Turkish Journal of Biodiversity

Turk J Biod, September 2020, 3(2): 69-75
https://doi.org/10.38059/biodiversity.729081
Journal homepage: http://turkbiod.artvin.edu.tr/
http://dergipark.gov.tr/biodiversity

e-ISSN:2667-4386

RESEARCH ARTICLE Open Access

Variation in biomass production of sunflower (*Helianthus annuus*) plants under the influence of Lemongrass (*Cymbopogon erectus*) extract

Limon otu (*Cymbopogon erectus*) ekstresinin etkisi altında ayçiçeği (*Helianthus annuus*) bitkilerinin biyokütle üretiminde varyasyon

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Article Info

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Article history
Received: April 29, 2020
Received in revised form: May 19, 2020
Accepted: May 22, 2020
Available online: May 31, 2020

Keywords:
Biomass, carbon sequestration, foliar extract, lemongrass, sunflower

Anahtar Kelimeler:
Biyokütle, karbon tutma, yaprak ekstraktı, limon, ayçiçeği

ABSTRACT

Plant extract is being used for crop yield and biomass enhancement since long time. Using plants extract for the enhancement of growth of other plant is a worthwhile strategy so as to enhance crop yield and crop biomass. Current study is an attempt to increase growth in sunflower plants using lemongrass foliar extract. For this purpose, various trials based on computer modeling have conducted. Pot experiment of sunflower plants has performed in greenhouse conditions that have irrigated by different concentrations of lemongrass extract. Results show that lower concentrations produced significant gain in biomass of crop i.e. greater fresh and dry weight was achieved by 1% samples (7.4±0.8mg and 2.0±0.3mg respectively) while lowest fresh and dry weight attained by 3% samples (2.5±0.2mg and 1.1±0.1mg respectively). Absolute growth rate (AGR) and Relative growth rate (RGR) of the plants are obtained in sequential order of treatment. Control, 0.5% and 2% samples form close linear fit to the model while 0.5% samples produce long tailed positive correlation fit whereas 3% samples are negatively fitted to the model. CDF model produce closely fitted relationship of 1% and control samples while 3% samples negatively corresponded to normal fit. Therefore, current study suggests promoting an efficient agriculture strategy that would be helpful in biomass gain of the crops to sequester carbon and effectively take part in climate mitigation.

ÖZ

Bitki özütü, uzun süredir ürün verimi ve biyokütle arttırımı için kullanılmaktadır. Bitki ekstraktının diğer bitkilerin büyümesini arttırmak için kullanılması, mahsul verimini ve bitki biyokütlesini arttırmak için değerli bir stratejidir. Mevcut çalışma limon yaprakçık özü kullanarak ayçiçeği bitkilerinde büyümeyi artırma girişimidir. Bu amaçla bilgisayar modellemesine dayalı çeşitli denemeler yapılmıştır. Ayçiçeği bitkilerinin pot deneyi, farklı konsantrasyonlarda limon otu ekstresi ile sulanan sera koşullarında gerçekleştirilmiştir. Sonuçlar, daha düşük konsantrasyonların mahsul biyokütlesinde önemli bir kazanç sağladığını, yani daha yüksek taze ve kuru ağırlığın% 1 numunelerle (sırasıyla 7.4 ± 0.8mg ve 2.0 ± 0.3mg), en düşük taze ve kuru ağırlığın ise% 3 numunelerle (2.5 ± Sırasıyla 0.2mg ve 1.1 ± 0.1mg) elde edildiğini gösterir. Bitkilerin mutlak büyüme oranı (AGR) ve nispi büyüme oranı (RGR), sırayla değerlendirme sırasına göre elde edilir. Kontrol,% 0.5 ve% 2 numuneler modele yakın doğrusal uyum sağlarken,% 0.5 numuneler uzun kuyruklu pozitif korelasyon uyumu üretir. % 3 numuneler modele negatif bağlanmıştır. CDF modeli % 1 ile yakın ilişki kurar ve kontrol numuneleri oluştururken,% 3 örnekler normal uyuma negatif olarak karşılık gelir. Bu nedenle, mevcut çalışma, karbonu ayırmak ve iklimin azaltılmasında etkin bir şekilde yer almak için bitkilerin biyokütle kazancında yardımcı olacak verimli bir tarım stratejisinin geliştirilmesini önermektedir.

Citation:

To cite this article: Asad M**,** Khan A, Jahan B (2020). Variation in biomass production of sunflower (*Helianthus annuus*) plants under the influence of Lemongrass (*Cymbopogon erectus*) extract. *Turk J Biod* 3(2): 69-75. **https://doi.org/10.38059/biodiversity.729081**

1. INTRODUCTION

Plants are the fundamental living bodies for carbon stock that aid in climate mitigation. Ecological processes combine a variety of factors integrating over plant's biomass accumulation. One of those factors is moisture; the fundamental requirement. For evaluation of carbon sequestration in plants, growth as an important physico-ecological process to be analyzed. Recent agriculture systems require smart utilization of land resources, bioenergy, biomass etc. Although, agriculture sector contributes to world's economic food demand, it can also helpful for environmental problems like soil erosion, soil fertility and maintenance of an effective carbon sink due to their great biomass. Cultivated areas have great potential to store carbon, thus expedition of agricultural areas into multidimensional purposes is one the present ecological requirements. UN Framework Convention of Climate Change (UNFCCC) declared that cropping system can be utilized for reduction in Greenhouse gases (GHG) emissions and carbon stock measurement as crop yield and food production is unaffected by implementing climate change mitigation strategies on crops (Green et al., 2007; Almgir & Al-Amin, 2007). Therefore, agricultural crops can be the safest biological tool for such practices. GHG reduction will occur with preservation of carbon in the form of plant biomass because carbon is bio-sequestered as a result of photosynthesis (Lal, 2004; SSSA, 2008). Many workers claim that carbon is bio-sequestered in the form of plant biomass in their stems and into the soil (IPCC, 2003; IPCC, 2006; FAO, 2005). However, forests are the largest carbon sinks because of collection of tree biomass (Schimel et al., 2001; Piechl & Arain, 2006; Lorenz & Lal, 2009; Loaiza et al., 2010; Thomas & Martin, 2012). In addition crop fields can also perform the same function in mitigation of climate change upto some extent (IPCC, 2003; IPCC, 2006; FAO, 2005). Therefore, biomass evaluation is needed in agricultural countries which are not well understood up to now. Carbon sequestered or biomass accumulation capability depends upon species to species, cultivar, age of plants and number of plants in a particular area (Lichaikul, 2004; Jenkins et al., 2003). Since, Pakistan is a developing country and its economy is mainly dependent on agriculture (Rashid et al., 2002), it could be beneficial for country's environmental sustainability to emphasize on carbon storage in agricultural fields. Pakistan's vulnerable environment strongly requires such kind of studies that could benefit in a multidimensional way. Sunflower crop is widely cultivated throughout the country. The plant has a great significance in oil production industry; it is Pakistan's fourth major crop (Shah et al., 2013). Several studies has produced on physical, physiological, medicinal and economic importance of sunflower.

Lemongrass (*Cymbopogon erectus*) is native to Asian countries and well known for its health benefits like stomach problems, skin problems and related issues can be cured by the help of this species (Leite et al., 1986; Borrelli & Izzo, 2000; Cheel et al., 2005; Runnie et al., 2004). It is also easily available and naturally grown in Pakistan. Keeping in consideration the current environmental needs, present study is an attempt to increase growth (biomass) of sunflower using lemongrass extract.

2. MATERIALS AND METHODS

Fresh lemongrass leaves were used for the preparation of foliar aqueous extract in different concentrations i.e. 0.5%, 1%, 2% and 3% in distilled water. Sunflower seeds were divided into groups to soak under given concentration of lemongrass extract. The seeds were sowed in their respective pots. Four sunflower seeds with five replicates were sown in each concentration. Soil composition was Sandy-clay mixed in a ratio of 1:3 respectively and pH was 6.8. The experiment was carried out in the month of November that ended up in the month of February i.e. took a total duration of 16 weeks. Plant physical attributes were monitored on weekly basis.

For biomass calculation following formulae were used (Paine et al., 2012):

$$\text{Absolute Growth Rate (AGR))} = \frac{M_2 - M_1}{t_2 - t_1}$$

$$\text{Rel. Growth Rate (RGR)} = \frac{l_n(M_2) - l_n(M_1)}{t_2 - t_1}$$

Leaf growth index (LAI), relative growth rate (RGR) and net assimilation rate (NAR) were evaluated in relation to assess the leaf growth efficiency per exposure. The formulation followed Rajput et al (2017).

Leaf Area Index (LAI) = Total leaf area/Shoot length

$$\text{Rel. growth rate} = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

$$\text{Net Assimilation Rate (NAR)} = \frac{(W_2 - W_1)(\text{Log } L^2 - \text{Log } L^1)}{(t_2 - t_1)(L^2 - L^1)}$$

where, t = spray interval = 10 sprays

M_1 and M_2 = Initial and final dry weight of plants.

L_n = Log n

$L^2 - L^1$ = Total leaf area at time t_2 and t_1

Bio-statistical analysis was implemented for evaluation of sunflower biomass under different concentration using EXCEL 2013 and MINITAB 17 software.

3. RESULTS

The experiment was completed in 16 weeks that examined vegetative growth of sunflower plants under treatment of lemongrass foliar aqueous extract at given concentrations. In this regard, above ground weight of plants was recorded that showed highest shoot fresh and dry weight achieved from 1% samples (7.4±0.8mg and 2.0±0.3mg respectively) which was greater than control samples (Figure 1). Similar condition observed in leaf fresh and dry weight, highest weights recorded from 1% samples i.e. 3.2±0.1mg and 0.8±0.1mg (Figure 1).

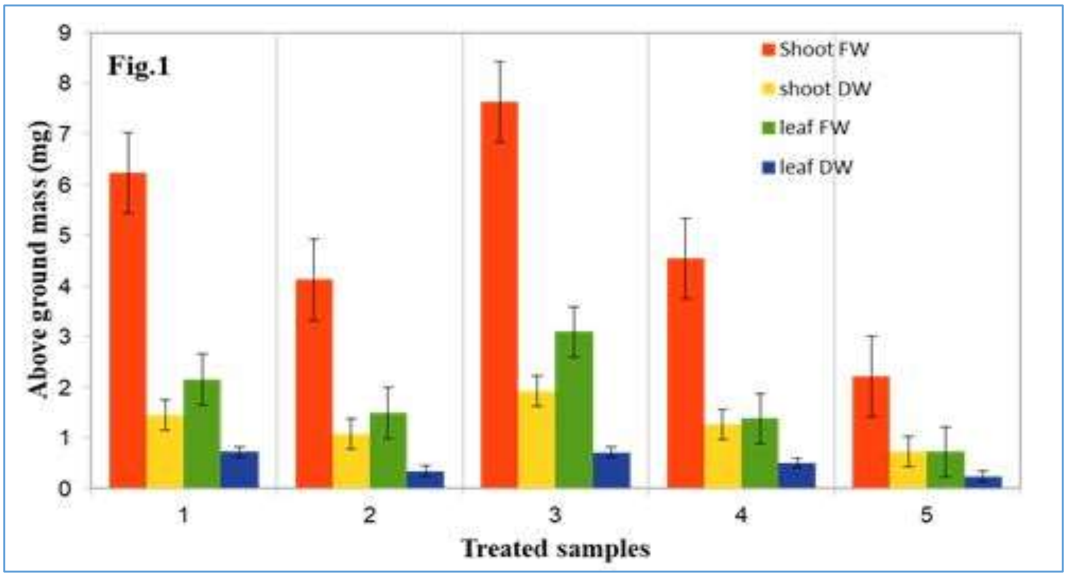

Figure 1. Mean biomass obtained by shoots and leaves of sunflower plants at different concentrations. where, 1 = control, 2 = 0.5%, 3 = 1%, 4 = 2% and 5 = 3% plant samples, FW = Fresh weight and DW = Dry weight..

ANOVA between fresh and dry weights of treatments showed strongly significant ($p < 0.001$) relationship while leaf fresh and dry weights produced a weakly significant ($p < 0.1$) relationship among treated sample plants. For the evaluation of extent of normality in plant biomass of predefined treatments, Normal probability model was implemented. The fits of correlation coefficients as a function of response (AGR) and predictor (RGR) were presented in Figure 2. Control, 0.5% and 2% lie significantly normally and show a strong linear pattern with some slight deviations. While 1% provided a long tailed departure, lie in the normally distributed medium with weakly positive correlation with normal fit. 3% also produced a negatively long tailed departure with weak correlation with the normal fit hence indicating some abnormalities in the data.

Another model of Empirical distribution for both the groups (AGR and RGR) was applied to identify a step-wise performance of plants as a response against increase in concentration of lemongrass extract. The CDF model showed that all the treated plants closely followed their corresponding distribution fits (Figure 3). Percentile lines showed 29.29 mg of AGR lie at 50% of total biomass attained after 16 weeks of the whole treatment while RGR attained poor biomass as expected at 2.33mg as an average expected value in 16 weeks. AGR and RGR distribution provided 98% confidence intercept. Control, 0.5% produced a wide connective feature in their growth effectiveness while between 1% and 2% showed a closer growth deviation between them. 3% samples occupied greater biomass variation than the other samples hence the correlation expectancy proved to be non-significant in these samples (Figure 3).

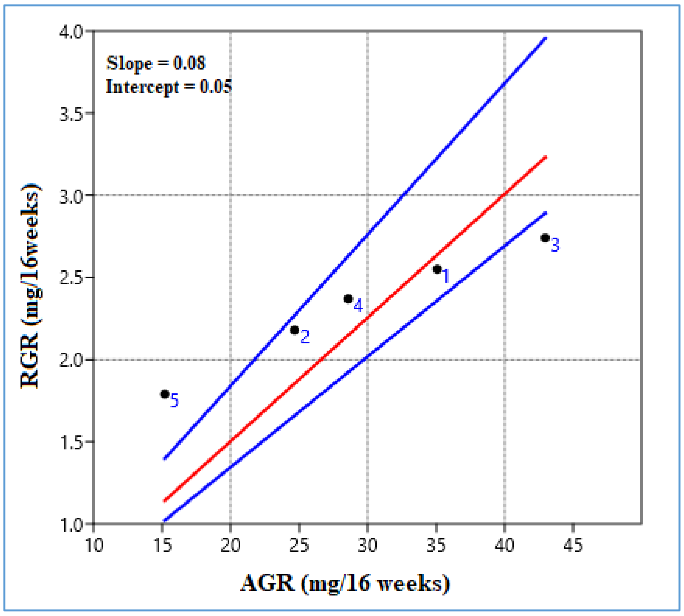

Figure 2. Normal probability of plant growth; AGR v/s RGR in 16 weeks. Normal fit distribution of growth of treatment samples. Where 1 = Control, 2 = 0.5%, 3 = 1%, 4 = 2% and 5 = 3%, Blue lines = upper and lower bounds and Red line = Spline.

Cumulative distribution function (CDF) distribution fits of leaf parameters were illustrated in figure 4, presenting all three groups (RGR, LAI and NAR) follow their corresponding distribution fits. However, RGR and LAI represented a close relationship with the distribution fit so far while NAR formed a low significant relationship and closer to non-significant patch over the spatial scale. Percentile lines corresponding to leaf area index showed 0.38cm increment as a 50% growth rate of leaf took place in 0.5% and 1% samples along with control. Control and 1% samples attained a greater leaf area index while 0.5% and 3% achieved lowest leaf area. Net assimilation rate was highest in control 0.4cm/16 weeks, in 0.5% (0.2cm/16weeks and in 3% (0.3cm/16 weeks). Leaf area index followed the same distribution pattern the samples as of RGR. All three parameters provided 98% confidence intercept.

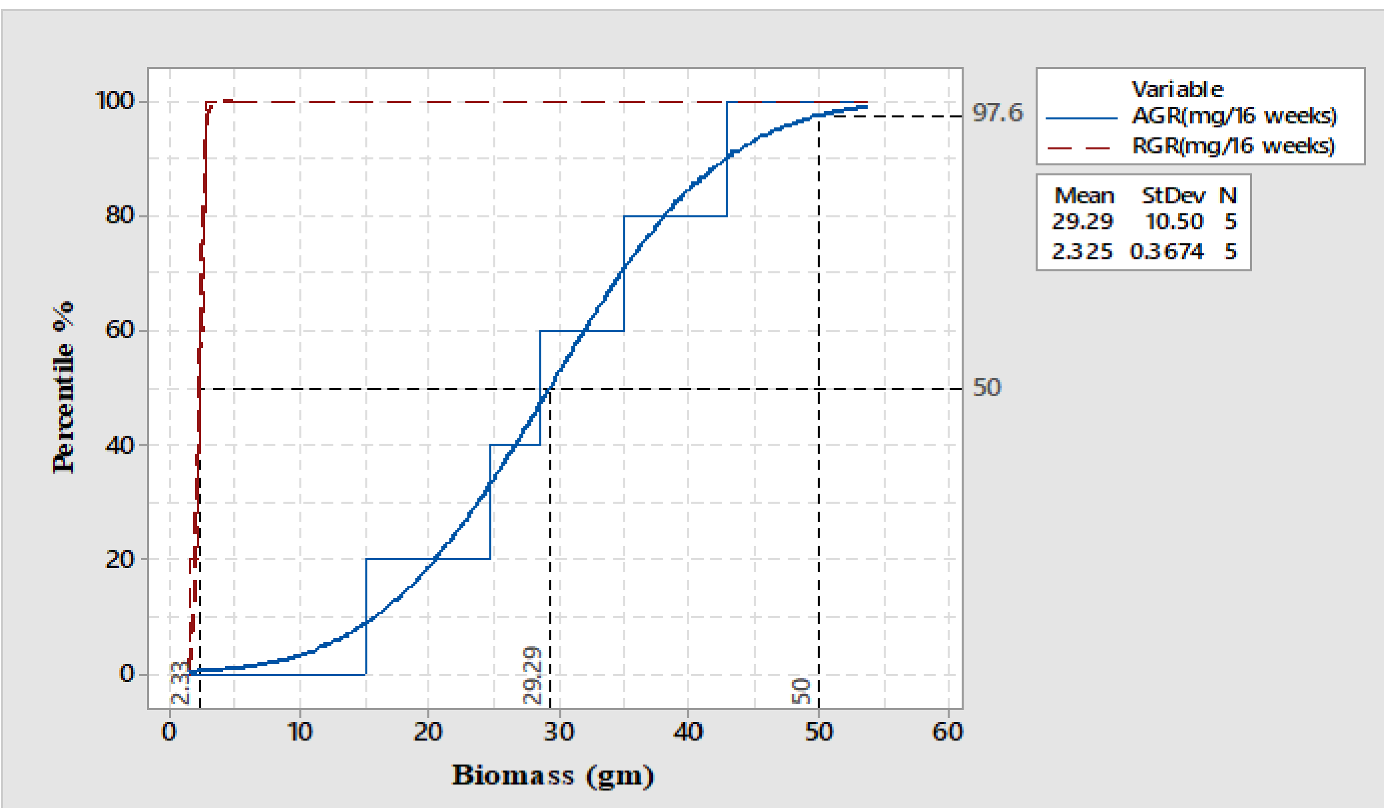

Figure 3. Empirical model of Cumulative distribution function (CDF) against plant biomass with respect to AGR and RGR.

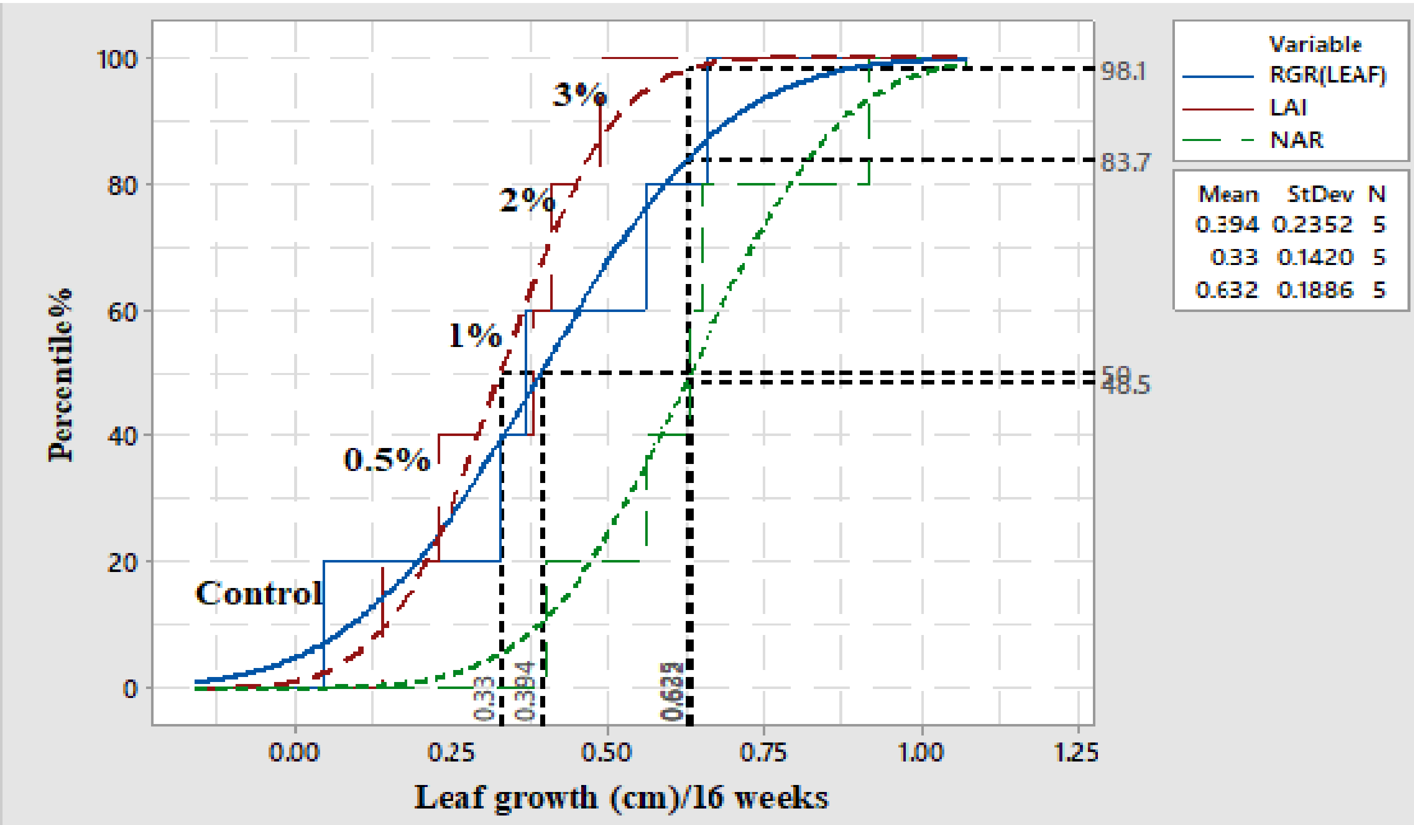

Figure 4. Emperical model of Cumulative distribution function (CDF) of leaves growth parameters; RGR, LAI and NAR.

4. DISCUSSION

Growth in plants refers to ontogenic change in a plant body that is closely related to gain in plant's biomass and its physiological and metabolic processes (Mc Mohan & Bonner, 1983). To understand growth process in plants, it is also important to understand the relationships of plants with various ecological attributes that host plant responses like competition, herbivory, moisture availability, interactions within population and community and other abiotic stimulants (Kobe, 1999; Tanner et al., 2005). Analysis of growth trend in plants however, ignored in many studies but it takes importance for development of growth models in stress related studies (Paine et al., 2012; Shi & Liu, 2017). Traditional growth analysis in a statistical mode was confined to linear regression model for AGR and RGR (Poorter, 1998; Hunt, 1981, 1982) that limited the sequential changes in biomass by time (Paine et al., 2012). Plant growth involves temporal dynamics in the biomass production (Paine et al., 2008; Rees et al., 2010) as there are a number of factors involved during growth process that may have variation by passage of time. Current study explained the absolute and relative increase or decrease in biomass by applying different models to confer the growth process took place in a particular season when there were similar ecological conditions compiled over the plants. Though, the stress intensity was variable and its significance level for growth rate was examined by utilizing normal probability and CDF model. Studies on RGR and AGR claimed that RGR could be decreased with the increase in AGR of plants (Rees et al., 2010). Decrease in RGR takes place due to the accumulation of non-photosynthetic biomass in roots and stems of plants that has resulted in increase in AGR that is in agreement to our findings. Leaf growth evaluations showed a higher NAI in leaves while LAI was the least recorded in all samples. In present study, growth rates accounted for comparison among different lemongrass concentrations effect that was highlighted in the normal distribution model. The normal distribution model summarized the effectiveness of the stress i.e. 0.5% and 2% samples closely fitted the model that predicted for a better tolerance mechanism of these samples than 1% samples. Even though, 1% samples were apparently observed to be the most successful plant samples within the growth process but the model showed a slightly lower extent of their tolerance mechanism. In the light of current findings, it is seen that lemongrass extract promoted the growth of sunflower plants predominantly at lower concentrations, sunflower plants showed gain in biomass even at greater concentration which was predicted for a sharp decline by passage of time. Hence, the investigations recommend that lemongrass could be a beneficial biological stimulant for the growth of sunflower crops and can be used in the fields in place or in combination with conventional fertilizers.

5. CONCLUSION

Implementing bio-stimulants in our agricultural systems is a healthy measure against the conventional unnatural methods for growing crops. From this study, it is concluded that Lemongrass extract successfully assisted the crop in biomass gain than normal conditions. However, higher concentration was not completely beneficial for the crop so far but it can be productive at earlier stages. Therefore, we strongly recommend introducing biological products in agriculture system for being closer to nature and become a recipient of non-hazardous healthy outcomes. Moreover, crop utilization for economic desires is the fundamental need that can simultaneously works for environmental health.

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