test data analysis on variable seed weight per plant and per plot where interaction between manure and EM4 occurs. [6] explains that in general the main obstacles to sunflower production are caused by natural and climate anomalies, but no less important are cultivation practices and supply of nutrients.

Manure contains a lot of organic material which is then combined with EM4 which is responsible for helping decomposition so that it can be absorbed by the soil. According to [7] N nutrients are not obtained from the results of weathering rocks, but are derived from the results of decomposition of organic matter. While the element of phosphorus is increased due to the overhaul of organic matter, it can contribute around 20 - 80% of the total P in the soil.

Then further [8] explained that to produce 2,713 kg of seeds per hectare, 160 kg N per hectare needed, 80 kg P2O5 and 50 kg K2O per hectare. Research conducted by [9] states that a lack of essential nutrients in the seed filling phase can reduce yield by 60%. Besides because nutrition, the percentage of empty seeds is also influenced by the nature of the plant. According to [10] explain that most sunflower capitules are hermaphroditic but protandri causing self-incompatibility.

### Table 3. Effect doses of manure and EM4 concentration on the average weight of dried seeds per plant

| Treatments | Means (g) |
|------------|-----------|
| N1D0 (Manure dosage of 10 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 178.67a |
| N1D1 (Manure dosage of 20 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 156.17ab |
| N1D2 (Manure dosage of 15 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 154.17bc |
| N1D3 (Manure dosage of 10 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 152.17cd |
| N1D4 (Manure dosage of 0 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 148.17de |
| N2D0 (Manure dosage of 20 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 137.67d |
| N2D1 (Manure dosage of 15 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 136.17de |
| N2D2 (Manure dosage of 10 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 134.17def |
| N2D3 (Manure dosage of 0 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 131.83def |
| N3D0 (Manure dosage of 20 ton ha⁻¹, EM4 concentration of 30 cc lt⁻¹) | 129.67ef |
| N3D1 (Manure dosage of 15 ton ha⁻¹, EM4 concentration of 30 cc lt⁻¹) | 118.67f |

The average treatment followed by the same letter in the same column is not significantly different.

#### 3.3. Sunflower Seed Oil Content

In table 4 and table 5, the results of the interaction treatments that were tried were presented, namely between doses of manure and EM4 concentration. It appears that the treatment of N2D3 (20 tons ha⁻¹ manure dose, 45 cc lt⁻¹ EM4 concentration) gives the lowest saturated fatty acid content of 8.39%, while treatment N1D3 (10 tons ha⁻¹ manure dose, EM4 concentration 45 lt⁻¹) gives the highest saturated fatty acid content of 48.39%. In the treatment of N2D3 (20 tons ha⁻¹ manure dose, 45 cc lt⁻¹ EM4 concentration) the highest unsaturated fatty acid content was 91.6%, while N1D3 (10 tons ha⁻¹ manure, EM4 concentration 45 cc lt⁻¹) found the lowest unsaturated fatty acid content of 51.6% (table 5). The results of this study are in accordance with [11] which states that sunflower seed oil contains 44-72% linoleic acid (unsaturated fatty acids) and 11.7% oleic acid (saturated fatty acids). The content of saturated and unsaturated fatty acids in sunflower seeds is inversely proportional.

According to [11] added that sunflower seed oil is used for various purposes such as cooking oil, making margarine for cosmetic raw materials, and medicines, in addition to oil-pressed cake or pulp.
containing 13-20% protein, which can be used as animal feed. Sunflower seeds are a group of low cholesterol oils that rival corn oil, peanut oil and soybean oil, so it is very good for health.

**Table 4.** Effect of doses of manure and EM4 concentration on saturated fatty acid content

| Treatment | Means (%) |
|-----------|-----------|
| N1D3 (Manure dosage of 10 ton ha⁻¹, EM4 concentration of 45 cc lt⁻¹) | 48.39a |
| N1D1 (Manure dosage of 10 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 29.65b |
| N1D0 (Manure dosage of 10 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 26.89c |
| N1D3 (Manure dosage of 20 ton ha⁻¹, EM4 concentration of 45 cc lt⁻¹) | 21.42d |
| N1D1 (Manure dosage of 20 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 21.18d |
| N1D0 (Manure dosage of 20 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 19.74e |
| N0D0 (Manure dosage of 0 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 18.76f |
| N0D3 (Manure dosage of 0 ton ha⁻¹, EM4 concentration of 45 cc lt⁻¹) | 18.58f |
| N0D0 (Manure dosage of 15 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 18.49f |
| N0D0 (Manure dosage of 20 ton ha⁻¹, EM4 concentration of 0 cc lt⁻¹) | 17.20g |
| N0D2 (Manure dosage of 10 ton ha⁻¹, EM4 concentration of 30 cc lt⁻¹) | 15.18h |
| N0D1 (Manure dosage of 15 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 10.01i |
| N0D2 (Manure dosage of 15 ton ha⁻¹, EM4 concentration of 30 cc lt⁻¹) | 8.66j |
| N0D1 (Manure dosage of 0 ton ha⁻¹, EM4 concentration of 15 cc lt⁻¹) | 8.60j |
| N0D3 (Manure dosage of 15 ton ha⁻¹, EM4 concentration of 45 cc lt⁻¹) | 8.39j |
| N0D2 (Manure dosage of 0 ton ha⁻¹, EM4 concentration of 30 cc lt⁻¹) | 8.32j |

The average treatment followed by the same letter in the same column is not significantly different.

According to [12] stated that plant height and flower head diameter did not show a positive correlation to the oil content of the seeds. Then according to [13] states that nitrogen actually reduces the concentration of sunflower seed oil but increases seed yield. Research conducted by [14] also concluded that Nitrogen has an important role in increasing the yield of sunflower seeds but decreasing oil quality. The more nitrogen supply is available, the more seed yields are abundant but with less oil content.

**Table 5.** Effect of manure doses and EM4 concentration on acid content unsaturated fatty acids (%)

| Treatment | Means (%) |
|-----------|-----------|
| N2D3 (Manure dosage of 15 ton ha⁻¹, EM4 concentration 45 cc lt⁻¹) | 91.60a |
| N0D1 (Manure dosage of 0 ton ha⁻¹, EM4 concentration 15 cc lt⁻¹) | 91.40a |
| N2D2 (Manure dosage of 15 ton ha⁻¹, EM4 concentration 30 cc lt⁻¹) | 91.33a |
| N1D1 (Manure dosage of 15 ton ha⁻¹, EM4 concentration 15 cc lt⁻¹) | 89.99a |
| N1D2 (Manure dosage of 10 ton ha⁻¹, EM4 concentration 30 cc lt⁻¹) | 84.81b |
| N2D0 (Manure dosage of 20 ton ha⁻¹, EM4 concentration 0 cc lt⁻¹) | 82.80c |
| N2D2 (Manure dosage of 0 ton ha⁻¹, EM4 concentration 30 cc lt⁻¹) | 81.76cd |
| N2D0 (Manure dosage of 15 ton ha⁻¹, EM4 concentration 0 cc lt⁻¹) | 81.52cd |
| N0D3 (Manure dosage of 0 ton ha⁻¹, EM4 concentration 45 cc lt⁻¹) | 81.41cd |
| N0D0 (Manure dosage of 0 ton ha⁻¹, EM4 concentration 0 cc lt⁻¹) | 81.24cd |
| N0D2 (Manure dosage of 20 ton ha⁻¹, EM4 concentration 30 cc lt⁻¹) | 80.26de |
| N2D1 (Manure dosage of 20 ton ha⁻¹, EM4 concentration 15 cc lt⁻¹) | 79.87de |
| N2D3 (Manure dosage of 20 ton ha⁻¹, EM4 concentration 45 cc lt⁻¹) | 78.57e |
| N0D0 (Manure dosage of 0 ton ha⁻¹, EM4 concentration 0 cc lt⁻¹) | 73.12f |
| N0D1 (Manure dosage of 10 ton ha⁻¹, EM4 concentration 0 cc lt⁻¹) | 70.35g |
| N0D3 (Manure dosage of 10 ton ha⁻¹, EM4 concentration 45 cc lt⁻¹) | 51.61h |

The average treatment followed by the same letter in the same column is not significantly different.
The highest seed production is achieved by administering manure at the lowest dose of N_1 (figure 1), providing the lowest unsaturated fatty acid content (Figure 3). In the treatment of administering manure with a dose of N_2, the highest unsaturated fatty acid content was obtained. It is clear that in producing good quality sun seed oil, a fairly high supply of manure (15 tons ha^{-1}) is needed, although the yield of dry seeds is less than that given with a dose of N_1 (10 tons ha^{-1}).

**Figure 3.** Effect of manure dosage of unsaturated fatty acids in seeds sunflower. N_0 (manure dosage of 0 tons ha^{-1}); N_1 (manure dosage 10 ton ha^{-1}); N_2 (manure dosage of 15 tons ha^{-1}); N_3 manure dosage 20 tons ha^{-1}). The average treatment followed by same letters is not significantly different.

Sunflower seed oil is one of the main oils in the world that comes from plants because of its best quality. Oil quality is determined by the presence of its fatty acid content, which is a combination of monounsaturated and double unsaturated fatty acids with low saturated fatty acid levels [15].

**4. Conclusion**

There are significant interactions between treatments given to variable seed weight per plant. The treatment combination N_1D_2 (manure dosage of 10 tons ha^{-1}, EM4 concentration 30 cc lt^{-1}) gave the highest yield of 178.67 grams while the combination treatment was N_3D_1 (manure dosage of 20 tons ha^{-1}, EM4 concentration 0 cc lt^{-1}) the lowest is 118.67 grams. In the treatment of N_2D_2 (manure dosage of 20 tons ha^{-1}, EM4 concentration 30 cc lt^{-1}) the lowest saturated fatty acid content was 8.39% and the highest unsaturated fatty acid was 91.6%, while the combination treatment of treatment N_1D_3 (manure dosage of 10 tons ha^{-1}, EM4 concentration 15 cc lt^{-1}) gave the highest saturated fatty acid content, which was 48.39% and the lowest unsaturated fatty acid was 51.61%. The N_1D_2 combination treatment is the best treatment which gave the highest yield of seed production while the unsaturated fatty acid was not the highest.

**References**

[1] Byrareddy K, Uppar D S, Vyakaranahal B S, Hiremath S M, Hunje R and Nadaf H L 2008 Effect of Integrated Nutrient Management on Sunflower Hybrid (KBSH-I) Seed Production *Karnataka J. Agric. Sci.* 21 171–5

[2] Katja D G 2012 Kualitas Minyak Bunga Matahari Komersial dan Minyak Hasil Ekstraksi Biji Bunga Matahari (Helianthus annuus L.) *J. Ilm. Sains* 12 59

[3] Noor-Mohammadi G and Ehdaie B 1980 Effect of Nitrogen and Phosphorus Fertilizer on Sunflower Seed Yield and Other Agronomic Caracter *Beitr. Trop. Landwirtsch. Veterinarmed.* 81
[4] Asadi S 2010 Influence of Different K Fertilizer Sources on Sunflower Production World Congress of Soil Science (Brisbane)

[5] Bernard J K 2016 Oilseed and Oilseed Meals Ref. Modul. Food Sci.

[6] Kostova B 2010 Prospects for Development of Sunflower Production in Bulgaria Trakia J. Sci. 8 215–8

[7] Hasibuan B . 2009 Pupuk dan Pemupukan (Medan: Universitas Sumatera Utara-Press)

[8] Sincik M, Goksoy A T and Dogan R 2013 Responses of sunflower (Helianthus annuus L.) to irrigation and nitrogen fertilization rates Zemdirbyste-Agriculture 100 151–8

[9] Andidarfi A and Sembiring N 2010 Kajian Beberapa Sumber Ca Untuk Meningkatkan Kebernasan polong pada berbagai varietas Kacang Tanah (Arachis hypogea L.) J. Penelit. Lumbung 9 21–31

[10] Suprapto S and Supanjani S 2009 Analisis Genetik Ciri-ciri Kuantitatif dan Kompatibilitas Sendiri Bunga Matahari di Lahan Ultisol J. Akta Agosia 12 89–97

[11] Rukmana R 2004 Budidaya Bunga Matahari (Semarang: Aneka Imu)

[12] Supriya S M, Kulkarni V V., Ranganatha C N and Suresha P G 2009 Quantitative analysis of oil yield and its components in sunflower (Helianthus annuus L.) Int.J.Curr.Microbiol.App.Sci (2017) 6 3088–98

[13] Zheljazkov V D, Vick B A, Ebelhar M W, Buehring N, Baldwin B S, Astatkie T and Miller J F 2008 Yield, oil content, and composition of sunflower grown at multiple locations in Mississippi Agron. J. 100 635–42

[14] Ali A and Ullah S 2012 Effect of nitrogen on achene protein, oil, fatty acid profile, and yield of sunflower hybrids Chil. J. Agric. Res. 72 564–7

[15] Onemli F 2012 Changes in Oil Fatty Acid Composition During Seed Development of Sunflower Asian J. Plant Sci. 11 241–5

Acknowledgement

The authors are grateful to the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia that have funded this research through the scheme of Penelitian Terapan Unggulan Perguruan Tinggi (PTUPT) for first year 2018.