Evaluation of Lemongrass (*Cymbopogonflexuosus* L.) Genotypes under Northern Dry Zone of Karnataka (Zone III)

ABSTRACT

Aim: To evaluate the lemongrass genotypes for growth, yield and quality contributing characters.
Study design: Fisher's method of ANOVA by Panse and Sukhatme.
Place and Duration of Study: Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bagalkot, Karnataka during *rabi* 2023-24.
Methodology: Forty genotypes of lemongrass were assessed for growth, yield and quality parameters.
Results: Among forty genotypes, Elite genotype recorded the maximum plant height and petiole length. Whereas, the highest plant spread, number of tillers, leaf length, leaf width and biomass yield per clump, per plot and hectare was found maximum in CKP25 and OD-83 for girth of the tiller at different growth stages.
Conclusion: The genotypes superior for growth, yield and quality parameters will be considered for future breeding program.

Keywords: lemongrass; Cymbopogonflexuosus; genotype; tiller; clump.

1. INTRODUCTION

Lemongrass (*Cymbopogonflexuosus* L.) is a tropical perennial grass from the Poaceae family and the Cymbopogon genus, which is known for its aromatic essential oil. The genus includes about 80 different species. The name "lemongrass" comes from the lemon-like scent of its essential oil. Native to Southeast Asia and Australia, lemongrass was one of the herbs traded along the spice route to Europe. In the global trade market, lemongrass oil is commonly called "Cochin oil" because 90 per cent of the oil is shipped from Cochin port [1].

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Kerala held a monopoly on the production and export of lemongrass oil. Worldwide, lemongrass oil production is approximately 1000 tonnes annually, cultivated across 16000 hectares of land. In India, it occupies about 4000 hectares, yielding around 300-350 tonnes yearly. Lemongrass cultivation is widespread in underutilized and marginal lands, often used as live mulch along embankments, aids in soil and water conservation because of its extensive root system [2].

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Lemongrass constitutes hundreds of organic compounds including terpenoids, benzenoids, organic sulphur and nitrogenous compounds, which work at different levels. Monoterpenes (96.37 %) constitutes the major part of lemongrass followed by diterpenes (0.21 %) and sesquiterpenes (1.25 %). Citral is the major bioactive compound in lemongrass essential oil which is the combination of neral (34.29 %) and geranial (40.29 %). The quality of lemongrass essential oil is determined by the amount of citral it contains. The diterpenesincludesphytol and sesquiterpenes which includes geranyl acetate (0.63 %), trans-caryophellene (0.11 %), caryophellene oxide (0.21 %) and others [3].

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Lemongrass is an aromatic grass that originates from a compact, rhizomatous base, producing multiple tillers. It possesses linear leaf blades, tapering at both ends, can reach length of up to 50 cm and width of 1.5 cm. Serving as a pseudo stem, the tubular leaf sheath encases the leaves. Upon reaching maturity, lemongrass develops flowers. Additionally, new tillers emerge from the clump, growing vertically to form new plants or clumps [1].

It is grown more especially in Indian states such as Kerala, Karnataka, Andhra Pradesh, Uttar Pradesh and Assam. Citral gives an enticing citrus fragrance and possesses biological activities like anti-inflammatory, antibacterial, antiparasitic, allelopathic and mosquito-repelling effects [4].

In India, several lemongrass species are grown which includes *C. flexuosus, C. pendulus, C. khasianus, C. nardus and C. commulatus*. The genus Cymbopogon has citral-rich species such as *C. citratus, C. flexuosus, C. pendulus and C. khasianus*. Geraniol and elemicin-rich oil from *C. nardus, C. commulatus* and certain *C. khasianus* is widely utilized to make mosquito repellent products, soaps, vitamin A synthase etc. [5]. Among these, three important commercial species are widely seen in India *viz., Cymbopogonflexuosus* (Nees ex Steud) Wats. (2n= 20, 40), *Cymbopogoncitratus* (DC) Stapf. (2n= 40,60) and *Cymbopogonpendulus* (Nees ex Steud) Wats.

2. MATERIAL AND METHODS

The present experiment was conducted during the period of rabi 2023 to 2024 at the experimental field of Department of Plantation, Spice, Medicinal and Aromatic crops, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka. Forty genotypes of lemongrass were grown in randomized complete block design with two replications at a spacing of 60 × 45 cm. The 40 genotypes viz, Kaveri, Pragati, Praman, CIM Chirharit, Local HUB-LG-1, CKP25, Krishna, Elite, OD-2, OD-13, OD-14, OD-19 (Sugandhi), OD-23, OD-24, OD-63, OD-80, OD-82, OD-83, OD-88, OD-93, OD-101, OD-106, OD-107, OD-110, OD-111, OD-120, OD-121, OD-123, OD-126, OD-130, OD-131, OD-132, OD-135, OD-144, OD-150, OD-152, OD-157, OD-158, OD-166 and OD-173 were evaluated for growth, yield and quality parameters.

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Observations were recorded and data were analyzed to identify the superior genotype with the growth parameters, i.e., plant height (cm), clump spread (cm), number of tillers, girth of the tiller (mm), leaf length, width and petiole length (cm), yield parameters includes fresh and shade dried biomass yield per clump (kg), per plot and hectare and quality parameters includes the essential oil content (%) and oil yield (kg/ha).

Statistical analysis of the data was done by following the Fisher's method of analysis of variance as given by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was P= 0.05 and critical difference (CD) values were worked out wherever 'F' test was significant.

3. RESULTS AND DISCUSSION

3.1.1 Growth parameters

Significant difference was recorded for plant height at different crop growth stages. Among 40 genotypes of lemongrass the plant height was maximum in Elite (90.45 cm, 106.62 cm and 118.41 cm at 60, 90 and 120 DAP). The variation in the plant height is due to

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the genetic composition of the genotype and interaction with suitable agroclimatic and soil conditions. The variation in plant height in lemongrass genotypes was also observed by Yogendra et al. (2022) [6] in which significantly higher plant height was noticed in CIM-Shikar (136.75cm). Mwithiga et al. (2022) [7] and Susilowati and Syukur (2022) [8] reported that, CICI 0003 was the tallest plant (84.42 cm) among 20 lemongrass accessions.

The highest clump spread in (E-W) direction and in (N-S) direction was observed in CKP25 (89.47 cm, 100.59 cm, 112.92 cm and 63.91 cm, 69.40 cm, 80.77 cm at 60, 90 and 120 DAP respectively). These variations were attributed to the genetic makeup of the genotypes and its interaction with the environmental variation. There are several reports indicating variation in clump spread among the genotypes under different agro-climatic conditions includesSusilowati and Syukur (2022) [8] and Hiremath et al. (2018) [9] in citronella.

The significantly higher number of tillers was recorded in CKP25 (27, 39.03 and 53.20 at 60, 90 and 120 DAP). The difference in the number of tillers was mainly due to dissimilarity in the inherited characters of the genotype as well as its interaction with the environment in which it is cultivated,influence the number of tillers, depicted in Table 1. The present observations on the lemongrass are in consonance with the Kumar et al. (2022) [10] in palmarosa, Sarma and Sarma et al. (2005) [11] in lemongrass, Ibrahim and Khalidh (2013) [12] in citronella.

OD-83 exhibited marked difference in girth of the tiller with the maximum girth (6.19 mm and 7.06 mm at 90 and120 DAP respectively). Wherein, the highest leaf length (86.38 cm and 92.78 cm) and leaf width (2.82 cm and 2.94 cm) was noticed in CKP25 at 90 and 120 days after planting. The similar works were reported by Ruswandi et al. (2023) [13] where the maximum leaf length of 116.60 cm was recorded in PuncakSirna (PS) 02 accession of citronella and Susilowati and Syukur (2022) [8] in lemongrass. The increased petiole length was noticed in Elite (3.89 cm, 5.39 cm at 60 and 120 DAP), the increased petiole length may be due to the enhanced water and nutrient absorption of specific genotype leading to the expansion of petiole tissue. The results are in line with the findings of Mallikarjun et al. (2021) [14] in citronella genotypes and Vinutha and Hegde et al. (2014) [15] noticed the highest petiole length (8.06 cm) in variety Mandakini.

3.1.2 Yield parameters

CKP25 recorded the highest fresh biomass yield (0.77 kg/ clump), per plot (19.13 kg), per hectare (21.25 t/ha) and shade dried weight (0.62 kg/ clump). The lowest biomass yield was noticed in OD-106 (0.43 kg/ clump), per plot (10.63 kg), per hectare (11.81 t) mentioned in Table 3. The increase in biomass yield may be due to the production of a greater number of tillers per plant, plant spread, leaf length and other factors which are positively associated with the yield. Similar findings were observed by Mwithiga et al. (2022) [7], Lal et al. (2018) [16] and Yogendra et al. (2022) [6] in lemongrass, Raja (2019) [17] in vetiver and Upadhyay et al. (2017) [18] in citronella.

3.1.3 Quality parameters

The information associated with the essential oil content revealed that, the maximum essential oil content was observed in CKP25 (1.21 %) depicted in Fig 1. with the yield of 256.06 kg/ha. This could be due to genotypic interactions with the environment, which influences the oil content. Similar works were also reported by Lal et al. (2020) [19] in lemongrass (0.58 % oil content), Kumar et al., (2022) [9] in lemongrass, Singh et al. (2017) [20], Devi and Singh (2023) [21] and Lal et al. (2023) [22] in palmarosa.

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Table 1. Growth parameters of lemongrass genotypes at different growth stages

Genotypes	Plant height			Clump spread (E-W)			Clump spread (N-S)			Number of tillers		
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
Kaveri	75.37	95.88	107.03	55.39	68.57	82.78	46.06	52.19	66.40	12.90	21.98	32.99
Pragati	65.78	85.35	92.03	58.51	71.19	81.70	56.62	62.55	68.26	13.59	23.15	34.01
Praman	62.00	81.36	89.99	53.05	64.67	78.68	45.10	51.58	58.73	11.43	28.46	40.70
CIM Chirharit	73.20	89.21	99.88	70.59	82.13	96.13	56.47	66.26	73.94	20.73	33.00	49.66
Local HUB-LG-1	68.08	81.83	90.26	56.07	69.25	78.10	53.18	59.34	69.95	13.28	24.27	31.98
CKP25	69.84	85.89	96.91	89.47	100.59	112.92	63.91	69.40	80.77	27.00	39.03	53.20
Krishna	85.16	100.33	114.03	84.13	99.93	106.72	60.04	71.40	78.28	23.44	36.31	52.22
Elite	90.45	106.62	118.41	66.02	85.49	99.43	58.13	65.65	72.44	17.13	26.73	39.04
OD-2	54.62	71.78	85.25	58.46	72.28	86.99	36.61	47.83	54.00	13.49	22.35	33.66
OD-13	67.41	81.18	93.03	44.00	55.25	68.04	35.99	48.20	51.97	15.44	24.58	36.03
OD-14	72.13	83.80	92.63	74.25	85.57	98.54	45.28	55.80	64.91	14.11	25.26	36.73
OD-19	90.55	103.83	115.75	87.72	95.14	104.41	40.38	51.71	62.79	23.10	32.74	47.40
OD-23	59.58	75.69	89.52	65.19	70.87	82.30	47.88	55.39	64.49	19.18	25.93	34.47
OD-24	68.21	84.34	95.68	63.62	77.99	90.92	56.01	68.64	71.99	17.26	25.97	43.25
OD-63	45.65	59.28	72.04	46.66	65.30	77.93	35.89	44.11	50.06	13.62	22.29	33.16
OD-80	80.63	91.20	106.83	53.23	68.26	79.82	43.99	53.42	62.77	16.49	30.13	35.32
OD-82	57.33	72.31	84.47	51.91	67.67	81.98	48.61	60.98	65.27	13.64	22.97	34.46
OD-83	80.32	96.53	109.58	63.58	75.29	88.59	40.39	51.39	59.95	18.49	29.23	43.49
OD-88	69.75	87.46	100.15	45.52	54.13	66.36	35.97	47.58	55.42	11.46	19.57	30.09
OD-93	90.52	103.79	113.46	75.71	89.12	104.13	59.33	68.36	78.46	18.16	28.62	40.86
OD-101	52.38	65.21	78.42	54.08	72.85	87.83	39.23	44.05	53.05	13.79	23.37	36.20
OD-106	48.19	60.89	78.71	41.92	55.44	70.94	33.67	43.50	49.83	10.43	22.05	32.17
OD-107	37.69	50.43	62.46	42.07	55.78	70.15	55.79	68.40	77.53	11.30	22.23	35.28
OD-110	59.66	74.32	83.90	51.56	65.66	77.86	50.34	54.71	59.86	16.90	26.44	36.90
OD-111	63.68	78.97	87.95	45.62	58.27	71.06	28.98	40.79	47.58	13.48	23.79	35.16
OD-120	57.88	72.14	85.13	53.64	73.76	84.99	45.13	54.89	58.84	15.16	21.50	33.50
OD-121	62.81	75.83	92.91	52.53	65.77	80.90	33.26	44.83	53.97	21.97	31.36	45.18
OD-123	70.87	87.45	98.48	65.23	77.76	90.19	43.20	51.22	54.84	22.15	28.42	40.97
OD-126	51.59	64.47	80.87	45.23	78.19	91.87	46.04	59.87	64.12	14.88	21.98	30.01
OD-130	72.12	86.45	97.60	62.25	78.31	89.74	41.85	50.89	59.00	22.18	24.67	44.95
OD-131	61.04	72.77	87.13	54.87	72.16	85.35	43.52	53.30	62.87	20.22	29.28	40.36
OD-132	51.72	71.70	85.58	41.93	55.53	69.36	32.48	39.60	42.88	14.46	23.67	34.65
OD-135	41.46	58.92	70.83	40.52	65.27	76.76	32.92	42.17	52.92	17.83	26.08	36.26
OD-144	76.32	92.73	106.15	58.69	77.45	85.29	38.72	44.30	54.07	17.16	25.85	42.75
OD-150	59.46	72.88	86.56	49.39	65.94	79.74	37.60	44.94	53.79	16.94	26.15	37.36
OD-152	51.61	64.09	78.62	42.71	56.70	69.91	35.85	40.89	53.56	20.36	32.60	39.16
OD-157	80.85	98.58	114.29	59.41	68.88	86.13	37.97	45.59	54.94	18.78	28.61	39.74
OD-158	59.44	71.32	87.00	54.17	76.80	85.35	43.67	48.93	57.88	17.62	26.51	37.08
OD-166	65.63	80.92	89.59	54.15	69.83	84.22	48.73	56.21	64.14	17.46	24.29	34.87
OD-173	44.12	57.49	72.27	50.31	63.40	76.18	43.12	56.02	64.91	12.59	24.00	35.69
S. Em±	0.69	0.93	1.15	0.59	0.73	1.03	0.65	0.60	0.85	0.21	0.71	1.03
CD (5 %)	1.96	2.66	3.28	1.68	2.09	2.94	1.87	1.72	2.42	0.60	2.03	2.95

Table 2. Growth parameters of lemongrass genotypes at different growth stages

Genotypes	Girth of tiller (mm)			Leaf length (cm)			Leaf width (cm)			Petiole length (cm)		
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
Kaveri	3.01	5.05	5.68	35.31	48.76	60.54	2.53	2.75	2.80	1.99	3.55	4.12
Pragati	3.23	5.20	5.84	49.90	62.43	73.92	2.49	2.64	2.72	2.54	3.21	3.85
Praman	3.17	5.16	5.74	37.41	49.19	66.76	2.18	2.25	2.56	2.77	3.57	4.29
CIM Chirharit	3.04	5.07	6.68	68.98	79.94	88.27	2.06	2.41	2.59	3.00	3.67	4.09
Local HUB-LG-1	3.04	5.06	6.55	46.22	56.91	70.28	2.22	2.65	2.69	2.86	3.20	3.87
CKP25	3.41	5.54	6.86	72.70	86.38	92.78	2.54	2.82	2.94	3.02	3.45	4.02
Krishna	3.61	5.13	6.75	54.12	64.38	74.58	2.43	2.73	2.75	3.14	4.24	4.89
Elite	3.01	5.51	6.68	53.80	68.93	81.15	2.26	2.32	2.37	3.89	4.75	5.39
OD-2	3.12	5.99	5.99	34.77	45.34	58.65	2.03	2.54	2.62	2.08	3.10	3.88
OD-13	3.01	5.80	5.62	48.76	60.73	72.91	2.35	2.46	2.54	3.57	3.77	4.29
OD-14	3.28	4.97	5.36	52.71	64.31	73.01	2.04	2.72	2.78	3.05	3.95	4.33
OD-19	3.03	5.15	6.52	75.87	81.01	92.62	2.26	2.72	2.77	3.57	4.86	4.96
OD-23	3.30	5.16	6.23	46.55	55.58	71.14	2.10	2.69	2.75	2.53	3.17	4.84
OD-24	3.01	6.07	6.56	52.24	67.82	78.61	2.39	2.46	2.61	2.55	3.54	3.92
OD-63	3.15	5.63	6.44	31.76	45.70	54.08	2.21	2.53	2.61	2.56	3.83	4.12
OD-80	3.26	5.13	6.48	52.27	66.69	79.85	1.59	2.03	2.47	3.23	4.01	4.65
OD-82	3.04	4.76	5.75	43.39	57.13	71.42	2.21	2.28	2.35	2.88	3.86	4.33
OD-83	3.05	6.19	7.06	49.11	53.69	61.18	2.10	2.68	2.71	2.43	3.26	3.53
OD-88	3.05	5.33	5.93	42.47	55.68	70.07	2.22	2.43	2.53	2.33	3.00	4.01
OD-93	3.05	5.56	5.50	70.64	82.50	90.32	2.27	2.45	2.52	3.03	3.67	4.24
OD-101	3.30	5.23	6.20	36.38	47.63	62.67	2.02	2.28	2.39	3.24	3.66	4.64
OD-106	3.25	5.17	5.94	35.64	50.27	64.30	1.98	2.45	2.65	2.37	3.47	3.77
OD-107	3.28	5.48	5.23	29.21	41.22	52.77	2.39	2.44	2.52	3.00	3.68	3.98
OD-110	3.10	5.34	5.59	40.45	49.11	63.92	2.34	2.45	2.58	2.77	3.22	4.27
OD-111	3.04	5.02	5.58	45.25	58.80	69.32	2.30	2.33	2.49	2.79	3.47	4.29
OD-120	3.29	5.07	6.24	39.40	51.54	66.35	1.85	2.15	2.49	1.90	2.57	3.23
OD-121	3.13	6.17	6.49	38.43	53.61	66.96	2.45	2.48	2.62	1.98	2.88	3.68
OD-123	3.18	6.00	6.15	45.13	59.45	70.15	2.06	2.49	2.56	1.87	2.70	3.70
OD-126	3.00	5.07	5.25	42.74	56.55	69.33	2.32	2.41	2.51	2.03	2.67	4.21
OD-130	3.22	5.28	6.45	55.78	64.42	79.54	2.37	2.49	2.60	3.04	3.86	4.22
OD-131	3.38	5.97	6.13	59.98	70.62	84.04	2.27	2.45	2.59	2.40	3.77	4.04
OD-132	3.01	5.84	6.17	39.02	48.78	61.96	2.59	2.68	2.85	3.22	3.99	4.80
OD-135	3.01	5.04	6.49	30.34	43.57	55.79	1.74	1.88	2.25	2.67	3.44	4.24
OD-144	3.36	5.10	5.13	49.62	63.04	78.80	1.97	2.02	2.25	2.38	3.80	4.43
OD-150	3.19	5.24	6.42	48.82	65.91	78.17	2.09	2.38	2.53	2.35	3.66	4.62
OD-152	3.03	5.36	6.51	32.37	41.23	53.78	2.32	2.43	2.53	2.52	3.27	3.70
OD-157	3.12	5.73	6.15	59.96	72.44	83.96	2.05	2.06	2.40	2.34	3.30	4.18
OD-158	3.35	4.96	5.22	44.45	57.02	68.70	1.98	2.25	2.53	2.82	3.79	4.24
OD-166	3.27	5.43	6.39	49.53	62.02	72.35	1.88	2.25	2.41	3.32	4.10	4.81
OD-173	3.09	5.15	6.47	36.33	48.58	60.82	1.58	2.26	2.47	2.92	3.28	3.76
S. Em±	0.11	0.08	0.12	0.56	0.58	0.62	0.03	0.16	0.15	0.03	0.04	0.09
CD (5 %)	NS	0.22	0.35	1.61	1.66	1.78	0.09	0.47	0.42	0.08	0.11	0.27

Table 3. Biomass and essential oil yield of different lemongrass genotypes

Genotype	Fresh biomass yield (kg/clump)	Shade dried weight (kg/clump)	Fresh biomass yield (kg/plot)	Fresh biomass yield (t/ha)	Essential oil yield (kg/ha)
Kaveri	0.49	0.33	12.25	13.61	83.69
Pragati	0.48	0.36	12.00	13.33	107.35
Praman	0.51	0.44	12.63	14.03	99.61
CIM Chirharit	0.69	0.60	17.50	19.44	155.94
Local HUB-LG-1	0.48	0.35	11.88	13.19	98.32
CKP25	0.77	0.62	19.13	21.25	256.06
Krishna	0.71	0.61	17.63	19.58	215.42
Elite	0.44	0.33	11.00	12.22	81.32
OD-2	0.45	0.32	11.13	12.36	112.50
OD-13	0.55	0.45	13.75	15.28	123.03
OD-14	0.53	0.43	13.13	14.58	126.15
OD-19	0.66	0.49	16.50	18.33	186.07
OD-23	0.48	0.39	11.88	13.19	105.56
OD-24	0.56	0.45	13.88	15.42	110.24
OD-63	0.48	0.38	11.88	13.19	125.14
OD-80	0.47	0.36	11.63	12.92	105.28
OD-82	0.49	0.38	12.25	13.61	118.58
OD-83	0.65	0.56	16.25	18.06	152.78
OD-88	0.47	0.39	11.63	12.92	92.99
OD-93	0.58	0.47	14.38	15.97	130.15
OD-101	0.58	0.49	14.50	16.11	110.43
OD-106	0.43	0.36	10.63	11.81	98.61
OD-107	0.47	0.35	11.63	12.92	95.00
OD-110	0.54	0.44	13.38	14.86	131.51
OD-111	0.48	0.35	12.00	13.33	100.67
OD-120	0.49	0.38	12.13	13.47	104.10
OD-121	0.68	0.60	17.00	18.89	160.14
OD-123	0.52	0.38	12.88	14.31	117.32
OD-126	0.47	0.37	11.63	12.92	104.06
OD-130	0.70	0.59	17.13	19.31	166.18
OD-131	0.66	0.56	16.38	18.19	132.68
OD-132	0.60	0.50	14.88	16.53	136.81
OD-135	0.49	0.39	12.13	13.47	121.97
OD-144	0.70	0.61	17.38	19.03	141.90
OD-150	0.53	0.44	13.25	14.72	125.94
OD-152	0.57	0.48	14.13	15.69	121.65
OD-157	0.59	0.48	14.81	16.46	138.10
OD-158	0.57	0.47	14.25	15.83	119.44
OD-166	0.52	0.42	13.00	14.44	107.50
OD-173	0.46	0.36	11.38	12.64	87.86
S. Em±	0.02	0.03	0.62	0.69	6.40
CD (5 %)	0.07	0.08	1.78	1.98	18.30

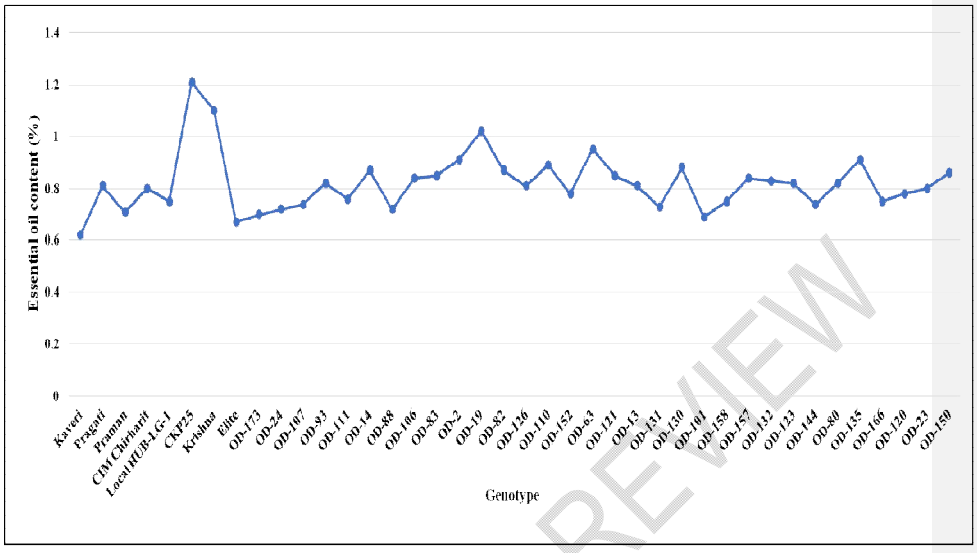

Fig. 1.Essential oil content (%) of different lemongrass genotypes

4. CONCLUSION

From the present study, the different genotypes showed significant difference with respect to morphological, yield and quality parameters. Specifically, Elite, OD-19 recorded the highest plant height and petiole length. Whereas, CKP25,exhibited maximum plant spread (E-W) and (N-S) direction and number of tillers, leaf length and leaf width. The girth of the tiller was found highest in OD-83. In yield parameters, fresh and dried biomass yield per clump, per plot and per hectare were recorded maximum in CKP25. In consideration with quality parameters, CKP25 and Krishna recorded the maximum oil recovery and oil yield.

From the present study it is concluded that, the different genotypes exhibited significant difference with respect to morphological, yield and quality parameters. Specifically, CKP25, Krishna, OD-19 had exhibited maximum number of tillers, biomass yield, oil recovery and oil yield under Bagalkot conditions

Comment [E21]: differences

Comment [E22]: study,

Comment [E23]: differences

Comment [E24]: under environmental conditions of Bagalkot.

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