RESEARCH ARTICLE   Indian Journal of Agricultural Research, Volume Issue : ()

Effect of Yeast Bio-fertilizer on Lettuce Growth and Productivity

Basel Natsheh[1], Wafa Masoud[2], Nawaf Abu-Khalaf[2]

10.18805/IJARe.AF-700

ABSTRACT

Background: Synthetic fertilizers and pesticides are widely used, with detrimental repercussions for soil microbial biodiversity and environmental contamination. The use of microorganisms as bio-fertilizers has been recommended as an alternative agricultural strategy. Due to their potential to safely boost plant development, yeasts can be used to make high-quality bio-fertilizers and biopesticides in a variety of ways. As a result, substantial yeast research could be promising and could provide an environmentally acceptable solution to the increasing agricultural output that would be necessary as the world's population grows.

Methods: The study was conducted to investigate the effect of different yeast concentrations on lettuce crop production and quality. The experiment consisted of four treatments (1%, 3%, 5% and 7% w/v yeast). The measurements included chlorophyll content, plant length (cm) and plant-wet weight for shoot and root (g). The design of the experiment was a complete factorial design with five replicates for each treatment. Three doses of each yeast solution, *i.e.* 1%-7% w/v, were added to soil after 7, 25 and 40 days from cultivation. The plants were harvested after 52 days.

Result: In the current study, it was found that the highest chlorophyll content with a value of 44.6 was obtained at 3% w/v of yeast concentration followed by 1% w/v (39.7), 5% w/v (44.3) and 7% w/v (41), respectively. The average maximum length of plants after 52 days was 26.6 cm at 3% w/v and 26.13 cm at 5% (w/v) of yeast concentrations. The other treatments gave lower values, *i.e.* 24.4 cm, 22.2 cm and 19.1 cm for 1% w/v, 7% w/v and control, respectively,. The values have the same trend during the experiment time at the three stages (7, 25 and 40) days from cultivation. The optimum plant wet weight for shoot and root with 3% w/v yeast concentration were 212.2 and 33.9 g, respectively. At 5% w/v of yeast concentration, the wet weight for shoot and root were 200.1 g and 30.7 g followed by 7% w/v (196.2 g and 25.6 g) and 1% w/v (171.2 g and 26.4 g).

Key words: Bio-fertilizer, Growth, Lettuce, Productivity, Quality, Yeast.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an annual plant that belongs to one of the important vegetables in the salad crop family Compositeae. It is the world's most sought-after salad crop. It is native to Europe, Asia and North Africa and has been grown for 5000 years. The word lettuce is often used to refer to the succulent, edible L leaves. Sativa is usually consumed raw in salads but can also be cooked (Natsheh and Abu-Khalaf, 2020).

Lettuce is a fragile crop *i.e.* perishability class is very high and must be handled with care to minimize discoloration and to avoid mechanical damage and pathological problems. During storage, temperatures must be kept low and relative humidity high to prevent loss of turgor and wilting and ethylene must be avoided. High-quality lettuce should generally be clean, free of browning, crisp and turgid and bright light green. Head lettuce should be solid, with no seed-stem, defects or decay (Tudela and Gil, 2020).

Using fertilizers is very important for high yield crop production. Fertilizers provide nutrients to plants, mainly nitrogen, phosphorus, calcium, sulfur, magnesium, potassium, iron and zinc. However, using chemical fertilizers has a negative impact on human and animals' health. In recent years, the world focused its attention to minimize environmental pollution by reducing the use of synthetic fertilizers and chemicals in crops production (Mona *et al.,* 2013).

An alternative to synthetic chemical fertilizers is bio-fertilizer. Biofertilizer can be defined as biological products containing living microorganisms that, when applied to seed, plant surfaces, or soil, promote growth by several mechanisms such as increasing the supply of nutrients, increasing root biomass or root area and increasing nutrient uptake capacity of the plant (Vessey, 2003). It is formulations of beneficial microorganisms, which upon application can increase the availability of nutrients by their biological activity and help to improve the soil health and therefore promote plant growth. Microbes involved in the formulation of bio-fertilizers not only mobilize N and P but also participate in the process of producing crops and foods naturally. It has

[1]Department of Environment and Sustainable Agriculture, Faculty of Agricultural Sciences and Technology, Palestine Technical University- Kadoorie, P.O. Box. 7, Tulkarm, Palestine.
[2]Department of Agricultural Biotechnology, Faculty of Agricultural Sciences and Technology, Palestine Technical University-Kadoorie, P.O. Box. 7, Tulkarm, Palestine.

Corresponding Author: Nawaf Abu-Khalaf, Department of Agricultural Biotechnology, Faculty of Agricultural Sciences and Technology, Palestine Technical University-Kadoorie, P.O. Box. 7, Tulkarm, Palestine. Email: n.abukhalaf@ptuk.edu.ps

How to cite this article: Natsheh, B., Masoud, W. and Abu-Khalaf, N. (2022). Effect of Yeast Bio-fertilizer on Lettuce Growth and Productivity. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.AF-700.

Submitted: 08-10-2021 **Accepted:** 23-03-2022 **Online:** 16-04-2022

been reported that bio-fertilizers increased the yields of the crop between 10-40% by increasing the content of proteins, essential amino acids, vitamins, as well as nitrogen fixation (Bhardwaj *et al.,* 2014).

Backing yeast (*Saccharomyces cerevisae*) is one of the bio-fertilizers that provide safe plant nutrition and is free of any environmental damaging products. It is very rich in amino acids and when yeast is placed in water it hydrolyses *i.e.* formed extracted as a result of internal enzymes activity without the addition of external enzymes to a large number of vitamins and mineral salts, amino acids.

Soil yeast communities play an important ecological role in processes such as mineralization of organic matter via respiration or fermentation, P solubilization, transformation of N compounds and inorganic S, plant protection against pathogens, increasing plant root growth and even act as food source for arthropods, bacteria, nematodes and protests (Botha, 2011). Yeasts occur in a broad range of different soil types from forest and cultivable land to soils of extreme environments such as Antarctica. Soil yeasts not only affect microbial and plant growth, but may also play a role in soil aggregate formation and maintenance of soil structure (Connell *et al*., 2008).

Agamy *et al*. (2013) studied the effects of using *kluyveromyces walti*, *Pachytrichospora transvaalensis* and *Sacharromycopsis cataegensis* as bio-fertilizers for sugar beet. It was found that the three yeast species increased photosynthetic pigments, soluble sugars, sucrose and total proteins in sugar beet. Furthermore, the yeast extracts were reported to improve the growth parameters and productivity of sweet potatoes (El-Tohamy *et al.,* 2015). It has also been reported that foliar application with yeast gave the highest significant values of nitrogen, protein and carbohydrate percentages of plants as well as stimulating cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation (Ibrahim *et al.,* 2020).

Therefore, the aim of this research was designed to study the influence of different concentrations of baking yeast on chlorophyll content, vegetative growth, productivity and quality of lettuce crop.

MATERIALS AND METHODS

Yeast preparation

Baking dry yeast was bought from the local market. Four concentrations of yeast (1%, 3%, 5% and 7% w/v) were prepared by dissolving of 1, 3, 5 and 7 g in 100 ml of water followed by adding 1, 3, 5 and 7 g of sugar to each yeast concentration, respectively. The prepared concentrations were incubated at 25°C for an hour to activate the yeast.

Experimental design and data analysis

The experiment was carried under a full control fibreglass house during the summer season. Started 8 April until 1 June 2021, at Palestine Technical University- Kadoorie (PTUK), Tulkarm. The effect of adding four different concentrations of yeast (T2-T5) to the soil on improving growth, productivity and quality of lettuce (*Lactuca sativa* L.) crop was investigated. The design of the experiment was a complete factorial design with five replicates for each treatment (Fig 1), control, 1% w/v yeast, 3% w/v yeast, 5% w/v yeast and 7% w/v yeast resulting in 25 experimental pots. Each pot contained 2.5 kg of clay, compost and vermiculite mixed in volumes of 2:2:1, respectively. Each pot was cultivated with one plant. The plants were grown with full controlled temperature regime ranges from 21 to 24°C. The irrigation water (tap water) was added manually

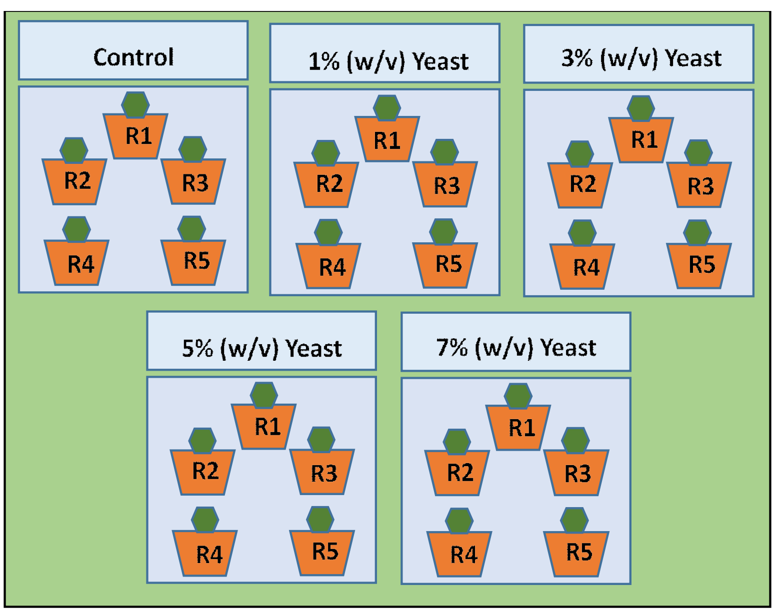

Fig 1: The layout of the experiment under the control of a fiberglass house.
R= Replicate, 5 treatments (control + yeast concentrations), 25 replicates
Plants = Lettuce (*Lactuca sativa*), (w/v) = weight per volume, pot with soil weight = 2500 (g).

according to the plant's requirement's day by day. Three doses of each yeast solution, *i.e.* 1%-7% w/v, were added to each pot after 7, 25 and 40 days (100 ml yeast solution) from cultivation. Measurements of chlorophyll content (%) by SPAD 502 Plus Chlorophyll Meter. In addition,the height of the plants (cm) and weight of the plants (g) were recorded and observations were evaluated based on eyes during the experimental time. the soil pH ranges between 6.1-6.5 during the expiremental time.

The plants were harvested after 52 days. One way analysis of variance (ANOVA) in Microsoft Office Excel (Microsoft Office, 2016) was used to investigate the significance degree ($p < 0.05$) between different treatments.

RESULTS AND DISCUSSION

Data in Table 1 shows that all yeast treatments significantly increased ($p \leq 0.05$) leaves' content of chlorophyll compared to control. The results indicated that 3% w/v of yeast concentration showed the highest chlorophyll content with a value of 44.6 followed by 5, 7 and 1%, w/v respectively. It seems that the yeast concentration plays a role in chlorophyll content as a green pigment that allows plants to photosynthesize. There were clear differences visually between the treatments in terms of the green color intensity in the treated plants injected with yeast compared to the control.

Shalaby and El- Nady (2008) reported that the increase in photosynthetic pigments could be attributed to the role of yeast cytokines in delaying the ageing of leaves by reducing the degradation of chlorophyll and enhancing the protein and RNA synthesis. Yeast increased the release of carbon dioxide through the fermentation process that effectively activates photosynthesis and accelerates the biosynthesis of carbohydrates (Mady, 2009).

Abdelaal (2015) reported that *Saccharomyces* sp. is among the microorganisms, which improve crop growth and yield by increasing photosynthesis, producing bioactive substances, such as hormones and enzymes and controlling soil diseases. It has been reported that the increase in total chlorophyll content in leaves might be due to Cytokinens and some nutrient materials content in seaweed extracts, nitrogen enters in the molecule structure of chlorophyll.

In comparison between treatments for the shoot length, Table 2 shows that all yeast treatments significantly increased ($p \leq 0.05$) shoot length compared to the control where no yeast was added. The highest length was found at 3% w/v concentration of yeast with 26.6 cm followed by 5% w/v with 26.1 cm. The remaining treatments gave lower values *i.e.* 1% w/v of yeast with 24.4 cm and 7 with 22.2 cm.

In terms of quality, the observations indicated that there were clear differences between the treatments. It was clear to eyes that the treatments 3 and 5% w/v of yeast concentrations were the best treatments in terms of size, height and bright green color, the total vegetative.

The role of bread yeast in increasing the vegetative growth parameters (number of stems per plant leaf area, fresh and dry weight of plant) may be due to many important nutrients elements (N, P and K) present in yeast, which is necessary for plant biological processers especially

Table 1: Chlorophyll content of letuuce at different treatments of yeast (1, 3, 5, 7% w/v) and their significance test using one way anova.

Samples date	Replicates	Control	1% (w/v)	3% (w/v)	5% (w/v)	7% (w/v)
	R1	36.7	38.1	46.9	46.5	38.3
	R2	39.4	48.3	46.4	44.6	36.9
25 April 2021	R3	35.9	39.2	50.7	43.8	48.1
	R4	34.8	36.2	49.4	41.3	43.6
	R5	35.7	47.2	48.7	46.2	49.2
	Average	36.5	41.8	48.42	44.48	43.22
			S according to the 5 treatments			
	R1	38.4	36.8	44.9	43.1	40.9
	R2	39.2	40.9	39.3	46.3	40.7
5 May 2021	R3	37.1	38.7	39.2	48.5	43.2
	R4	36.4	42.3	49.8	37.9	44.3
	R5	37.9	34.1	46.9	43.8	45.9
	Average	37.8	38.56	44.02	43.92	43
			S according to the 5 treatments			
	R1	29.5	34.5	35.6	46.5	41.3
	R2	29.2	38.3	47.8	42.3	43.2
1 June 2021	R3	34.7	43.2	48.6	37.9	40.5
	R4	33.4	45.1	48.6	45.2	39.8
	R5	30.8	36.2	42.5	48.2	38.2
	Average	31.52	39.46	44.62	44.02	40.6
			S according to the 5 treatments			

S: Significant at $p \leq 0.05$ level.

photosynthesis, cell division and elongation (Nassar *et al.,* 2015). Taha *et al*. (2011) reported that bread yeast caused a significant increase in shoot characteristics plant height as compared with control. This enhancement in the characteristics of the vegetative shoot growth may be attributed to the ability of yeast to increase the production of stimulants for plant growth, especially Gibberellins, Auxins and Cytokinins which work to improve the plant cell division and its growth (Taha *et al*. 2011). The increase in shoots characteristics might be due to the Auxins content in the seaweed extracts, which have an effective role in cell division and enlargement. This leads to an increase in the shoot growth, leaves' area and plant dry weight (Thomsen, *et al.,* 2016). These extracts contain Cytokinins as well, which induce the physiological activities and increase the total chlorophyll in the plant. This will positively reflect on the activity of photosynthesis and the synthesized materials which will positively reflect on shoots characteristics.

The effect of yeast treatments on shoot and root plant weight is shown in Table 3 and 4, respectively. It can be seen that all yeast treatments significantly increased shoot and root plant weight. The optimum plant weight value for shoot and root treated with 3% w/v of yeast gave 212.2 and 33.9 gm respectively, at harvest stage, followed by 5% of yeast concentration (200.1 and 30.7 gm). The other treatments gave lower values with 7% of yeast concentration gave (196.2 and 25.6 gm) while 1% of yeast concentration gave (171.2 and 26.4 gm). In addition, there were clear differences between the treatments in terms of shoot weight, at the harvest stage of the crop, the best results were observed with treatment ranked 3, 5, 7 and 1% w/v yeast concentrations, respectively. All yeast treatments gave greater weight and volume to the crop compared to the control. Furthermore, there was a clear effect of yeast on root total by weight. The height of the plants for all treatments (vegetative total) was recorded and the best heights were observed with 3 and

Table 2: Plant length (cm) at different treatments of yeast (1, 3, 5, 7% w/v) and their significance test using one way anova.

Samples date	Replicates	Control	1% (w/v)	3% (w/v)	5% (w/v)	7% (w/v)
	R1	11.1	10.5	16.1	15.2	12.5
	R2	10.5	11.1	15.2	14.6	11.2
25 April 2021	R3	11.2	12.2	15.6	13.3	12.1
	R4	10.9	11.8	14.9	13.6	11.6
	R5	10.1	10.9	15.3	14.2	12.2
	Average	10.76	11.3	15.42	14.18	11.92
			S according to the 5 treatments			
	R1	16.2	19.1	22.5	23.2	21.5
	R2	15.4	21.3	23.6	21.9	16.5
5 May 2021	R3	15.2	19.5	22.4	21.6	19.4
	R4	17.1	19.1	21.3	21.4	18.2
	R5	14.8	19.4	24.2	24.6	19.3
	Average	15.74	19.68	22.8	22.54	18.98
			S according to the 5 treatments			
	R1	19.8	24.2	26.4	25.9	25.3
	R2	18.7	25.3	27.1	26.3	20.1
1 June 2021	R3	18.6	24.1	24.3	27.8	22.3
	R4	20.4	25.3	27.6	24.9	21.3
	R5	18.1	23.2	27.8	25.9	21.9
	Average	19.12	24.42	26.64	26.16	22.18
			S according to the 5 treatments			

S: Significant at $p \leq 0.05$ level.

Table 3: Root weight (g) at different treatments and their significance test using one way anova.

Samples date	Replicates	Control	1% (w/v)	3% (w/v)	5% (w/v)	7% (w/v)
	R1	24.4	25.6	34.9	28.8	19.7
	R2	27.1	21.7	33.2	28.9	32.3
1 June 2021	R3	21.8	22.6	32.6	31.6	29.4
	R4	19.76	33.1	34.1	35.4	26.9
	R5	26.3	28.9	34.8	28.9	19.7
	Average	23.87	26.38	33.92	30.72	25.6
			S according to the 5 treatments			

S: Significant at $p \leq 0.05$ level.

Table 4: Shoot weight (g) at different treatments and their significance test using one way anova.

Samples date	Replicates	Control	1% (w/v)	3% (w/v)	5% (w/v)	7% (w/v)
	R1	148.5	162.9	199.9	193.8	189.4
	R2	150.6	167.4	224.7	167.9	198.7
1 June 2021	R3	155.9	187.2	198.5	158.9	206.1
	R4	146.3	151.5	192.4	244.8	204.6
	R5	144.9	186.8	245.3	228.5	182.3
	Average	149.24	171.16	212.16	200.02	196.22
				S according to the 5 treatments		

S: Significant at $p \leq 0.05$ level.

5% w/v yeast concentrations, followed by 7% then 1% w/v. The lowest height was obtained without yeast treatment.

The shape of the plant at the harvest stage was bright green color with an increased leaves thickness, hardness almost equal in treatments (3 and 5% w/v) followed by 7 and 1% w/v, respectively. Our results agreed and supporting the same trend of Maqsuda *et al*. (2020), who reported that yeast at concentrations of 1, 2 and 3% w/v were significantly ($p \leq 0.05$) increased total leaf area (cm^2) per plant, as well as fresh and dry weight (g) of shoot system as compared with the water spraying control. The highest values of the mentioned parameters were 47.53 cm^2 per plant, 21.67 g and 11.93 g respectively, recorded at 3% yeast extract. It is clear from all parameters measured that 3 w/v of yeast concentration was the optimum concentration in modifying the lettuce. On the other hand, increasing yeast to more than 3% w/vshowed less modification of the lettuce parameters measured. This might be due to saturation of soil with yeast metabolites that might have a negative effect on plant.

CONCLUSION

The present study demonstrates that the application of yeast in different concentrations improves the growth and quality of lettuce crop plants grown in a soil system by increasing chlorophyll pigments, plants height and crop wet weight. Moreover, the treated lettuce showed the bright green color of leaves with an increase in thickness and hardness. The concentration of 3% w/v yeast was the best-applied dose for the achievement of better yield and quality of lettuce grown in comparison to other yeast concentration treatments. Therefore, we recommend the application of 3% w/v of yeast to improve the production and quality of lettuce crop.

ACKNOWLEDGEMENT

The authors would like to thank Palestine Technical University- Kadoorie (PTUK) for the continuous support.

Conflict of interest: None.

REFERENCES

Abdelaal, K.A. (2015). Pivotal role of bio and mineral fertilizer combinations on morphological, anatomical and yield characters of sugar beet plant (*Beta vulgaris* L.). Middle East J. Agric. Res. 4(4): 717-734.

Agamy, R., Hashem, M. and Alamri, S. (2013). Effect of soil amendment with yeasts as bio-fertilizers on the growth and productivity of sugar beet. African Journal of Agricultural Research. 8(1): 46-56.

Bhardwaj, D., Ansari, M.W., Sahoo, R.K., Tuteja, N. (2014). Bio-fertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity. Microb. Cell Fact. 13: 1-10.

Botha, A. (2011). The importance and ecology of yeasts in soil. Soil Biol. Biochem. 43:1-8. https://doi.org/10.1016/j.soilbio.2010.10.001.

Connell, L., Redman, R., Craig, S., Scorzetti, G., Iszard, M., Rodriguez, R. (2008). Diversity of soil yeasts isolated from South Victoria Land, Antarctica. Microb Ecol. 56: 448-59. https://doi.org/10.1007/s00248-008-9363-1.

El-Tohamy, A.E. and Al Raoush, A.T. (2015). The impact of applying total quality management principles on the overall hospital effectiveness: An empirical study on the HCAC accredited governmental hospitals in Jordan. European Scientific Journal. 11(10).

Ibrahim, N., Sereno, P.C., Varricchio, D.J., Martill, D.M., Dutheil, D.B., Unwin, D.M. and Kaoukaya, A. (2020). Geology and paleontology of the upper cretaceous Kem Kem group of eastern Morocco. ZooKeys. 928: 1.

Mady, M.A. (2009). Effect of foliar application with yeast extract and zinc on fruit setting and yield of faba bean (*Vicia faba* L). J. Biol. Chem. Environ. Sci. 4(2): 109-127.

Maqsuda Q.M., Mohammed Q.K. and Nihayat H.H. (2020). Effect of foliar application with yeast extract and methanol on morphological and yield characteristics of faba bean (*Vicia faba* L.). Plant Archives. 20(2): 2020 9120-9124.

Mona, D.G., El-Lethy, S.R. and Mervat, Sh. (2013). Role of methanol and yeast in improving growth, yield, nutritive value and antioxidants of Soybean. World Applied Sciences Journal. 26(1): 06-14.

Nassar, M.A., El-Segai, M.U. and Azoz, S.N. (2015). Influence of foliar spray with yeast extract on vegetative growth, yield of fresh herb, anatomical structure, composition of volatile oil and seed yield components of basil plant (*Ocimum basilicum* L.). International Journal. 3(10): 978-993.

Natsheh, B., Abu-Khalaf, N. (2020). Influence of different types of fertilizers application on the lettuce (*Lactuca sativa* L.) growth and quality. Palestine Technical University Kadoorie Research Journal. 8 (2): 40-53.

Shalaby, M.E.S. and El-Nady, M.F. (2008). Application of *Saccharomyces cerevisiae* as a biocontrol agent against *Fusarium* infection of sugar beet plants. Acta Biologica Szegediensis. 52(2): 271-275.

Taha, Z., Sarhan, Smira, T. Ali, Sanaa M.S. Rasheed (2011). Effect of bread yeast application and seaweed extract on (*Cucumis sativus* L.) plant growth, yield and fruit quality. Mesopotamia j. of Agric. (ISSN 1815-316X) Vol: (39) No(2).

Thomsen, M.S., Wernberg, T., South, P.M., and Schiel, D.R. (2016). Non-native Seaweeds Drive Changes in Marine Coastal Communities Around the World. In: Seaweed Phylogeography. Springer, Dordrecht. pp: 147-185.

Tudela, J.A. and Gil, M.I. (2020). Leafy vegetables: Fresh-cut Lettuce. In: Controlled and modified atmospheres for fresh and fresh-cut produce. Academic Press. pp: 545-550.

Vessey, J.K. (2003). Plant growth promoting rhizobacteria as biofertilizers. Plant and Soil. 255(2): 571-586.