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Allelopathic activity of the aqueous extracts of *Cladophora* and *Spirogyra* on the germination and growth of three cultivars of bread wheat *Triticum aestivum* L.

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Abstract---Since algae is one of the natural sources of chemical compounds, including nutrients, fats and vitamins, that stimulate the germination and growth of plants, so the aim of the research was to study the effect of aqueous extracts of *Cladophora* and *Spirogyra* at a concentration of (0, 1, 2) % in the germination and growth of three cultivars of the bread wheat *Triticum aestivum* (Baraka, Buhooth-22 and Sham-6) through the application of the pots experiment. The results showed that the aqueous extract of the algae affected positive the assessed variables increase considerably as the concentration increased, and treatments at concentration (1 and 2%) had an encouraging effect on the germination and growth of plants of both cultivars Buhooth-22 and Baraka, while cultivar Sham-6 was less responsive to the extracts.

Keywords---algae, allelochemicals, cultivars, wheat growth.

Introduction

Allelopathic is a biological phenomenon of the release of secondary metabolites produced by living organisms, including algae, that affect the growth and development of the biological and agricultural system [1]. Secondary metabolites

are known as allelochemicals, which have direct or indirect negative or positive effects when produced from one type of living organism to affect the growth and development of other types of living organisms through the release of their compounds to the environment [2], which affect the growth of plants by different mechanisms, including affecting the activity of some genes responsible for growth characteristics, nutrient absorption and some anatomical characteristics of the plant [3]. Algae is one of the important natural sources of secondary metabolites, in addition to its high content of vitamins, amino acids and carbohydrates[4]and it is considered one of the modern strategies in sustainable agriculture because it is environmentally friendly [5], , and therefore it has been widely used in the agricultural field to increase the productivity of plants, including green algae, from the study of [6]an increase in the percentage of germination and growth of alfalfa plant was observed when it was treated with *Spirogyra sp* extract at a concentration of 1%, as well as an increase in root length, dry weight of the shoot system and leaf area of cowpea and sesame plants with the effect of *Cladophora sp* extract at a concentration of (1,2 and 3%) [7]. A significant increase was also observed in the percentage of germination, seedling length and wet weight of radish due to the effect of *Cladophora glomerata* extracts at (60 and 80%) [8] , since the wheat crop is one of the important strategic crops, as it is ranked first in cultivated area and production, as it is the main food for more than 60 countries in the world [9], so the aim of the research is the possibility of using aqueous extracts of the wet biomass of *Cladophora* and *Spirogyra* in improving some growth indicators of three cultivars of bread wheat (Baraka,Buhooth-22, Sham-6).

Materials and Methods

Algae sample collection

Green algae samples were collected from the Tigris River near the Fifth Bridge in Mosul Woods on 25/11/2020 and then washed with running water for several times to get rid of the dust and dirt stuck in them until they are sure of their cleanliness and then spread them on a layer of paper to get rid of excess water to use them in the experiment.

Algae diagnosis

The genera were diagnosed based on phenotypic diagnosis, as glass slides were prepared from the isolates, then examined under a light microscope, and after imaging the sample, their morphological characteristics were determined, and based on books and taxonomic keys, their genera were determined [10, 11].

Preparation of aqueous extracts

The concentrations (1 and 2) %weight: volume were prepared with the weight of (1 and 2) g of wet biomass for each of the two algae and crushed with 100 ml of distilled water using an electric mixer (Silver crest) for 10 minutes and filtered with a piece of gauze and then with filter papers of the type (Whatman No.1), then the filtrate was kept in the refrigerator at 4°C.

Pots experiment

In the experiment, plastic pots with a capacity of 6 kg, a height of 24 cm and a diameter of 21 cm were used and filled with loamy soil, then 10 seeds of each cultivar of bread wheat (Baraka, Buhouth-22 and Sham-6) were planted with a depth of 0.5 cm from the soil surface on 28/11/2020 and in three replications, 300 ml of prepared extracts were added to the soil, and the control treatment (distilled water).

Studied characteristics

The percentage of seeds germination

It was calculated by applying the equation [12]

$$\text{Germination percentage \%} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds sown}} \times 100$$

The percentages of change from the control were calculated according to the equation of [13].

Percentage of increase over control = $\frac{\text{treatment} - \text{control}}{\text{control}} \times 100$

Percentage of decrease over control = $\frac{\text{control} - \text{treatment}}{\text{control}} \times 100$

The length of the shoot and root system (cm) and their dry weight (g)

After three months from the date of planting, the plants were removed and washed, the shoot system was separated from the root system. Measurements were taken using the standard ruler for each of them, for five plants, and for three replicates in each treatment, and after drying them in the electric oven at a temperature of 70°C for 72 hours, their dry weights were recorded using a sensitive scale.

Total chlorophyll content

It was estimated according to the method [14], and its absorbance was recorded at wavelength 645 and 663 nm using a spectrophotometer, it was estimated according to [15].

$$\text{Total chlorophyll } (\mu\text{g/ml}) = 20.2 (A_{645}) + 8.02 (A_{663})$$

Statistical analysis

The experiment was designed according to the randomized complete block design (R.C.B.D) and the data were analyzed statistically according to the SAS program. The averages of the coefficients were distinguished using Duncan multiple range test at a probability level of 5% [16].

Results

From Table (1), it was observed that there were significant effects in the percentage of germination by the effect of *Spirogyra* and *Cladophora* extracts, and from comparing the average type of extract, the highest percentage of germination was recorded (91.48%) with the effect of *Spirogyra* extract, and from comparing the average concentration, the highest percentage of germination was recorded (92.22%) when at 1% concentration. in the binary interaction showed significant differences between the treatments, from triple interaction showed a significant difference between the treatments, From comparing the percentages of increase from the control, it was found that the highest percentage of increase was (25%) in the cultivar Buhooth-22 with the effect of *Spirogyra* extract at 1%, and the lowest percentage increase from the control was in the cultivar Sham-6, which amounted to (3.85%) by the effect of *Cladophora* extracts at 2%.

Table (1): Effect of aqueous extracts of the biomass of *Cladophora* and *Spirogyra* algae on the percentage of seed germination of three cultivars of bread wheat

Cultivars	Concentration	Type of extract		Concentration ×cultivar	Average cultivar
		<i>Cladophora</i>	<i>Spirogyra</i>		
Baraka	0%	83.33 de	83.33 de	83.33 de	90.00 a
	1%	93.33 ab	90.00 b-d	91.66 ab	
	2%	90.00b-d	100.00 a	95.00 a	
Cultivar ×Type of extract		88.88 ab	91.11 ab		
Buhooth-22	0%	80.00 e	80.00e	80.00 e	87.77 a
	1%	80.00e	100.00 a	90.00 bc	
	2%	90.00b-d	96.66 ab	93.33 ab	
Cultivar ×Type of extract		83.33c	92.22 a		
Sham-6	0%	86.66 c-e	86.66 c-e	86.66 cd	89.44 a
	1%	90.00b-d	100.00a	95.00 a	
	2%	86.66 c-e	86.66 c-e	86.66 cd	
Cultivar ×Type of extract		87.77 b	91.11 ab		
Average type of extract		86.66 b	91.48 a	average concentration	
Concentration×Ty pe of extract	0%	83.33 c	83.33 c	83.33 b	
	1%	87.77 b	96.66 a	92.22 a	
	2%	88.88 b	94.44 a	91.66 a	

The results in Table (2) showed a significant difference in the length of the shoot system as a result of treatment with extracts of the algae *Cladophora* and *Spirogyra*. From the comparison of the average cultivar, the highest length of the shoot system was recorded in the cultivar Buhooth-22 as it reached (39.61) cm, and from the comparison of the average concentration, the highest length was recorded (35.72 cm) at a concentration of 2%, From the binary interaction showed significant differences between the treatments, while in the triple interaction, the highest length of the shoot was 46.13 cm in the cultivar Buhooth-22 at 2%,the

percentages of change from the control, the highest percentage of increase in the length of the shoot system was recorded (36%) in the cultivar Baraka by the effect of *Spirogyra* extract at 2%, and the highest percentage of reduction from the control was in the cultivar Sham-6 which amounted to (17.87%) by the effect of *Spirogyra* extract at 1%.

Table (2): Effect of aqueous extracts of the biomass of *Cladophora* and *Spirogyra* on shoot system length (cm) for three cultivars of bread wheat

Cultivars	Concentration	Type of extract		concentration × cultivar	Average cultivar
		<i>Cladophora</i>	<i>Spirogyra</i>		
Baraka	0%	20.00 f	20.00 f	20.00 e	22.56 b
	1%	20.80 f	24.00 ef	22.40 ed	
	2%	23.40 ef	27.20 e	25.30 d	
Cultivar × Type of extract		21.40 c	23.73c		
Buhooth-22	0%	35.53 cd	35.53 cd	35.53c	39.61 a
	1%	35.80 cd	42.70 b	39.25 bc	
	2%	42.00 ab	46.13 a	44.06 a	
Cultivar × Type of extract		37.77 b	41.45 a		
Sham-6	0%	40.50 a-c	40.50 a-c	40.50 ab	37.98 a
	1%	38.06 b-d	33.26 d	35.66 c	
	2%	39.60 bc	36.00 cd	37.800 bc	
Cultivar × Type of extract		39.38 ab	36.58 b	Average concentration	
Average Type of extract		32.85 a	33.92 a		
Concentration × Type of extract	0%	32.01 bc	32.01 bc	32.01 b	
	1%	31.55 c	33.32 a-c	32.43 b	
	2%	35.60 ab	36.44 a	35.72 a	

In Table (3) the results showed a significant variation in the length of the root system with the effect of algae extracts. From comparing the average of the cultivar, the cultivar Baraka recorded the highest length of the root system, reaching (29.51 cm), and from comparing the average type of the extract, the *Cladophora* extract gave the highest increase in the length of the root system (28.67) cm, From the binary interaction showed significant differences between the treatments. Significant differences appeared between the treatments in the interaction between the cultivar, the type of extract and the concentration, from comparing the percentages of change from the control, the highest significant increase in the length root system (43.07%) was recorded in the Buhooth-22 cultivar from the control, by the effect of *Cladophora* extract at a concentration of 2%, while the lowest percentage of increase in the length root system was (1.41%) was in Sham-6 cultivar by the effect of *Spirogyra* extract at a concentration of 1%

Table (3): Effect of aqueous extracts of the biomass of *Cladophora* and *Spirogyra* algae on root system length (cm) of three cultivars of bread wheat

Cultivars	concentration	Type of extract		concentration × cultivar	Average cultivar
		<i>Cladophora</i>	<i>Spirogyra</i>		
Baraka	0%	28.66 c-e	28.66 c-e	28.66 c	29.51 a
	1%	27.40 e-g	30.00 b-d	28.70 c	
	2%	31.80 b	30.56 bc	31.18 b	
Cultivar × Type of extract		29.28 ab	29.74 ab		
Buhooth-22	0%	25.86 g	25.80 g	25.80 d	29.42 a
	1%	27.76 fg	28.40 c-f	28.08 c	
	2%	37.00 a	31.80 b	34.40 a	
Cultivar × Type of extract		30.18 a	28.66 b		
Sham-6	0%	23.40 h	23.40 h	23.40 e	25.49 b
	1%	28.03 d-f	23.73 h	25.88 d	
	2%	28.20 d-f	26.20 fg	27.20 cd	
Cultivar × Type of extract		26.54 c	24.44 d		
Average type of extract		28.67 a	27.61 b	Average concentration	
Concentration × Type of extract	0%	25.95 d	25.95 d	25.95 c	
	1%	27.73 c	27.33 c	27.55 b	
	2%	32.33 a	29.52 b	30.92 a	

In Table (4) significant differences were observed between the treatments, from comparing the average of the cultivar Baraka gave the highest dry weight of the shoot system amounted to (0.55) g, and from comparing the average type of algal extract, the highest dry weight of the shoot system (0.45 g) was recorded by the effect of *Cladophora* extract and from the comparison of the average concentration, the highest dry weight of the shoot (0.56) g was recorded at 2%. From the binary interaction showed significant differences between the treatments, and the triple interaction showed a significant variation in the dry weight of the shoot system, as the highest dry weight of the shoot system reached (1.24) g in the cultivar Baraka at 2% of *Cladophora* extract, and the percentage increase from the control was (254.28%), while Sham-6 cultivar recorded the lowest dry weight of the shoot system (0.24 g) by the effect of *Spirogyra* extract at a concentration of 1%, while the percentage of reduction from the control was (27.27%).

Table (4): Effect of aqueous extracts of the biomass of *Cladophora* and *Spirogyra* algae on the dry weight of shoots (g) of three cultivars of bread wheat

Cultivars	Concentration	Type of extract		concentration × cultivar	Average cultivar
		<i>Cladophora</i>	<i>Spirogyra</i>		
Baraka	0%	0.35 ef	0.35 ef	0.35 cd	0.55 a
	1%	0.34 ef	0.34 ef	0.34 cd	
	2%	1.24 a	0.71b	0.98 a	
Cultivar × Type of extract		0.64 a	0.47 b		
Buhooth-22	0%	0.27 ef	0.27 ef	0.27 d	0.39 b
	1%	0.32 ef	0.67 bc	0.49 b	

	2%	0.53 cd	0.32 ef	0.42 b	
Cultivar × Type of extract		0.37 cd	0.42 bc		
Sham-6	0%	0.33 ef	0.33 ef	0.33 cd	0.32 c
	1%	0.43 ed	0.24 f	0.33 cd	
	2%	0.30 ef	0.30 ef	0.30 d	
Cultivar × Type of extract		0.35 cd	0.29 d	Average concentration	
Average type of extract		0.45 a	0.39 b		
Concentration ×Type of extract	0%	0.31 c	0.31 c	0.31 c	
	1%	0.36 bc	0.42 b	0.39 b	
	2%	0.69 a	0.44 b	0.56 a	

Table (5) showed significant differences in the effect of green algae extracts on the dry weight of the root system compared to the control treatment. From comparing the mean of the cultivar, the Baraka cultivar recorded the highest dry weight of the root group, which amounted to (0.36) g, and from comparing the average type of the algal extract, the *Cladophora* extract recorded the highest dry weight of the root system was (0.28)g, and from the comparison of the average concentration, the highest dry weight of the rootstock was recorded (0.38)g at the concentration 2%, and in the binary interaction showed significant differences between the treatments. The triple interaction showed a significant variation in the dry weight of the root system, from the comparison of the percentages of change from the control, the highest percentage increase was (330.76%) in the cultivar Sham-6 with the effect of 1% concentration of *Cladophora* extract, and the highest percentage of reduction amounted to (30.76%) in the same cultivar by the effect of the concentration 2% of *Spirogyra* extract.

Table (5): Effect of aqueous extracts of the biomass of *Cladophora* and *Spirogyra* algae on the dry weight of the root system (g) of three cultivars of bread wheat

cultivars	concentration	Type of extract		concentration × cultivar	Average cultivar
		<i>Cladophora</i>	<i>Spirogyra</i>		
Baraka	0%	0.29 cd	0.29 cd	0.29 bc	0.36 a
	1%	0.19 c-e	0.35 bc	0.27 bc	
	2%	0.61 a	0.48 ab	0.54 a	
Cultivar × Type of extract		0.36 a	0.37 a		
Buhooth-22	0%	0.11 e	0.11 e	0.11 d	0.18 b
	1%	0.12 de	0.22 c-e	0.17 cd	
	2%	0.29 cd	0.23 c-e	0.26 bc	
Cultivar × Type of extract		0.17 b	0.19 b		
Sham-6	0%	0.13 de	0.13 de	0.13 d	0.21 b
	1%	0.22 c-e	0.15 de	0.19 cd	
	2%	0.56 a	0.09 e	0.33 b	
Cultivar × Type of extract		0.30 a	0.12 b	Average concentration	
Average type of extract		0.28 a	0.23 b		
Concentration ×Type of extract	0%	0.17 c	0.17 c	0.17 b	
	1%	0.18 c	0.24 bc	0.21 b	
	2%	0.49 a	0.27 b	0.38 a	

The results in Table (6) showed a variance in the total chlorophyll content of bread wheat cultivars by the effect of the extracts of both *Cladophora* and *Spirogyra*, from the comparison of the average cultivar, the cultivar Baraka recorded the highest total chlorophyll content (28.68 $\mu\text{g/ml}$), while the comparison of average type of extract, the *Spirogyra* extract was superior to the *Cladophora* extract, and by comparing the average concentration, the concentration of 2% recorded the highest content of total chlorophyll as it reached (29.71 $\mu\text{g/ml}$), in the binary interaction showed significant differences between the treatments, The triple interaction between extracts, cultivars and concentration showed different effects, as the highest content of chlorophyll was (38.38 $\mu\text{g/ml}$) in the cultivar Buhooth-22 at 1% of *Spirogyra* extract, and the increase from the control amounted to (175.32)%, while the same cultivar recorded in the control treatment the lowest content of chlorophyll (13.49 $\mu\text{g/ml}$), and from the comparison of the percentages of reduction compared to the control, the cultivar Sham-6 recorded the highest percentage of reduction, which amounted to (35%) by the effect of *Spirogyra* extract at 1%.

Table (6): Effect of aqueous extracts of the biomass of *Cladophora* and *Spirogyra* algae on the total chlorophyll content ($\mu\text{g/ml}$) for three cultivars of wheat

Cultivars	concentration	Type of extract		concentration \times cultivar	Average cultivar
		<i>Cladophora</i>	<i>Spirogyra</i>		
Baraka	0%	28.2 I	28.21 i	28.21 f	28.68 a
	1%	30.54 a	28.40 h	29.47 d	
	2%	27.34 j	29.42 g	28.38 e	
Cultivar \times Type of extract		28.69 b	23.44 f		
Buhooth-22	0%	13.94 o	13.94 o	13.94 i	24.01c
	1%	26.66 k	38.38 a	32.52 b	
	2%	29.72 f	21.46 m	25.59 g	
Cultivar \times Type of extract		28.55 d	28.67 c		
Sham-6	0%	30.02 e	30.02 e	30.02 c	28.66 b
	1%	22.15 l	19.46 n	20.80 h	
	2%	33.49 c	36.84 b	35.16 a	
Cultivar \times Type of extract		24.59 e	28.77 a		
Average type of extract		26.89 b	27.37a	Average concentration	
Concentration \times Type of extract	0%	24.05 e	24.05 e	24.05 c	
	1%	26.45 d	28.74 c	27.59 b	
	2%	30.18 a	29.24 b	29.71 a	

Discussion

The reason of the variance may be due to the variation in the type, nature and concentration of allelochemical compounds in algae extracts, which when released into the soil undergo biochemical transformations due to microorganisms, as well as their variation in their impact as its effect is increasing at low concentrations and may be decreasing at high concentrations [17], The increase in length of the shoot and root system was accompanied by the increase in the of the shoot and root system, which due to increase in the

absorption of nutrients found in the algae extract, including iron, as it activates the oxidation and reduction enzymes in the electron transport chain in the process of respiration and helps it in building chlorophyll and storing iron in Chloroplast in the form of Phytoferritin, which leads to increased vegetative growth. In addition to the algae extracts containing zinc, which contributes in the produce of the amino acid Tryptophane, which has an important role in the transfer of electrons and the transfer of sugars, which encourages the process of photosynthesis and thus increases vegetative growth [18], in addition to the algae content of vitamins, minerals and fats that stimulate germination and plant growth [19], search agree results with [20] that aqueous extracts of *Cladophora crispata* stimulated the germination of Sunflower seeds, and this is consistent with what [21] mentioned, that *Cladophora glomerata* gave a significant increase in the height of the soybean plant, [22] observed that the germination rate of maize seeds increased as a result of treatment with polysaccharides extracted from green algae *Ulva* sp.

Conclusion

The results showed that the biomass extracts of *Cladophora* and *Spirogyra* had a stimulating effect on the germination and some growth characteristics of three cultivars of bread wheat, and that the cultivar Buhoth-22 was the most responsive cultivar to algae extracts and the concentration of 2% gave the highest significant increase in most of the studied traits, and algae extracts could be used in the agricultural system as one of the modern strategies to improve the growth of crops.

References

1. Al-Atrakche, Faten Khalil Ibraheem Mahmood.(2022) Physiological, Anatomical and Chemical Growth indicators of some Cultivars of yellow maize *Zea mays L* under the influence of Allelopathic stress of some bushes. PhD thesis, College of Science, Biology, University of Mosul, Iraq. 171.
2. Al-Hafiz, Fadia Abdul-Sattar Abdul-Jabbar Abbas. (2020). Response of bread wheat cultivars to the Allelopathic activity of three remaining species of the Cucurbitaceae family. PhD thesis, College of Science, Biology, University of Mosul, Iraq. 147.
3. Alkhafaji, B. Y., Malih, H. R., &Elkheralla, R. J. (2019, September). Effect of fertilization by *Cladophora* algae on morphological characteristics of *Vigna radiate* & *Sesamum indicum* plants. In *Journal of Physics: Conference Series* (Vol. 1294, No. 7, p. 072024). IOP Publishing.
4. Al-Myali, A. A. H. (2021). Effect of algae and Bio-fertilizers on some growth characteristics and yield of wheat *Triticum aestivum L*. *Journal of Kerbala for Agricultural Sciences*, 8(2), 36-47.
5. Al-Sahhaf, Fadel Hussein (1989) Applied Plant Nutrition, House of Wisdom, University of Baghdad, Ministry of Higher Education and Scientific Research, Iraq.
6. Anaya, A. L. (1999). Allelopathy as a tool in the management of biotic resources in agroecosystems. *Critical reviews in plant sciences*, 18(6), 697-739.

7. Arnon, D.I. (1949). Copper enzyme in isolated chloroplast polyphenol oxidase in *Beta vulgaris*. *Plant physiol.*, 24:1-15.
8. Brahmabhatt, N. H., and Kalasariya, H. S. (2015). Effect of algae on seedling growth of “Queen of Forages”. *International Journal of Engineering Research and General Science*, 3(2), 827-833.
9. Chung, I. M., Ahn, J. K., & Yun, S. J. (2001). Assessment of allelopathic potential of coastal Bermuda grass. *Agron. J*, 80, 557-560.
10. Dziergowska, K., Wełna, M., Szymczycha-Madeja, A., Chęcmanowski, J. and Michalak, I. (2021). Valorization of *Cladophora glomerata* biomass and obtained bioproducts into biostimulants of plant growth and as sorbents (biosorbents) of metal ions. *Molecules*, 26(22), 6917.
11. Hamouda, R. A., Hussein, M. H., El-Naggar, N. E. A., Karim-Eldeen, M. A., Alamer, K. H., Saleh, M. A., Al Masoudi, L.M.; Sharaf, E.M. and El-Azeem, R. M. A. (2022). Promoting Effect of Soluble Polysaccharides Extracted from *Ulva* spp. on *Zea mays* L. Growth. *Molecules*, 27(4): 1394.
12. Hassan, S. M., Ashour, M., Sakai, N., Zhang, L., Hassanien, H. A., Gaber, A., and Ammar, G. (2021). Impact of seaweed liquid extract biostimulant on growth, yield, and chemical composition of cucumber (*Cucumis sativus*). *Agriculture*, 11(4): 320.
13. ISTA.(1976).International rules for seed testing .*Seed Sci. and Technol.*4:3-49.
14. Karthik, T., Sarkar, G., Babu, S., Amalraj, L. D., & Jayasri, M. A. (2020). Preparation and evaluation of liquid fertilizer from *Turbinaria ornata* and *Ulva reticulata*. *Biocatalysis and Agricultural Biotechnology*, 28, 101712.
15. Lewandowska, S., Marczewski, K., Kozak, M., Ohkama-Ohtsu, N., Łabowska, M., Detyna, J. and Michalak, I. (2022). Impact of Freshwater Macroalga (*Cladophora glomerata*) Extract on the Yield and Morphological Responses of *Glycine max* (L.) Merr. *Agriculture*, 12(5), 685.
16. Michalak, I. and Chojnacka, K. (2015). Algae as production systems of bioactive compounds. *Engineering in Life Sciences*;15(2):160-76.
17. Milind, J and Mahadik, B (2020) Use of extract of green alga *Cladophora crispata* (Roth) Kuetzing in seed germination of sunflower. *Purakala* ,31(63): 121-125.
18. Prescott, G. W. (1962). *Algae of the western Great Lakes area*.
19. Rice, E.L. (1984). *Allelopathy* .2nd Edition , Academic Press , New York, 422 PP.
20. Sahoo, D., and Seckbach, J. (Eds.). (2015). *The algae world*. Dordrecht: Springer Netherlands.
21. Steel, R.G.D. and Torrie, J.H. (1980). *Principles and procedures of statistics*. 2nd Ed., McGraw – Hill Company, Inc.
22. Yadav S. G.(2019.)The Promoting Effect of the Extract of Blue Green Alga *Nostoc muscorum* (Agardh ex Born. et Flah. 1888) in Seed Germination of Groundnut (*Arachis hypogea* L.). *International Journal of Science and Research*,9(11):1185:1187.