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Effects of Nitrogen and Phosphorous Fertilizers on Herbage Yield, Essential oil Yield and Essential Oil Content on Lemongrass *(CymbopogonCitratus L.)*

Melkamu Hordofa Sigaye*, Belstie Lulie and Aynalem Gebire

*Ethiopian Institute of Agricultural Research, Wondo Genet Agriculture Research Center
P.O. Box 198, Shashemene, Ethiopia
Corresponding Author: MelkamuHordofaSigaye: hordofa.mel@gmail.com

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Lemongrass (*Cymbopogon Citratus* L.) is one of the most widely grown and essential oil bring plant. The field experiment was conducted at central rift valley of Ethiopia (Koka) to find the effects of Nitrogen (at 0, 30,60 and 90 kg ha^{-1}) and Phosphorous (at 0,10, 20 and 30 kg ha^{-1}) on lemongrass herbage yield, essential oil yield, and essential oil content. Application of nitrogen and phosphorous fertilizers were significantly increased crop growth characters such as number of tillers, number of leaf hill, herbage yield, essential oil yield. The results proved interaction effects of application fertilizer were gives a higher yield of lemongrass herbage yields, essential oil yields, number of tiller and leaf per hill compared to 0 kg ha^{-1} N and P (unfertile plot). The results showed maximum herbage yield (25.9 t ha^{-1}) essential oil yields (155.5 kg ha^{-1}), a number of tillers per hill (81) and a number of leaf per hill (352) were obtained from the application of 90 N + 20 P_2O_5 kg ha^{-1} fertilizers. Generally, the results clearly indicated that the application nitrogen and phosphorous fertilizers in appropriate quantity form can boost up the growth and oil yield of lemongrass.

Keywords: Lemongrass, herbage, essential oil yields, nitrogen and phosphorous

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INTRODUCTION

Lemongrass (*CymbopogonCitratus L.)* is a perennial multi-harvest aromatic grass cultivated in many parts of the world especially in tropical and subtropical countries (Singh and Sharma, 2001). Lemongrass essential oil is an economically important that has been used for centuries and characterized by a high content of citral (main constituent of lemongrass essential oil) composed of neral and geranial isomers (c. 69%) Hussain *et al.* (2011), which is used in perfumery, cosmetics, confectionery and infusions, and used as raw material in the synthesis of ionone, aromatic substances, vitamin A,and anti-inflammatory(Katsukawa*et al.,* 2010).

Plant nutrition plays a key role in the growth and development of all crop plants. Among the various nutrients, nitrogen and phosphorus are the three important nutrients that are frequently short supply in the soil and their application plays a very important role in altering various growth, yield and quality attributes of the plants (Marschner, 2002). Nitrogen and Phosphorous are major essential minerals, responsible for one of is used by plants to build many organic compounds; amino acids, proteins, enzymes, and nucleic acids and thus for the high cation concentrations in DNA and RNA, phospholipid and electron carriers in chloroplasts and mitochondria and are known to be the major modifier of crop productivity (Marschner, 2002). In the case of aromatic plants essential plant nutrients that can help to synthesize essential oils, effectively increase oil yield and quality that studied by (Aziz *et al.,* 2010, Jabbari *et al*., 2011 and Zheljazkov *et al*. 2010-2011).

Several studies conducted on different medicinal and aromatic plants show that nitrogen and phosphorus fertilization significantly contributes to an enhancement in active constituents and composition of essential oil, through their effect on biomass yield, plant height, leaf area and photosynthetic rate (Ashraf *et al.,* (2016), Daneshkhah *et al.,* (2007) and Hendawy and Khalid(2011). Also, Arabaci *et al.* (2004)) reported that nitrogen and phosphorus is used in the development of essential oil-producing plants and in essential oil biosynthesis as well as can effectively increase biomass yield of lemongrass. Fertilizers are used in order to supplement the natural nutrient supply in the soil, especially to correct the yield-limiting factors. Fertilizer application resulted in marked crop yield increases, which for most crops was more than hundred percent, while low fertilizer use results in declining soil fertility and crop production; it also increases soil degradation through nutrient mining (Mengel *et al.,* 2001)

Ethiopia is characterized by vast arable land, available resources and diversification of climate are regarded as one of the richest country. The government recommended an increase in the production of medicinal and aromatic plants in order to face the extending demands of the local markets and exportation. However, in Ethiopian most, soils have low levels of essential plant nutrients and organic matter content, especially low availability of N and P has been demonstrated to be a major constraint to crop production (Tekalign*et al .,* 1988). Considering the fact that soil fertility decline is one of the biggest challenges, an obvious strategy is to increase fertilizer application and promote good agronomic practices to enhance productivity (Borlaug and Dows 1994).

Keeping in view the scientific research requirements, recently there is a great gap on the production of lemongrass has with regard to specific fertilizer recommendations in the study area of central rift valley of Ethiopia (Koka). Hence, The objective of the present study was to determine the effectsof nitrogen and phosphorous fertilizer on herbage yield, essential oil yield and essential oil content of lemongrass (*Cymbopogon CitratusL*.).

MATERIAL AND METHODS

Description of the Experimental Area

The study was carried out during the two successive seasons of 2017 and 2018 at central rift valley of Koka, medicinal and aromatic plants experimental Station, Ethiopia(39°2’20’’ E and 08°26’20’’N, 1617; meters above sea level). The climatic condition of the area is categorized under semi-arid with total annual precipitation of 830.9 mm and 131.8 mm of rainfall. According to, FAO (2006), the dominant soil type of the site is Andisols, with the textural class of clay loam.

Experimental Design and Treatment Set Up

The experiment was designed as two-factor factorial in a randomized complete block design with three replications were used, following the procedure of Gomez and Gomez, (1984).The experiment was included four levels N (0, 30, 60 and 90 kg ha^{-1}) and four levels of P_2O_5 (0, 10, 20 and 30 kg ha^{-1}) totally 16 treatments combinations. Each treatments sequencing was randomized and plot areas were 4.80 m x 4m. A space of 0.5 m was left between plots and 1.0 m between blocks, to avoid border effects of treatments. Stolen of lemongrass was directly planted in the experimental field in the recommended spacing of 60 vs 60 cm. Triple superphosphate (TSP) P_2O_5 was basal applied once at planting and nitrogen-containing fertilizer (UREA) was applied in the row in three applications; applied in split form (1/3 during planting, 1/3 after first harvest and the remaining 1/3 after the second harvest of the first and second year to minimize losses and increase efficiency. All required crop management practices were done uniformly to all experimental plots.

Soil analysis

Initial representative composite surface soil samples were collected from 0-20 cm depth at each experimental unit just before sowing for physico-chemical analysis of soil. After manual homogenization, the samples were ground to pass a 2-mm sieve. Soil samples were analyzed for particle size distributions was determined byboycouos hydrometermethod(Van Reeuwijk, 2002); pH of the soils was measured in water suspension in a 1:2.5 (soil: water ratio) (Van Reeuwijk, 2002); EC measurement was performed using saturated paste extracts; Organic carbon (OC)% was determined using the wet oxidation method(Walkley and Black, 1934); Total nitrogen % determined by using Kjeldahl digestion (Black, 1965); Available phosphorus was determined using the Olsen method(Olsen and Sommers, 1982); CEC using ammonium acetate (1N NH_4OAc) at pH 7.0 method (Sahlemedhin and Taye, 2000). The exchangeable bases (Ca^{2+}, Mg^{2+}, $Na^{+,}$ and K^{+}) were determined by atomic absorption spectrophotometer(Anderson and Ingram, 1996). Percent base saturation was estimated from the sum of exchangeable bases as a percent of the CEC.

Data Collection

The plant samples were harvested 120 days after planting for the first harvest and 60 days after the first harvest, the second harvest for both seasons was made. Data collection for field experiment and laboratory was carried out by taking a number of tillers per hill, a number of leaves per hill, fresh biomass, essential oil yield, and oil content. Essential oil yields distilled by hydrodistillation and to quantify oil content using Clevenger apparatus (Zheljazkov *et al*., 2010) and essential oil content was calculated as a ratio of essential oil yield obtained and a sample weight of distilled biomass.

Statistical Analysis

Data from the field and laboratory were tested for normality before being subjected to analysis of variance (ANOVA) by two-way analysis, using SAS software program version 9.4, (SAS, 2014). The significant difference among treatment means comparison was completed by comparing the least squares means of the corresponding treatment combinations at ($p< 0.05$).

RESULT AND DISCUSSION

Physico-chemical Properties of the Experimental Field Soil

Based on soil analysis result the soil particle size distribution were 43, 27 and 30% sand, silt and clay respectively (Table 1). Based on USDA,(1993), soil textural classification of the soil is clay loam. The soil pH (1:2.5 soil: water ratio) and EC (mS/m^{-1}) were 8.41 and 4.08 respectively. The EC value indicated that the soils of the area are salt-affected (Havlin *et al.,* 1999) but not sodic in the surface as the pH is below 8.41 which is moderately alkaline (Table 1). This might be due to higher evapotranspiration than precipitation in this area.

Total nitrogen% and OC% of experimental soil were 0.23% and 2.01% respectively and rated as medium to low and low according to Landon, (2014) (Table 1). The available P content of the soil was is 18.45 mg kg^{-1} and is considered adequate for the surface soils, According to Havlin *et al.*(1999) the relatively high content of available P found in soils due to the continuous application of P fertilizer as was also reported by Whitebreed *et al.* (1998). The CEC of soil was 43.26 cmol kg^{-1}. According to Hazelton and Murphy, (2007) this range is above the satisfactory value 15-25 cmol kg^{-1} for agricultural lands. The Na content is found to be medium with ESP less than 15, which is usually taken as the critical limit for classification of sodic soils(Brady and Weil, 2002) (Table 1).

Table 1. Some selected chemical properties of experimental site soil

pH	TN	OC	C:N	Av.P	EC	Na	Ca	Mg	K	CEC	ESP
	%			(mg kg^{-1})	(mS m^{-1})	Cmol (+) kg^{-1}					%
8.41	0.23	2.01	16.8	18.45	4.08	8.79	32.71	5.07	1.92	24.26	36.23

Effects of Nitrogen and Phosphorus on plant Growth Characters

Application of different levels of nitrogen and phosphorous fertilizes had a pronounced effect number tillers and number of leaves per hill of lemongrass as shown in Table (2). According to pulled mean analysis results revealed that the interaction effects nitrogen and phosphorous fertilizes application were affected significant ($P \le 0.05$) increment on number tillers and a number of leaves per hill were observed during the study period (Table 2).

The pulled mean analysis revealed that the average mean number of tillers per hill and number of leaf per hill ranges from 29-81 and 119-332 were obtained during the study. Moreover, the maximum number of tillers per hill (81) and a number of leaves per hill (352) were obtained from the application of 90 N + 20 P_2O_5 kg ha^{-1} fertilizers respectively when compared to plots which are treated alone with N or P fertilizers (Table 2). However, the lowest number of tillers per hill (29) and a number of leaf per hill (119) were obtained from control or unfertilized plots.

These results are in accordance with the finding of, Rajan *et al.* (1984) and Prakasha *et al.* (1985) found that the application of 100 N kg ha^{-1} produced significantly higher fresh biomass yield and plant growth (height 130 cm), number of branches (56.4), number of stalks/plant (50.40), width of stalks (5.64), weight of stalks (24.2) compared with that from 0 N kg ha^{-1} or unfertilized plot. Similarly, Singh *et al.* (1994)suggested that maximum plant height, tillers plant, leaves obtained from the application of NPK combination at 120 + 40 + 40 NPK kg ha^{-1}, respectively in Citronella. Likewise, Rao *et al.* (1998)found that lemongrass responded to application of 100 N kg ha^{-1} under the irrigated condition and 75 to 80 N kg ha^{-1} under rained condition. Furthermore, Singh *et al.* (2008) reported that nitrogen fertilization of lemongrass has resulted in more tillers, number of leaves, the large size of leaves, and a higher rate of re-growth after cutting. This is due to fertilization of nitrogen and phosphorous were responsible for transfer or storage of energy, producing protein, improving the various growth characters and development of plants (Hull and Liu, 2005) and (Bauer *et al.,* 2012).

Table 2. Pooled mean comparison of a number of tillers, leaf per hill as affected by the interaction effects of nitrogen and phosphorus fertilizers.

Nitrogen Level	Number of tiller per hill				Number leaf per hill			
	Phosphorus level				Phosphorus level			
	0	10	20	30	0	10	20	30
0	29^{h}	32^{gh}	33^{fgh}	36^{efgh}	119^{i}	118^{i}	123^{hi}	137^{ghi}
30	39^{defg}	39^{def}	40^{cdef}	41^{cde}	134^{ghi}	152^{fg}	152fg	157^{efg}
60	41^{cde}	44^{cd}	42^{cde}	47^{c}	162^{ef}	179^{de}	199^{cd}	204^{c}
90	43^{cde}	67^{b}	81^{a}	76^{a}	143^{fgh}	194^{cd}	332^{a}	259^{b}
LSD (<0.05)		7.3*				23.5**		
CV		14.0				11.8		

Means followed by the same letters within columns does not differ significantly at the 0.05 probability level.

Effects of Nitrogen and Phosphorus on Fresh herbage, Essential Oil Yield

Data presented in Table 3 indicated that application of nitrogen and phosphorus fertilization a significant ($P<0.01$) effects on fresh herbage yield and essential oil yield of lemongrass. The fresh herbage yield and essential oil yield were per hectare were progressively increasing with the advance in the age of the plants in each treatment during the study period. This is due to increasing application nitrogen and phosphorus fertilization amounts pronounced effect on fresh herbage yield and essential oil yield of lemongrass.

The pooled mean analysis result revealed that the interaction effect of treatments 90 N + 20 P_2O_5 kg ha^{-1} application were responses most remunerative with a maximum of lemongrass fresh herbage yield (25.9 t ha^{-1}) and essential oil yield (155.5 kg ha^{-1}) respectively (Table 3). Whereas, the lowest fresh herbage yield (12.2 t ha^{-1}) and essential oil yield (70.6 kg ha^{-1})obtained from control or unfertilized plots. The fresh herbage and essential oil yield were superior by 53.1% and 54.6% respectively when compared to 90 N + 20 P_2O_5 kg ha^{-1} and from unfertilized or control plots. This may be due to the influence of nitrogen in promoting the vegetative growth, which resulted in increased herbage production, consequently, essential oil yield increased to a greater extent. In fact that N and P fertilizer application do have a synergistic effect and hence N might have stimulated the uptake of P and vice versa(Sharma and Tandon, 1992). Similar trend was also observed in fresh herbage yield and essential oil yield of lemongrass in different fertilizer application were stated by different authors,Sundaravadivel *et al.*(2000) observed that application of urea at 75 kg ha^{-1} registered the highest herb yield (10606 kg ha^{-1}) and oil yield (392 kg ha^{-1}) Palmarosa (*Cymbopogon martini*) in Vertisols under rain-fed conditions. The application of 100 kg ha^{-1} with 40 each P and K ha^{-1} was given a higher return than control. It yields 20 t $ha^{-1}$of fresh herbage from the rain-fed crop, 30 t ha^{-1} from irrigated and produced 100 kg and 180 kg lemongrass oil yield ha^{-1}respectively(Anonymous, 2001).Addition of nitrogen (N) at 80 kg ha^{-1} per year enhanced the total biomass yield by 57.6% and total essential oil yield by 60.3% in comparison to no N application(Jayalakshmi *et al.,* 2013).Also, Nandi and Chatterjee, (1997) and Ram *et al.*(1999) reported that increase in the level of nitrogen with a combination of phosphorous was significant yield response on herbage and essential oil yield on lemongrass, Palmarosa, and Java citronella. Similarly, Ram *et al.*(1999)investigated that application of 100 kg N ha^{-1} maximized herb (27.6 t ha^{-1}) and essential oil yields (123.5 kg ha^{-1}) in the first year. At least 150 N kg ha^{-1} was required in the following years to maximize yields 38.4 and 164.8 kg ha^{-1} of herb and essential oils, respectively.

However, the essential oil content was not affected by the application of different levels of N and P fertilizers. This results also supported by, Munnu*et al.* (2005) and Rao *et al.* (1991)stated that essential oil content was not affected by N and application.

Table 3. Pooled mean comparison of herbage yield and essential oil yield as affected by the interaction effects of nitrogen and phosphorus fertilizers

Nitrogen Level	Herbage yield (t ha^{-1})				Essential oil yield (kg ha^{-1})			
	Phosphorus level				Phosphorus level			
	0	10	20	30	0	10	20	30
0	12.2^{g}	12.6^{g}	12.2^{g}	12.6^{g}	70.6^{h}	72.08gh	80.6^{fgh}	81.6f^{gh}
30	14.3^{f}	15.0^{f}	14.3^{f}	15.4^{ef}	88.4^{f}	89.48ef	88.4^{ef}	87.7^{ef}
60	16.5^{ed}	16.8^{ed}	19.9^{c}	21.1^{bc}	86.3^{efg}	97.4^{ed}	127.0^{b}	123.1^{bc}
90	17.4^{d}	20.3^{c}	25.9^{a}	22.4^{b}	108.9^{cd}	124.1^{b}	155.5^{a}	136.4^{b}
Lsd (<0.05)		1.5**				14.9**		
CV		7.5				12.8		

Means followed by the same letters within columns does not differ significantly at the 0.05 probability level.

CONCLUSION AND RECOMMENDATION

The present study clearly indicates that the application of nitrogen and phosphorous fertilizers have the potential for improving on fresh herbage yield and essential oil yield, number of tillers and number of leavesof lemongrass (*Cymbopogon Citrates L.).* Our finding demonstrated that application of 90 N +20 P_2O_5 kg ha^{-1} produce the maximum herbage and oil yields of lemongrass. For future, considering the importance of this crop every effort is made to boost the herbage yield and essential oil yield production of the crop by using more research on improved nutrient management and other agronomic practices would be helpful.

Conflict of Interests

The authors have not declared any conflict of interests

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