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Effect of partial substitution on mineral fertilizers with yeast on growth, yield and essential oil content of lemongrass (*Cymbopogon citratus* (DC.) Stapf)

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Abstract

Nowadays, there is excessive use of chemical fertilizers to reach high crop productivity without considering its environmental negative impacts. The aim of this study was to estimate the effect of partial replacement of mineral fertilizers with biofertilizer (yeast) on growth, yield and essential oil content of lemongrass (*Cymbopogon citratus* (DC.) Stapf). The experiment was carried out during 2018 and 2019 seasons at the Agricultural Experimental Farm, Faculty of Agriculture and Natural Resources, Aswan University, Sahary, Aswan, Egypt. The results showed a variation in the plants' response to reducing mineral fertilizer and replacing it with yeast. There were significant decreases in tillers number and fresh biomass of the plant, while the decreases were less in the dry biomass of plants, leaf greenness, as well as the essential oil yield. On the other hand, the oil percentage was not affected by the decrease in the amount of mineral fertilizer. From these results, it is recommended for sustainable agriculture that strikes a balance between productivity and environmental considerations, reducing mineral fertilizer to 50-75% NPK combined with bio-fertilizer.

Keywords: Essential Oil, Biofertilizer, Lemongrass, NPK, Yeast

Introduction

In recent times, the rapid thrive of worldwide population expanded the necessities for food and electricity, leading to the enhancement of agricultural productivity in regions with limited cultivation area (Liu and Lal, 2015; Chen and Yada, 2011). In the traditional agricultural systems, the immoderate use of chemical inputs allowed to improve the agricultural productiveness, but unfavorable implications at the environment and human fitness from lengthy-term use of chemical fertilizers have been well evidenced (Bansal, 2017). The immoderate use of chemical fertilizers in traditional agricultural systems decreased the nutrient use efficiency and caused critical environmental issues consisting of waterway pollution, mineral depletion, soil acidification and different troubles (Daneshmandi and Seyyedi, 2019; Ostadi et al. 2020). The soil management is essential for ensuring ecological and agricultural productions and retaining plant variety. The negative effects of chemical fertilizers forced the agrochemical corporations to replace them with biofertilizers in sustainable agricultural structures with a view to attain applicable crop productiveness (Sharma et al., 2013).

There may be an urgent need to improve agricultural practices to make certain that meals production is balanced with environmental sustainability. There is also a whole lot interest in harnessing the blessings of plant-boom-selling microorganisms for sustainable crop production (Vessey, 2003). Microorganisms can sell plant boom and health via more than a few mechanisms, which include imparting vegetation with biologically fixed nitrogen, phytohormones, volatiles, protection compounds, and enzymes (Ryu et al., 2003; Kuklinsky-Sobral et al., 2004; Lugtenberg and Kamilova, 2009).

Yeast is a price-effective biofertilizer that improves no longer simplest plant vitamins however additionally plant energy during the early boom segment. It stays to be mounted which yeast-derived substances trigger the located plant boom results, and the way rhizophagy contributes to plant nutrient acquisition (Lonhienne et al. 2014). Yeast extract, that is environmentally pleasant, nutritious, and convenient to apply, has blessings over not unusual plant increase regulators and soil conditioners. It is well worth verifying the impact of the utility of yeast extract to afforestation in a semiarid soil location (Xi et al. 2019).

Currently, a top notch deal of attention has been paid to components that are more herbal, safe, and occasional-price. Yeast extract has come to be a hot subject matter as it's far secure, nutritious, and handy to use. Yeast extract is rich in powerful components, consisting of low-molecular-weight organic compound, amino acids, nucleotides, peptides, nitrogen, phosphorus, and trace elements. Moreover, yeast extract is freed from chemically synthesized hormones and toxic ingredients (Zhang et al., 2000; Vieira et al., 2016). Yeast extract has been studied in the area of agriculture (Li et al., 2016), in which it has been indicated that application of yeast notably accelerated the vegetative growth, yield, and quality of lettuce (*Lactuca sativa* L.) (Fawzy, 2007), eggplant (*Solanum melongena* L.) (El-Tohamy et al., 2008), potato (*Solanum tuberosum* L.) (Ahmed et al., 2011), cucumber (*Cucumis sativus* L.) (Shehata et al., 2012), soybean (*Glycine max* (L.) Merrill) (Dawood et al., 2013), and turnip (*Raphanus sativus* L.) (Shafeek et al., 2015), and also caused an increase in elemental content, along with N, P, K, Fe, and Zn, in greens. Some of these researches have proved that the enhancement effects of yeast extracts were more stated than other additives, such as Methanol (Dawood et al., 2013).

Lemongrass, *Cymbopogon citratus*, is a perennial medicinal grass, and it is distributed worldwide especially in tropical and subtropical areas of Africa, Asia, and America (Akhila 2010; Francisco et al. 2011; Chanthal et al. 2012). Lemon grass includes 1-2% essential oil in its herb. The main active compounds of lemongrass' essential oil are citral A (geranial) and citral B (neral) (Carlson et al. 2001; Soliman et al. 2017). Many factors effect on the chemical composition of lemongrass essential oil such as genetic diversity, maturity stage, temperature, light intensity, water deficit and agricultural practices (Paviani et al. 2006; Tajidin et al. 2012).

Given the terrible results from the use of chemical fertilizers on the human health and environment, opportunity strategies for decreasing their utility in agriculture are urgently wished. The current take a look at became aimed to estimate the effect of partial replacement of mineral fertilizers (NPK) with biofertilizer (yeast) on growth, yield and volatile oil content of lemongrass (*Cymbopogon citratus* (DC.) Stapf).

Materials and methods

This study was conducted out during the two successive 2018 and 2019 seasons at the Agricultural Experimental Farm, Faculty of Agriculture and Natural Resources, Aswan University, Sahary, Aswan, Egypt. The experiment was designed in a completely randomized design with three replicates. The fertilization treatments were 100% NPK, 75% NPK and yeast, 50% NPK and yeast, 25% NPK and yeast, and yeast only. The 100% NPK represented the recommended dose of compound fertilizer of N-P-K 20:20:20 (150 kg/Feddan). The yeast treatment was at a rate of 20 mL 6% yeast per plant. The fertilization treatments were added two month after planting as well as two month after cut in both seasons.

Plant materials and growth conditions

Homogenous stalks of lemongrass, *Cymbopogon citratus* (DC.) Stapf, were obtained from the Tropical Farm, Agricultural Research Center, Kom-Ombo, Aswan, Egypt. The planting area was designed in the form of terraces and each sub-plot consisted of two terraces with width of 60 cm and length of 3 meter. Organic compost was used in the preparation period by adding and mixing $10m^3$ compost per Feddan in soils before planting. On the 20^{th} of March in each year 2018 and 2019, the homogeneous stalks of lemongrass were cultivated on both sides of terraces, and distance between plants was 30 cm with total of 40 plants/plot. Soil samples were obtained from a depth of 30 cm from the used soil surface in this study and some physical and chemical properties of the soil were done according to the methods described by Jackson (1973) and Black et al. (1982) as shown in Table (1).

Drip irrigation system was used for irrigation purpose and normal agricultural practices were carried out. After two months of planting, the fertilization doses have been added. Plants were harvested twice each season by cutting the shoots 10 cm above ground. The first cut was after two months of treatments. After two months from the first harvest, the fertilization doses have been added and the second harvest has been done after another two months.

Vegetative growth characters

Number of tillers per plant, and fresh and dry herb weight per plant were recorded. Fresh and dry herb yield per feddan (ton) was calculated by multiplying shoot fresh weight per plant and plant number per feddan.

Relative leaf greenness

Chlorophyll Meter reading (SPAD) used for measuring the relative leaf greenness (relative chlorophyll index) in lemongrass leaves using SPAD chlorophyll meter (SPAD-502plus, Konica Minolta, INC., Osaka, Japan). The SPAD values of lemongrass were measured on the middle part of the leaf blade.

Chemical analysis

For chemical analysis, dried plant shoots (0.2 g) were wet-degisted with concentrated H_2SO_4:H_2O_2 (1:1, v/v) using a heating digester (DK, Velp Scientific Srl, Italy). The extracts were used for chemical analysis. Nitrogen (N) content was measured using semi-micro kjeldahl method (Black et al., 1965). Phosphate content was estimated by using vanadate-molybdate-yellow method (Chapman and Pratt, 1961). The density of color was measured using a spectrophotometer at wave length 470 nm and calculated using a standard curve of potassium dihydrogen orthophoshphate (KH_2PO_4). Potassium was estimated by using a flame photometer which was standardized with standard solution (Chapman and Pratt, 1961).

Essential oil extraction

The fresh shoot (300g) was hydro-distillated using Clevenger-type apparatus for three hours (Clevenger, 1928). Then, essential oil content (%) and total essential oil yield per plant were calculated according to the fresh weight. Then the extracted essential oils have been collected and dried using anhydrous sodium sulphate for chemical constituents' identification.

Statistical analysis

Data obtained were subjected to statistical analysis using "F" Test (Snedecor and Cochran 1989) and the means were compared using a least significant difference (L.S.D.) test according to Gomez and Gomez (1984). Statistical analysis was performed using Statistix 8.1 program.

Results and discussion

In this study, fertilization treatments showed significant effects on the growth parameters; number of tillers and shoot fresh and dry weights. All growth parameters decreased when amount of mineral fertilizer (NPK) decreased, and the highest value were shown under treatment of 100% NPK and the lowest values were shown under treatment of yeast only (Figure 1). Leaf greenness slightly affected with fertilization treatment, and the obvious differences were shown in plants fertilized with 100% NPK and plants fertilized with yeast only, and the other treatments showed values between them (Figure 2). Nitrogen content in plant significantly decreased with decreasing mineral NPK fertilizer, while phosphorus and potassium did not show clear response to fertilization treatments (Figure 2). Essential oil percentage in plant leaves showed fluctuation between increases and decreases under fertilization treatments. On the other hand, essential oil content per plant showed no significant differences in the 1st cut of both season, and slightly decreases in the 2nd cuts which due to decreases of plant growth parameters (Figure 3).

Dry yeast extract is a herbal bio- substance advised having stimulating, dietary and protecting capabilities. Used of yeast extract became discovered to growth increase, yield and quality of many vegetable plants (Abou EL-Nasr et al. 2001). On this regard, yeasts have been advised to be enriched source of phytohormones (especially cytokinins), nutrients, enzymes, amino acids and minerals (Barnett et al., 1990; Fathy and Farid, 1996; Mahmoud, 2001; Khedr and Farid, 2002). It changed into additionally announced about its stimulatory impact on mobile department and growth, protein and nucleic acid synthesis as well as chlorophyll formation (Castel-franco and Beale, 1983). It is a herbal bio substance includes many nutrient factors and effective compounds of semi increase regulator compound like auxins, gibberellins and cytokinins. It is use as soil fertilization or as foliar application of vegetable vegetation (El-Ghamriny et al., 1999). Hussain and Khalaf (2007) suggested that using yeast extract multiplied the vegetative growth characters, yield/plant, tubers dry be counted percentage and overall soluble solid (TSS). Ahmed et al. (2011) proven that expanding of foliar utilization of active dry yeast awareness accelerated the vegetative boom characters, productivity and pleasant of potato tubers. In this study, reducing the amount of mineral fertilizer and replacing it with yeast did not compensate for the lack of nitrogen fertilizer, especially in the growth characteristics; the number of tillers and shoot fresh weight of plant, while the yeast had the effect of reducing the negative effect of the decrease in mineral fertilization with regard to the dry weight of the shoots, where the yeast plays a role in regulating the water content within the plant tissues. Also, the yeast played a role in reducing the negative effect of the decrease in mineral fertilization in relation to leaf greenness and the quality characteristics represented by the percentage of essential oil in the plant, which was not significantly affected by the decrease in mineral fertilizer and its substitution with yeast. Using yeast only leads to negative effects on all aspects of growth and yield, but not with regard to the percentage of oil in the leaves.

Conclusion

From these results, we recommend partial replacement of chemical fertilizer with yeast to reduce the negative impact of chemical fertilizers, and the replacement can be economically without significant reductions in productivity by using 50% or 75% mineral fertilizer NPK with yeast.

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Table (1): Physical and chemical properties of the experimental soil.

1- Physical Analysis			
Sand %		94.67	
Silt %		2.27	
Clay %		3.07	
Soil Texture		Sandy	
2- Chemical Analysis			
pH	8.25	Electrical Conductivity (ds/m)	0.25
Soluble Cations meq/L		Soluble Anions meq/L	
Na^{+}	17.74	CO^{-3}	0.00
K^{+}	7.51	HCO^{-3}	4.67
Ca^{++}	2.08	Cl^{-}	2.33
Mg^{++}	0.53		

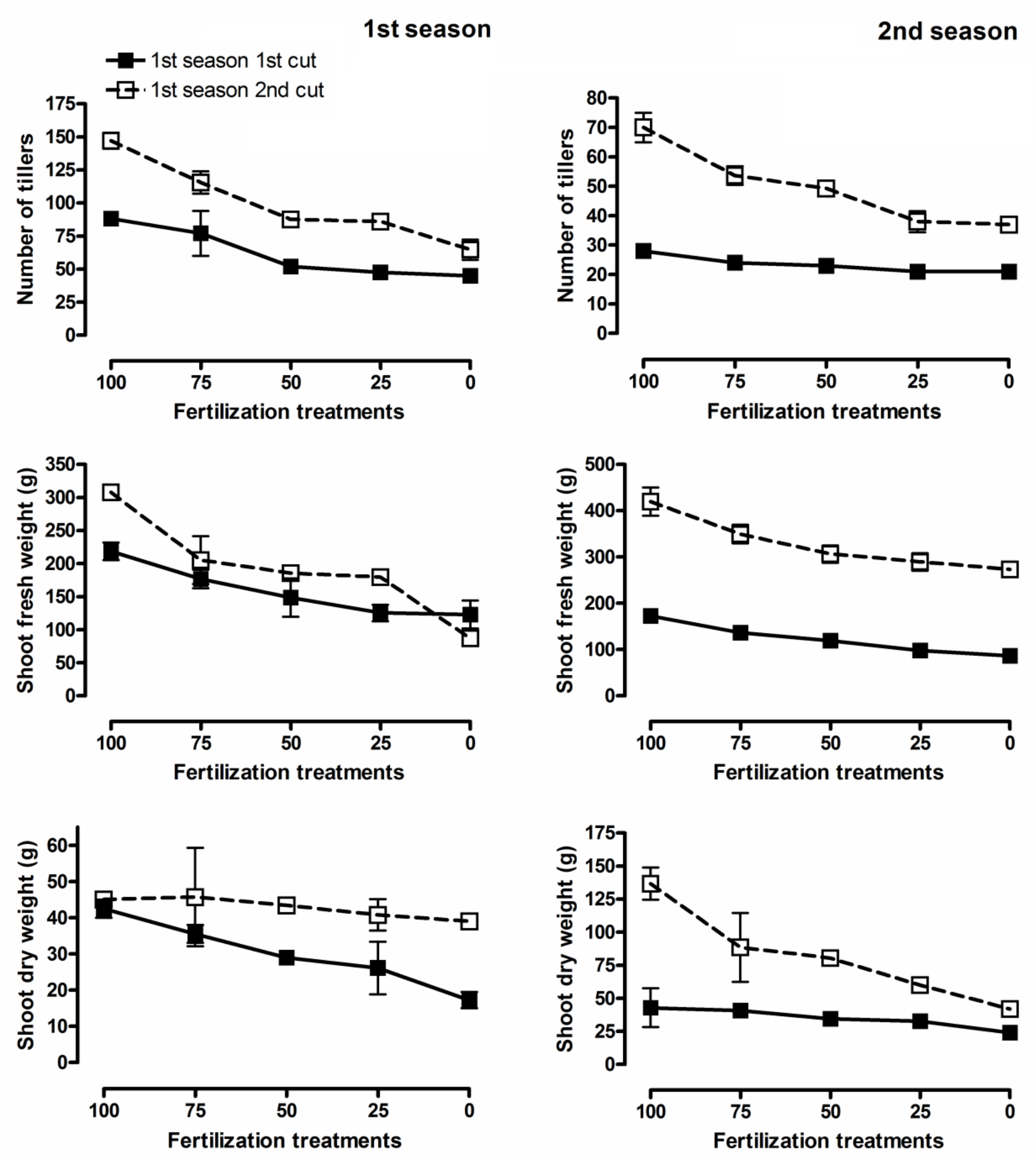

Figure 1. Effect of different fertilization treatments; 100 (100% NPK), 75 (75% NPK+ Yeast), 50 (50% NPK+Yeast), 25 (25% NPK+Yeast), and 0 (Yeast only) on the growth parameters of lemongrass.

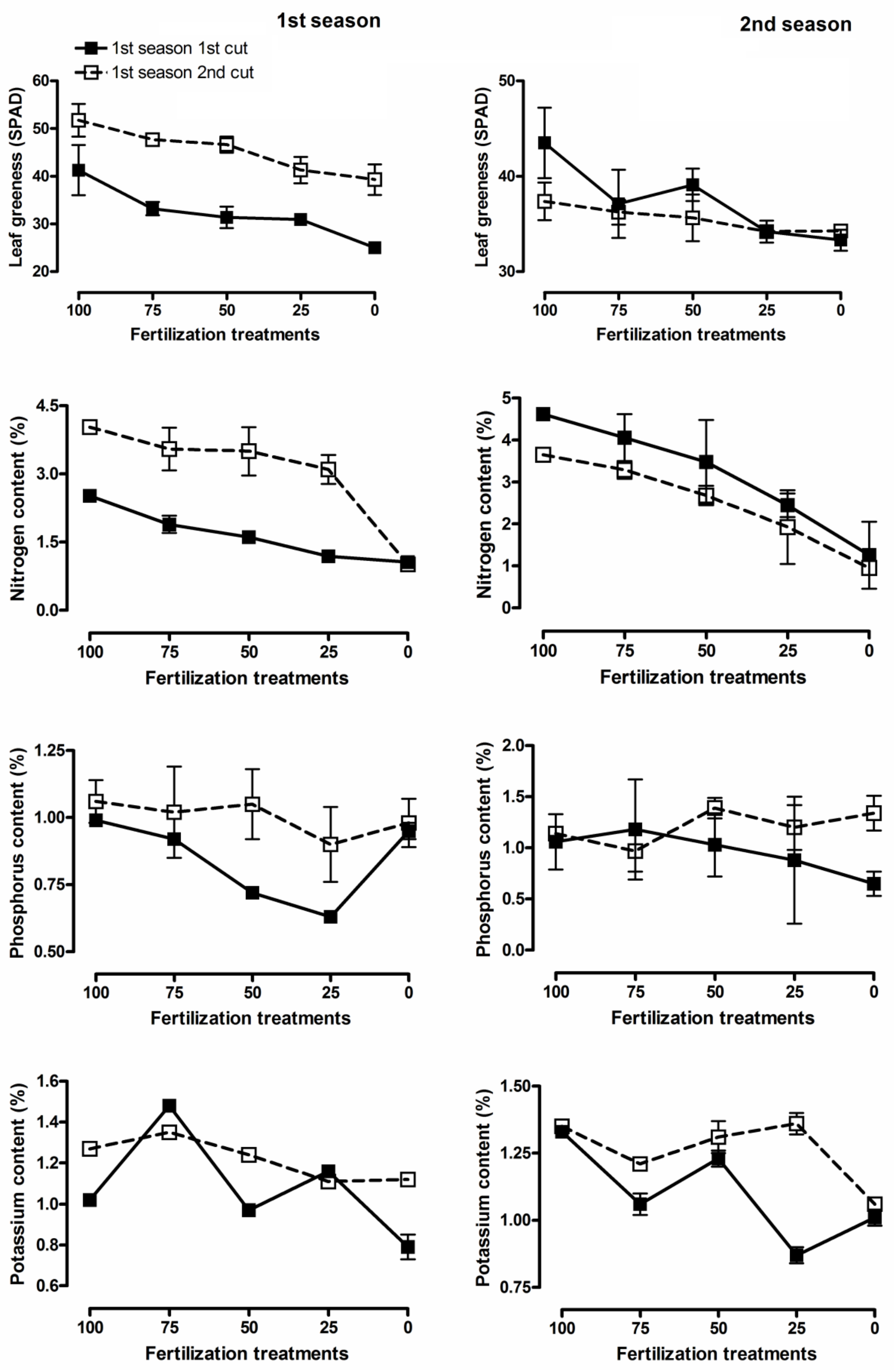
1st season
2nd season
1st season 1st cut
1st season 2nd cut
Leaf greeness (SPAD)
Nitrogen content (%)
Phosphorus content (%)
Potassium content (%)
Fertilization treatments
100
75
50
25
0

Figure 2. Effect of different fertilization treatments; 100 (100% NPK), 75 (75% NPK+ Yeast), 50 (50% NPK+Yeast), 25 (25% NPK+Yeast), and 0 (Yeast only) on the leaf greenness and mineral nutrients contents of lemongrass.

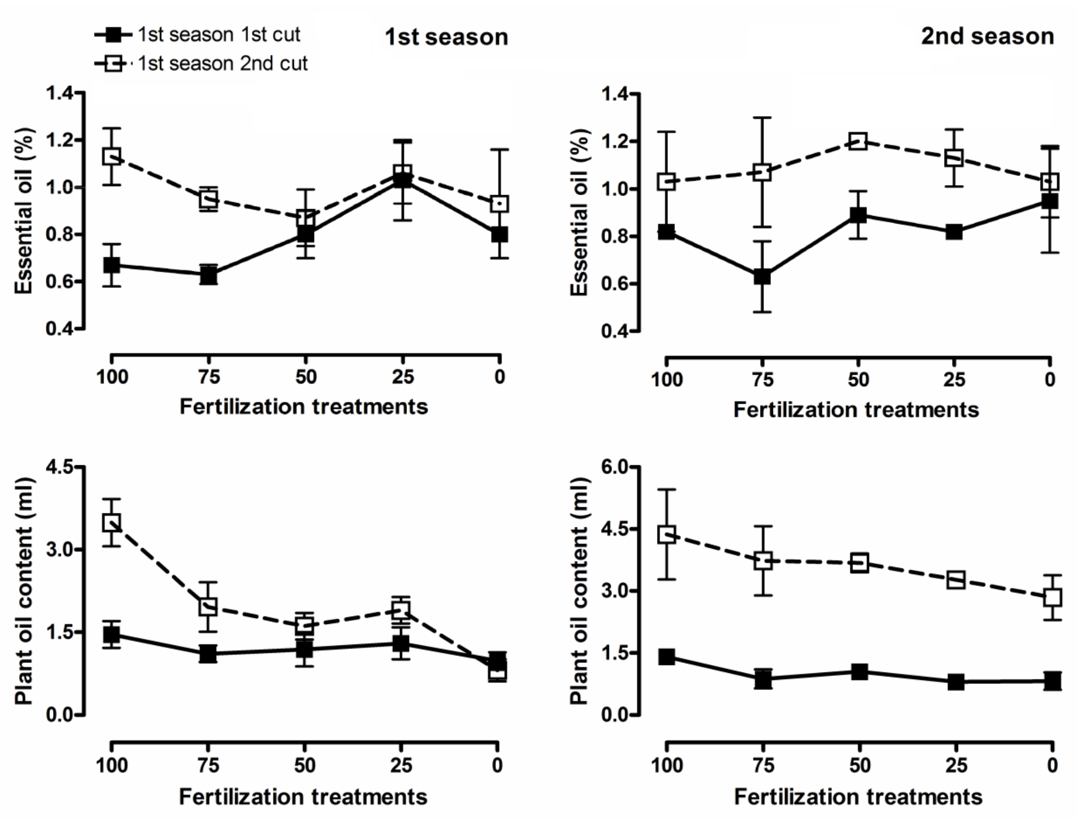

Figure 3. Effect of different fertilization treatments; 100 (100% NPK), 75 (75% NPK+ Yeast), 50 (50% NPK+Yeast), 25 (25% NPK+Yeast), and 0 (Yeast only) on the essential oil content of lemongrass.