

# GROWTH AND YIELD OF CITRONELLA (*CYMBOPOGON WINTERIANUS*) AS INFLUENCED BY DIFFERENT RESIDUAL FERTILITY LEVELS AND INTERCROPPING WITH LENTIL AND LINSEED

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**Abstract:** A field experiment was conducted at, student Instructional Farm (SIF) Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) India during rabi season 2013-14. with an object to find out the effect on growth parameters and yield attributes of linseed and lentil as intercrops, with citronella (*Cymbopogon winterianus*). The experiment was laid out in randomized block design with 9 cropping system with different combination [sole citronella, sole linseed, sole lentil, citronella + linseed (100%), citronella + linseed (75%), citronella + linseed (50%), citronella + lentil (100%), citronella + lentil (75%), citronella + lentil (50%) each replicated four times (once in each replication). The citronella sole cropping system gave significantly the highest citronella equivalent oil yield than other cropping systems. Citronella + Linseed (50%) treatment ranked next in order of merit, proving significant better than other cropping system. Citronella + Lentil (100%) ranked next in order of merit, proving significant superior over other cropping system. Citronella sole brought about 57.35 (30.30%), 61.63 (33.32%), 84.56 (52.04%), 85.35 (53.09%), 90.45 (57.93%), 92.69 (60-63%), 179.27 (266.37%) and 192.80 (258.56%) lit/ha higher citronella equivalent oil yield than citronella + linseed (100%), citronella + linseed (75%), citronella + linseed (50%), citronella + lentil (100%), citronella + lentil (75%), citronella + lentil (50%), linseed sole and lentil sole respectively. LER was more than sole crops which showed an advantage of intercropping over sole system in terms of the use of environment resources for plant growth and development. LER values in citronella + linseed (75%) and citronella + linseed (100%) intercropping system was 1.34.

**Keywords:** Residual fertility, LER, Citronella, Growth parameters, Yield attributes

## INTRODUCTION

In today's agriculture diversification and intensification of crop and their combination and sequence both in space and time with new adoptable and remunerative crops and their species has become absolutely necessary as the present food base has been narrowed down coupled with effect of climate change making it prone to frequent crop failures. Today intercropping with various non-exploited crops are gaining importance due to their adoptability to changing climatic conditions prevailing in the region and for achieving higher returns under adverse conditions.

Citronella (*Cymbopogon winterianus*) is an aromatic crop belonging to family Poaceae. Citronella is a perennial grass and is propagated by vegetative slips. It grows well under varying soil conditions. Citronella oil has great demand in India. According to FFDC (Fragrance and Flavour Development Centre, Govt. of India, Kannauj) the demand of citronella oil is 620 tonnes per year but the production 480 tonnes per year in India. The country facing deficit of 140 tonnes per year (Anon., 2011-2012). The increasing importance of natural extracts in recent time has opened up new vistas for green revolution beyond their wide spread use as flavors

and fragrance ingredients. Citronella oil is a raw material for production of geraniol, citronellal and other similar high value perfumery bases. Citronella oil is widely used in scented soaps, sprays, deodorants, detergent, polishes, mosquito repellents etc. The present experiment was carried out with an object to study about the growth parameters and yield attributes of Citronella (*Cymbopogon winterianus*) as Influenced by different residual fertility levels and Intercropping with lentil and linseed.

## MATERIALS AND METHODS

A field experiment was conducted during rabi season, 2013-14 at Students Instructional Farm (SIF), C.S. Azad University of Agriculture and Technology, Kanpur to study the Growth and Yield of lentil and linseed as Influenced by Recommended Doses of Fertilizer and Intercropping with citronella (*Cymbopogon winterianus*). The experiment was laid out in Randomized block design with 9 treatment of cropping systems with 3 residual fertility levels (RFL) i.e. [Sole citronella, Sole Lentil, Sole Linseed, Citronella + lentil (100%RFL), citronella + lentil (75%RFL), citronella + lentil (50%RFL), citronella + Linseed (100%RFL), citronella +

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Linseed (75% RFL), citronella + Linseed (50% RFL)], were replicated in three time. The soil of experimental field was sandy loam, slightly alkaline in nature. The soil is low in organic carbon and available nitrogen (260 kg/ha), medium in available phosphorus (17.55kg/ha) and potash (175 kg/ha). Root slips of Citronella variety BIO-13 were used for transplanting. After removing upper sheath the root slips was transplanted in line on 30 July, 2010 at a spacing of 60 × 60 cm. The row ratio of 2:2 was maintained in citronella intercrop plots. Seed of linseed cv. Laxmi was used @ 25 kg/ha. The crop was sown with the help of Desi plough in line on 28 October, 2013 at a spacing of 25 × 5 cm. The total number of row in sole and intercrops are 20 and 10 respectively. Seed of Lentil cv. K-75 was used @ 30 kg/ha. The crop was sown with the help of Desi plough in line on 2 November, 2013 at a spacing of 30 × 30 cm. The total number of rows in sole and intercrops are 20 and 10 respectively. In order to determine the effect of different treatments, a number of observation on growth characters, yield contributing characters and yield of crops (Herbs, grain, straw etc.), oil content in citronella and weed population were recorded at different stages of crop growth. It was not possible to study the all characters of individual plants, 5 sample plants from main and intercrops of each treatment (main and intercrop) were selected randomly and tagged for further study. All the observations taken are categorized as pre harvest studies and post harvest studies

#### (A) Observations for Citronella crop:-

**(1) Pre - harvest observation:** Prior to harvesting of citronella observations for plant population, plant height, number of tillers per plant, leaf length and leaf width has been taken.

**(2) Post harvest studies:** After harvesting of citronella crop observations for herbage yield and steam distillation has been carried out.

#### (B) Observations for Lentil:-

All the observations taken during experimental period are categorized in to the following groups:

**Pre Harvest studies:-** Prior to harvesting of lentil observations of plant population per meter square at 30 DAS, 60 DAS and at maturity, plant height at 30 DAS, 60 DAS and at maturity, number of branches per plant, number of pods per plant(5 selected plants), number of grains per pod(calculated by dividing the total number of grains from 5 plants by the total number of filled pods from these plants.), weight of pods per plant(total pods were collected from the sample plants and their pods were weighted to work out for statistical analysis.) and test weight has been taken during experiment.

**Post harvest studies:-** Observations for biological yield, grain yield and straw yield of lentil was taken. The produce of individual net plots was weighed before threshing to record the biological yield under different treatments. The produce of each net plot

was beaten through wooden stick by manual labour and grains were separated from the material through winnowing. The grains yield was recorded in kg per plot. Straw yield was found out by subtracting the grain yield from biological yield of each plot. Later on biological yield, grain yield and straw yield converted in to quintal per hectare, through multiplying factors.

#### (C) For Linseed

All the observations taken in each treatment during experimental period are categorized below:-

**Pre harvest studies:-** Growth characters of linseed crop such as plant population. The plant population of each treatment was recorded twice after first thinning and at harvest stage. For this purpose, one meter scale was placed randomly in 3 places in each plot after thinning and at harvest stage. In marked places, plants were counted for both initial and final plant population. The total sum of plant number of 3 places was divided by 3 to get number of plant population per running meter., plant height of 5 tagged plants at 30 DAS, 60 DAS and at maturity, number of branches per plant of 05 selected plant and average number of branches calculated per plant on mean basis for statistical analysis, number of capsules per plant. Total numbers of capsule were counted from each selected plants and average value was worked out for statistical analysis. Number of grains per capsule (total numbers of capsule were collected randomly from the sample plants and their grains were counted) and test weight have observed during growth period of linseed crop.

**Post harvest studies:** Observations for biological yield, grain yield and straw yield of lentil was taken. The produce of individual net plots was weighed before threshing to record the biological yield under different treatments. The produce of each net plot was beaten through wooden stick by manual level and grains were separated from the material through winnowing. The grains yield was recorded in kg per plot after weighed. Straw yield was found out by subtracting the grain yield from biological yield of each plot. Later on biological yield, grain yield and straw yield converted in to quintal per hectare.

#### Harvest index (%)

The recovery of grain in total weight of produce was considered as harvest index which was calculated in percentage and expressed as absolute figures. The harvest index (HI) of Lentil and Linseed of each crop/plot was calculated by using the following formula:-

$$\text{Harvest index (H.I.)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

#### Land Equivalent Ratio (LER)

Land equivalent ratio is the relative land area under sole crops i.e. required to produce the yield achieved in inter cropping. In the present experiment the LER was estimated by following formula/equations.

$$(i) \text{ LER for Linseed} = \frac{\text{Yield of citronella in inter cropping}}{\text{Yield of citronella in sole cropping}} + \frac{\text{Yield of Linseed in inter cropping}}{\text{Yield of Linseed in sole cropping}}$$

$$(ii) \text{ LER for Lentil} = \frac{\text{Yield of citronella in inter cropping}}{\text{Yield of citronella in sole cropping}} + \frac{\text{Yield of Lentil in inter cropping}}{\text{Yield of Lentil in sole cropping}}$$

For determining the significance of difference caused by different treatments data were subjected to statistical analysis by using ANOVA.

## RESULTS AND DISCUSSION

### Effect of different treatments on growth characters and yield attributes of the main crop citronella:

#### Growth characters:

Data recorded regarding to leaf length and number of tillers per plant at 8<sup>th</sup> cutting of citronella of the 5<sup>th</sup> and 6<sup>th</sup> year is presented in Table 1 showed that highest leaf length (72.45 cm) and number of tillers (95.34 cm) was recorded in Citronella sole crop which was significantly superior over all the treatments. Such higher growth performance in sole crop as compared to intercropping system has also been observed by Ram et al. (2000) and Patra et al. (2005). It is also clear from the table that next to citronella sole, among the intercropping fertility level treatment C:Li (75%) and C:L (75%) were letter than 100% are 50% fertility level in relation to leaf length. But in case of number of tiller, the highest number of tillers/plant after 8<sup>th</sup> cutting was obtained in 50% fertility level of both intercrops which was statistically at par. Sole Citronella recorded higher values for herbage yields than their intercropping with linseed and lentil. This may be optimum spacing available for the plant. The higher growth performance in sole crop as compared to intercropping system has also been observed by Patra et al. (2005). These results of experiments are in close conformity with the findings of Sher et al. (2008) also.

#### Yield characters

Data presented in table 1 regarded herbage yield and oil yield indicated that there are significantly difference have been recorded in yield characters. The highest herbage yield recorded in citronella sole which was (196.30 q/ha) and oil yield (165.36 lit/ha) was significantly superior over rest of the treatments, under 100% fertility level. Among the intercropping treatments there was no significance difference in respect of herbage and oil yield under different residual fertility level.

#### Citronella equivalent yield:

The data pertaining to Citronella yield and Citronella equivalent yield have been given in Table 2. Results indicate that different cropping systems were found

to exhibit significantly variations in Citronella equivalent oil yield. The citronella sole cropping system gave significantly the highest citronella equivalent oil yield than other intercropping system of different residual fertility levels. Among the different residual fertility combination of intercrops there was significant different in citronella: linseed, combination but in case of citronella: lentil, significantly highest equivalent yield (127.98) was found in 50% residual fertility level over 75% and at par with 100%. Numerically, the highest equivalent was found in citronella: linseed 75% residual fertility level.

### Effect of different treatments on growth and yield attributes of linseed

#### Growth characters

Data recorded regarding to plant population, plant height at 30 DAS, 60 DAS and at maturity stage and number of branches per plant were recorded, analyzed and presented in table 3. Data presented in table 3 showed that the highest plant population (105.34/m<sup>2</sup>), plant height at 30 DAS (20.34 cm) and at maturity (73.42 cm) and number of branches per plant was recorded significantly superior in sole linseed treatments over all other treatments. Data regarding to plant height at 60 DAS showed that there are non significantly differences in plant height at 60 DAS among the treatments. Among the intercropping treatments with different fertility levels there was to significant difference in growth characters i.e. plant population/m<sup>2</sup>, plant height of 30, 60 DAS and at maturity No. of branches/plant but numerically 75% fertility level in C:Li intercropping system found better. The results of present investigation are in close conformity with the findings of Singh and Hussain (2005).

#### Yield attributing characters

Data presented in table 3 showed that number of capsules/plant, number of seed/capsules, test weight and seed weight/plant were influence significantly differences in the treatments. The highest number of capsule/plant (55.43), number of seed/capsule (7.65), test weigh (7.54) and seed weight/plant (4.43) was recorded linseed sole which was significantly superior over all treatments. Among the

intercropping fertility level treatment numerically the highest number of capsule/plant, number of seeds/capsule, test weight and seed weight was found in citronella : linseed 50% fertility level and which was of part with 100% and 75% level.

#### Yield and Harvest index

According to the data presented in table 3 the highest biological yield (64.77 q/ha), seed yield (19.67 q/ha), and harvest index (30.36%), was recorded in linseed sole which was significantly superior over all other treatments. Among the difference intercropping combination significantly highest biological yield (62.23 q/ha) and straw yield (46.13 q/ha) was found in 100% residual fertility level of intercropping but the highest grain yield was obtained in 50% of fertility level which was numerical at par with 100 and 75% of residual fertility level. Significantly lowest straw yield was found in 50% of residual effect of fertility level over all other treatments.

#### Effect of different treatments on growth and yield attributes of lentil

##### Growth characters

Data presented in table 4 showed that the highest plant population (113.50/m<sup>2</sup>), plant height at maturity (45.60 cm), and number of branches/plant (20.10) was recorded in Lentil sole which was significantly superior over all other treatments. The finding of Renu Dhar Basu et al. (2007) is in agreement with the present investigation. But in intercropping treatment of residual effects the highest plant population (110.72 m<sup>2</sup>) was found in C:L (75%) residual fertility level followed by 100% and 50% residual fertility treatments. There was no significant different. In plant height characters recorded at 30DAS, significantly lowest in 50% residual fertility level but at 60DAS it is highest. There was significantly difference regarding number of

branches/plant recorded at 100%, 75% and 50% residual fertility levels. Thus, the growth behavior of the crop performed in a similar way for development activities of plants was reflected in yield attributes and yield of lentil. Similar results were also obtained by Munni *et al.* (1998).

#### Yield attributing characters

Data presented in table 4 showed that there non-significant differences in number of grains/pod among the treatments. Numerically the highest number of grain/pod was recorded in lentil sole (2.30).

The number of pods/plant, weight of pods/plant and test weight have been recorded significantly highest in sole treatment. Next to sole treatment, the highest number of pods/plant was recorded in 75% residual fertility of intercropping (89.50) follow by 50% (88.70) and 75% (88.25), weight of pods/plant (3.40) and test weight (22.30) was recorded highest in 50% of residual fertility dose of intercropping.

#### Yield and harvest index

Data in table 4 regarding biological yield, grain yield and straw yield significant difference over other treatments. The highest biological yield (50.25q/ha), grain yield (17.28q/ha) and straw yield (32.35q/ha) were recorded in lentil sole which were significantly superior over all treatments. Next to sole crop and among the intercrop treatments the highest biological yield (27.20 q/ha), grain yield (9.15 q/ha), and straw yield (17.35 q/ha), was recorded in 50% residual fertility combination of intercrops which was significantly superior over 75% residual fertility combination followed by 100% residual fertility level citronella + lentil combination. The lowest biological yield (24.35 q/ha), grain yield (8.20 q/ha), and straw yield (14.45 q/ha), were recorded

**Table 1.** Effect of different treatments on growth characters and yield attributes of citronella:

Treatments	Leaf length at 8 <sup>th</sup> cutting (cm)	Number of tiller at 8 <sup>th</sup> cutting	Herbage yield of 8 <sup>th</sup> cutting (q/ha)	Oil yield of 8 <sup>th</sup> cutting (Lit/ha)
Citronella sole	72.45	95.34	196.30	165.36
C:Li (100%)	67.63	92.45	103.63	86.54
C:Li (75%)	68.30	91.80	102.62	86.50
C:Li (50%)	67.70	92.70	103.65	85.53
C:L (100%)	67.25	92.30	102.58	84.54
C:L (75%)	68.25	91.75	102.67	85.64
C:L (50%)	67.65	92.65	103.62	84.64

S.E. (d)	0.7621	0.6386	3.2179	0.8431
CD (P = 0.05)	1.6018	1.3425	6.7613	2.2946

**Table 2.** Effect of Cropping system on Citronella equivalent oil yield (kg/ha)

Cropping system	Citronella	Linseed	Lentil	C:Li (100%)	C:Li (75%)	C:Li (50%)	C:L(100%)	C:L (75%)	C:L(50%)	CD	SE (d)
Equivalent yield	165.36	82.82	81.85	154.32	154.50	154.35	127.50	124.48	127.98	<b>1.642</b>	<b>0.791</b>

**Table 3.** Effect of different treatments on growth and yield attributes of linseed:

Treatments	Plant population /m <sup>2</sup>	Plant height at 30 DAS	Plant height at 60 DAS	Plant height at maturity (cm)	Number of branches per plant	Number of capsule/plant	Number of seed /capsule	Test weight (g)	Seed weight/plant	Biological yield (q/ha)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Linseed sole	105.34	20.34	50.48	73.42	35.83	55.43	7.65	7.54	4.43	64.77	19.67	45.10	30.36
C:Li (100%)	102.21	18.64	48.32	70.35	33.24	51.48	7.20	6.80	3.80	62.23	16.10	46.13	25.86
C:Li (75%)	102.35	19.42	48.80	70.26	34.65	52.41	6.82	7.05	3.75	61.60	16.15	45.45	26.21
C:Li (50%)	101.72	19.65	48.05	70.45	32.70	52.70	7.35	7.25	4.10	60.33	16.35	43.98	27.09
S.E (d)	0.8563	0.3973	0.8621	0.5821	0.2792	0.2872	0.1064	0.0316	0.0224	0.0347	0.0316	0.0387	0.0528
CD (P =0.05)	1.9358	0.8750	N.S.	1.3160	0.6322	0.7234	0.2060	0.0651	0.0376	0.0471	0.0634	0.0881	0.0577

**Table 3.** Effect of different treatments on growth and yield attributes of linseed:

Treatments	Plant population /m <sup>2</sup>	Plant height at 30 DAS	Plant height at 60 DAS	Plant height at maturity (cm)	Number of branches per plant	Number of capsule/plant	Number of seed /capsule	Test weight (g)	Seed weight/plant	Biological yield (q/ha)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Linseed sole	105.34	20.34	50.48	73.42	35.83	55.43	7.65	7.54	4.43	64.77	19.67	45.10	30.36
C:Li (100%)	102.21	18.64	48.32	70.35	33.24	51.48	7.20	6.80	3.80	62.23	16.10	46.13	25.86
C:Li (75%)	102.35	19.42	48.80	70.26	34.65	52.41	6.82	7.05	3.75	61.60	16.15	45.45	26.21
C:Li (50%)	101.72	19.65	48.05	70.45	32.70	52.70	7.35	7.25	4.10	60.33	16.35	43.98	27.09
S.E (d)	0.8563	0.3973	0.8621	0.5821	0.2792	0.2872	0.1064	0.0316	0.0224	0.0347	0.0316	0.0387	0.0528
CD (P =0.05)	1.9358	0.8750	N.S.	1.3160	0.6322	0.7234	0.2060	0.0651	0.0376	0.0471	0.0634	0.0881	0.0577

**Table 4.** Effect of different treatments on growth and yield attributes of lentil

Treatments	Plant population /m <sup>2</sup>	Plant height at 30 DAS	Plant height at 60 DAS	Plant height at maturity (cm)	Number of branches per plant	Number of pod/plant	Number of grain /pod	weight of pods/plant (g)	Test weight (g)	Biological yield (q/ha)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Lentil sole	113.50	10.50	20.50	45.60	20.10	90.50	2.30	3.50	22.80	50.25	17.28	32.35	33.85
C:L (100%)	109.50	9.20	19.72	40.65	18.56	88.25	2.15	3.30	22.25	26.65	9.07	16.32	35.30
C:L (75%)	110.72	9.80	19.45	41.73	18.70	89.50	2.05	3.25	22.28	24.35	8.20	14.45	36.45
C:L (50%)	109.42	8.90	19.80	40.90	18.70	88.70	2.25	3.40	22.30	27.20	9.15	17.35	34.80
S.E (d)	0.0592	0.0707	0.0866	0.7919	0.4576	0.4695	0.0810	0.0632	0.0774	0.8759	0.4271	0.8794	0.2828
CD (P =0.05)	0.1332	0.1627	0.1973	1.1121	1.0343	1.0613	N.S.	0.1395	0.1785	1.9803	0.9655	1.9881	0.6388

**LER:**

LER reflects the extra advantage of intercropping system over sole cropping system. LER was more than sole crops which showed and advantage of intercropping over sole system in terms of the use of environment resources for plant growth and development. LER values in citronella + linseed (75%) and citronella +linseed (100%) intercropping system was 1.34. The results indicated that 0.34% more area would required by a sole cropping system to recover the yield of intercropping system, citronella + linseed (50%) intercropping system recorded the maximum equivalent yield than sole cropping. It might be due to significant increases in grain yield of linseed in aforesaid treatment over sole which resulted in higher citronella equivalent yield followed by citronella : lentil (75%).

**REFERENCES**

**Aktar, M. S. Haque, M. F. and Rahman, A. R. M. S.** (1993). Effect of mixed cropping lentil and linseed at various seeding ratios. *Lens*;20(1): 39-42.

**Ansari, M.H. and Srivastawa, A.K.** (2012). Intercropping of kharif (pigeonpea & maize) and rabi (lentil) crop with Citronella (*Cymbopogon winterianus*) M.Sc.Ag. Thesis (Agonomy), Department of Agronomy, C.S.Azad University of Agriculture & Technology.

**Ram, Munni, Ram, Dasha, Prasad, Arun, and Kumar, Sushil** (1998). Productivity of citronella java (*Cymbopogon winterianus*) with spring Legume intercrops under subtropical environment. *Journal of Essential oil research*, 10 (3) : 269-275.

**Patra, D. D., Sukhmal, Chand, Lal, R. K., Bahl, J. R. and Khanuja, S. P. S.** (2005). Agro-packages for cultivation of palmarosa (*Cymbopogon martinii* var. *motia*). *Journal of Medicinal and Aromatic Plant Sciences*.27( 4): 727-735.

**Ram, P., Kumar, Birendra, Kothari, S. K., Mohd, Yaseen and Rajput, D. K.** (2000). Productivity of Java citronella based inter-cropping systems as affected by fertility levels under Tarai region of Uttar Pradesh. *Journal of Medicinal and Aromatic Plant Sciences*.22, 1B: 494-498.

**Renu, Dhar, Basu, T.K. and Bandyopadhyay, S.R.** (2007). Nodulation of lentil as influenced by irrigation and its effect on yield of rapeseed grown in association with lentil. *Journal of Mycopathological Research*, 45:2, 257-260.

**Subedar, Singh and Singh, N. P.** (1991). Grain yield and water use by crops in linseed based intercropping systems as influenced by irrigation. *Annals of Agricultural Research*; 12(1): 32-37.

**Singh, Sher, Narayan, Om, Yadav, R. K. Chauhan, N. K. and Lohani, H.** (2008). Effect of different plant geometry on growth, yield and quality of citronella (*Cymbopogon winterianus* (Jowitt.)). *Journal of Medicinal and Aromatic Plant Sciences*.30(3): 267-269.

**Singh, Jyoti, Hussain, Karam, Chandra, R. and Singh, K.** (2005). Effect of intercropping on disease incidence and grain yield in linseed. *Farm Science Journal*; 14 (1):25-26.

**Sinha, M. N. and Rai, R. K.** (1993). Effect of linseed and lentil planting pattern on their productivity under rainfed condition. *Annals of Agricultural Research*; 14 (3): 355-356.