International® Baccalaureate

Extended essay cover

Candidates must complete this page and then give this cover and their final version of the extended essay to their supervisor.

Candidate session number			
Candidate name			
School number			
School name			
Examination session (May or November)	May	Year	2012

Diploma Programme subject in which this extended essay is registered: Biology

(For an extended essay in the area of languages, state the language and whether it is group 1 or group 2.)

Title of the extended essay: A study on the effect of Indole acetic acid, a growth hormone, on the growth of crop plants, rice (*Oryza sativa L*) and wheat (*Triticum species*)

Candidate's declaration

This declaration must be signed by the candidate; otherwise a grade may not be issued.

The extended essay I am submitting is my own work (apart from guidance allowed by the International Baccalaureate).

I have acknowledged each use of the words, graphics or ideas of another person, whether written, oral or visual.

I am aware that the word limit for all extended essays is 4000 words and that examiners are not required to read beyond this limit.

This is the final version of my extended essay.

Candidate's signature: [redacted] Date: 17.2.2012

Supervisor's report and declaration

The supervisor must complete this report, sign the declaration and then give the final version of the extended essay, with this cover attached, to the Diploma Programme coordinator.

Name of supervisor (CAPITAL letters) _____

Please comment, as appropriate, on the candidate's performance, the context in which the candidate undertook the research for the extended essay, any difficulties encountered and how these were overcome (see page 13 of the extended essay guide). The concluding interview (viva voce) may provide useful information. These comments can help the examiner award a level for criterion K (holistic judgment). Do not comment on any adverse personal circumstances that may have affected the candidate. If the amount of time spent with the candidate was zero, you must explain this, in particular how it was then possible to authenticate the essay as the candidate's own work. You may attach an additional sheet if there is insufficient space here.

I became the DP Biology teacher at the
at the beginning of the school year
2011-2012. was a new student at
at the onset of the same school year.
Thus I was not her initial supervisor for this Extended
Essay project. arrived with her data collection from
her plant populations and a partial draft of an essay. In
meetings with her, impressed me as a very diligent
and thoughtful student of high integrity. From our
discussions about her challenges in collecting copious
amounts of data, her thoughts about the trends in the
data and the Essay overall, I have full confidence in the
authenticity of work.

This declaration must be signed by the supervisor; otherwise a grade may not be issued.

I have read the final version of the extended essay that will be submitted to the examiner.

To the best of my knowledge, the extended essay is the authentic work of the candidate.

I spent 3 hours with the candidate discussing the progress of the extended essay.

Supervisor's signature _____ Date: 17 2 2012

Assessment form (for examiner use only)

Candidate session number	

Criteria	Achievement level				
	Examiner 1	maximum	Examiner 2	maximum	Examiner 3
A research question	1	2	2	2	
B introduction	2	2	2	2	
C investigation	4	4	4	4	
D knowledge and understanding	3	4	3	4	
E reasoned argument	4	4	4	4	
F analysis and evaluation	4	4	3	4	
G use of subject language	3	4	3	4	
H conclusion	1	2	1	2	
I formal presentation	4	4	4	4	
J abstract	2	2	2	2	
K holistic judgment	4	4	4	4	
Total out of 36	32		32		

e of examiner 1: _____ Examiner number: _____
PITAL letters)

e of examiner 2: _____ Examiner number: _____
PITAL letters)

e of examiner 3: _____ Examiner number: _____
PITAL letters)

IB Cardiff use only: **B:** ✓

IB Cardiff use only: **A:** 184837 **Date:** 6/05

May 2012

			Effect of Indole Acetic acid, a growth hormone, on growth of rice (Orgza sativa) and wheat (Tritium spp)
A question	2	1	RQ is clearly stated within the introduction on page 6, but is too broad in scope for effective treatment in 40 hrs and 4000 words: (too many variables).
B introduction	2	2	RQ is formally stated and sources are cited (obj 5) to set it into context and make the significance clear.
C investigation	4	4	Well-planned investigation; relevant data gathered and careful selection of materials. Not sure best medium was selected for rice growth.
D knowledge (academic context)	4	3	Academic context is highly in place and good understanding is apparent - largely due to broadness of the RQ not enough info on the proposed mechanism or perhaps dose-related effects of hormones was present, as well as on the particular organism.
E argument	4	4	A well constructed argument that "flows" throughout the essay very well and uses both existing research and the experiment to support the claims made.
F analysis and evaluation	4	4	The strengths of evaluating the results and the data, which was very well executed, outweigh the weaknesses in evaluating the experimental methodology ... I ended up opting for the 4 and the 3.
G language	4	3	Reliance on quotes over paraphrasing of sources. A few minor errors in grammar and sentence structure. Consistent with the discipline, for the most part clear and precise.
H conclusion	2	1	Not entirely consistent with the data as the error bars shown in fig 7 but not in figure 6 would suggest that there really is not much effect on height here...
Total	26	22	
I presentation	4	4	Location of elements - Acknowledgments should follow the abstract. Some Citations appear to be secondary. Font size, line spacing, margins very good. Effective use of tables and figures. Well-presented, Polished product
J abstract	2	2	Within word limit. All required elements clearly present, method includes scope.
K holistic	4	4	Considerable evidence of such qualities as required are shown in this essay.
Total	10	10	
Overall total	36	32	

Additional comments:

had the candidate focused the RQ more - a single crop plant - this would have helped, I think, to focus the analysis and not end up with so much "corpus data". This would allow a little more "word space" for discussion about the organism's response to IAA and proposed mechanism of action. The candidate has a sharp "sense" for analysis, so including this would round out the essay nicely. A very nice essay!

A study on the effect of Indole acetic acid, a growth hormone, on the growth of crop plants, rice *(Oryza sativa L.)* and wheat *(Triticum species)*

Class of 2012

Word Count: 3355

location – should follow abstract, TOC.

Acknowledgements:

I would like to thank and for their support, as well as my parents, brother and

Abstract

A higher food demand, caused by the increased population, sets demands on the food production. However the lower-than-expected yields caused by climate changes have increased food prices. Research has been conducted to enable larger yields of food in order to feed the ever-growing population. Plant hormones have been used in agriculture and in horticulture for a longer time and research is being done in order to enlarge the field of plant hormones. This investigation is an attempt to do some further research in this area, by looking at **'How will different concentrations of Indole actetic acid affect the growth of crop plants, rice (*Oryza sativa L.)* and Wheat (*Triticum species*)".**

Rice *(Oryza sativa)* and Wheat *(Triticum species)* were grown and treated with different concentrations of Indole actic acid (IAA). 100 seeds of both species were first soak and then planted into pots (5 plants per pot) containing compost. The 20 pots were then divided into four groups (1ppm, 10^{-2} ppm, 10^{-4} ppm and control group). The four groups indicated the concentration of IAA the plants were receiving. The control group received no treatment of IAA. The plants were sprayed with IAA every other week. The height, number of leaves and the flowering rate of the plants was then measured for 8 weeks. After 8 weeks the fresh and dry weight of the plants was taken.

The results of the present investigation indicated that a higher concentration of IAA increased the flowering rate and yield of wheat. For rice a higher concentration of IAA decreased the growth and a relatively low concentration of IAA stimulated rice growth.

RQ

grammar

Method includes scope

conclusion

If this investigation was to be conducted again more suitable plants for tropic climate has to be chosen or the rice and wheat would need to be grown in more appropriate settings.

Word count: 299 ✓

— All 3 required elements present, bit weak on relating conclusion to RQ directly due to phrasing.

Table of Contents

- TOC Correct, Clear and located appropriately.

Chapter 1

Introduction

United Nations has reported that our world is facing dangerously low food production and high prices, which can lead to a feared food crisis. There is a rising demand for food and because of the lower-than- expected yields, stocks of some grains have fallen sharply and hence increased the food prices, almost to that level seen in 2007- 2008, when a food crisis struck the world (Rudolf, 2010). An estimated cause for the low production in the wheat-producing countries is due to changes in the climate, like the Russian heat wave and the floods in Pakistan. Rice and wheat being the "two most important agricultural commodities for global food security" (Blas, 2011), and changes in production and hence in the price will have a big impact on the global food security. The price of rice is relatively stable compared to wheat. It is also feared that the prices will keep on rising due to climate changes, causing low harvest (Blas, 2011) and an estimated production of wheat would have to increase by 3.5 percent, in order to avoid further increase in price. (Rudolf, 2010)

"Plant hormones have long been used in horticulture application for plant propagation and fruiting control, as well as in agriculture for weed and fungus control. Researchers are now looking at plant hormones to provide the next advances in improved crop growth and yield" (Hager, 2008). If improved crop growth and yield would succeed then the food crisis would slow down, and it would prevent it from occurring again, at least in a significant manner. Therefore this investigation will look at **'How will different concentrations of Indole actetic acid affect the growth of crop plants, rice (*Oryza sativa L.*) and Wheat (*Triticum species*)? ".**

RQ broad in scope

Plant hormones are naturally produced in plants to regulate growth and adaptation to changes in the environment. There are different types of plant hormones such as auxins, abscisic acids, cytokinins and gibberellins, and they take part in various functions of the plant.

Table 1 showing the functions of various plant hormones

Plant Hormone	Example	Functions
Auxin	Indole acetic acid (IAA)	• Cell division • In seedless fruits: regulate the development of the fruit. • Delaying fruit drop • Promote root growth • Control weed. (Schmitz, 2001)
Abscisic acid	Referred to as ABA	• Stimulates the stomata to close • Gives rise to seeds to synthesis storage protein and gene transcription • Restrain the shoot growth (Plant-hormones.info, 2011)
Cytokinin	Zeatin	• Stimulate cell division, leaf enlargement, and growth of lateral buds. • In some species: may support the opening of stomata. (Plant-hormones.info, 2011)
Gibberellins	GA_3	• Stimulates stem elongation, flowering in long day plants and enzymes production • Can cause seedless fruits to develop and delay the deterioration of leaves in citrus fruits. (Plant-hormones.info, 2011)

Research has currently been done mostly on crop plants such as wheat, corn and soybeans as in various types of hormones. Furthermore there could be conflicts within people wanting to eat modified plants. However the advantages of using hormones that already exist in the plant is that no new foreign genes need to be introduced into the plant, but only manipulation of the already existing ones (Hager, 2008).

Studies have been conducted in order to gain more information about the different plant hormones. Pavlista (2008) used gibberellins in order to see if the early growth of winter wheat could be improved with the help of plant hormones. He applied small amounts of gibberellins, GA_3, to wheat seeds, and found that the treated seeds grew taller and faster. Since the earlier 1900th century plant physiologist have found that auxins , IAA, could be used to modify flowering and growth in crop plants. "Thimann and Lane (1938) obtained better vegetative growth accompanied by slight hastening of flowering with IAA on oat and wheat". In 1949 Thimann and Leopod found that "both flowering and growth being promoted by relatively low concentrations and inhibited by higher concentrations of auxins". Huseey and Greogyr (1954) observed the effect of auxin, NAA, and found an increased number on flower primordial in Winter barley but found no effect on Petkus rye. In 1955 Bhardwaj and Rao used IAA and NAA on wheat and observed a higher vegetative growth and grain yield with IAA and lower with NAA. Only a small number of studies have been done on the effect of plant hormones in rice.(Mitra & Gupta, 1945) However the Agronomy department at Yangzhou in China demonstrated that negative phototropism of rice roots were results of an unequal lateral distribution of IAA in root tips (Yi-wei et al., 2004). Based on these earlier done studies it can be believed that the effect of IAA on crop plants wheat and rice can be tested, using different concentrations of IAA. Therefore a hypothesis can be proposed based on the earlier findings by other scientist as discussed, that a higher vegetative growth and grain yield would be produced by lower concentration of auxins. With the help of this experiment, and its findings it could in a small way provide some useful information that then could be used for future research in enhancing growth of crop plants.

Chapter 2

Materials and Methods

Materials used:

1) Rice *(Oryza sativa L.)*- the seeds were obtained from India and supplied by the supervisor.
2) Wheat (*Triticum species*)- the seeds were obtained from India and supplied by the supervisor.
3) The hormone Indole acetic acid was bought from Sigma-Aldrich, Singapore. It was used in three different concentrations 1 ppm, 10^{-2} ppm and 10^{-4} ppm (parts per million).
4) Compost soil and flowerpots (12 dm^3) were brought from a florist in Singapore.
5) Other materials used, were those that are found in a normal biology lab.

Method:

1) Bags of compost were purchased from the nursery and measured amounts (8 dm^3) were placed in pots.

2) Seeds of Rice and wheat were soaked in water before planting, and kept indoors in classroom conditions.

Figure 1. Seeds of rice at an early stage of soaking.

Figure 2. Seedlings of wheat ready to be planted.

3) After 1-1 ½ weeks a total number of 100 seeds, respectively, were planted in the pots containing compost. 100 seedlings of rice were placed in 20 pots, five plants in each pot, and a similar number of wheat seeds were placed in an additional 20 pots. The pots were kept outdoors, at a balcony, in order for the plants to receive natural sunlight and rain. Hence the plants were also exposed to tropical winds.

4) The 40 pots of both rice and wheat, were then divided into four groups, each containing 5 pots. Each group of pots was then labeled with the concentration of IAA that the seedlings were sprayed with. One group of pots made up the control group.

Figure 3. A labeled wheat pot

Figure 4. Growth of wheat after a few days, and rice at an early stage

Is this the best medium for rice?

5) When the seedlings were two or three leaves then the seedlings were sprayed with the concentration of IAA.

6) The plants received IAA treatment every two weeks, during the 8 weeks that the plants were grown.

7) Measurements of the height, using a ruler (± 0.01cm) of the plants and the number of leaves was taken once a week.

8) At the end of 8 weeks the wheat stem were separated from the wheat head. The plants were uprooted, the soil washed away from the roots and then the fresh weight was taken, using a electrical balance (±0.01g). The rice plants were also treated in a similar manner. The plants were appropriately labeled, wrapped in aluminum foil and put in the oven at 50°C (±0.2°C) for a week or until a constant weight was reached. The dry weights of the plants were taken.

Figure 5.
The wheat being packed inside the aluminum foil, in order to be put in the oven.

The average measurement for each treatment is provided in the next chapter and the raw data is provided in the appendix A.

Chapter 3

Results

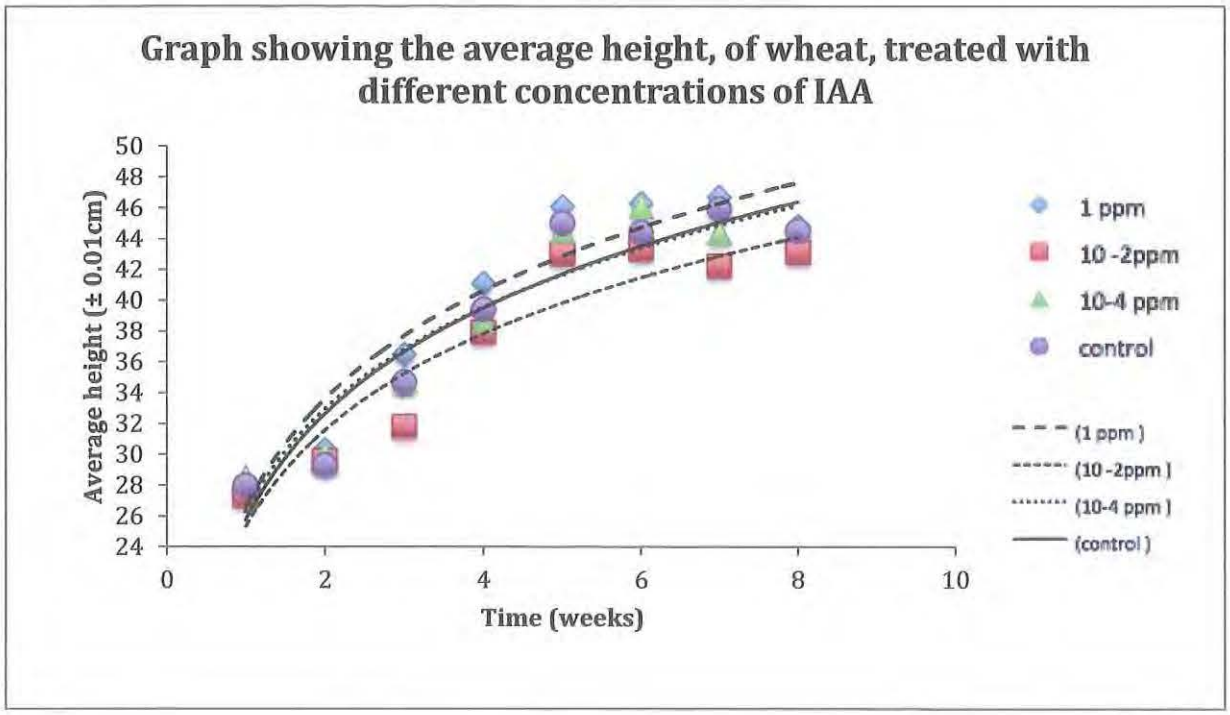
The results of the investigation are given below.

HEIGT OF WHEAT AFTER TREATMENT WITH IAA

Table 2 showing average height, in wheat, treated with different concentrations of IAA

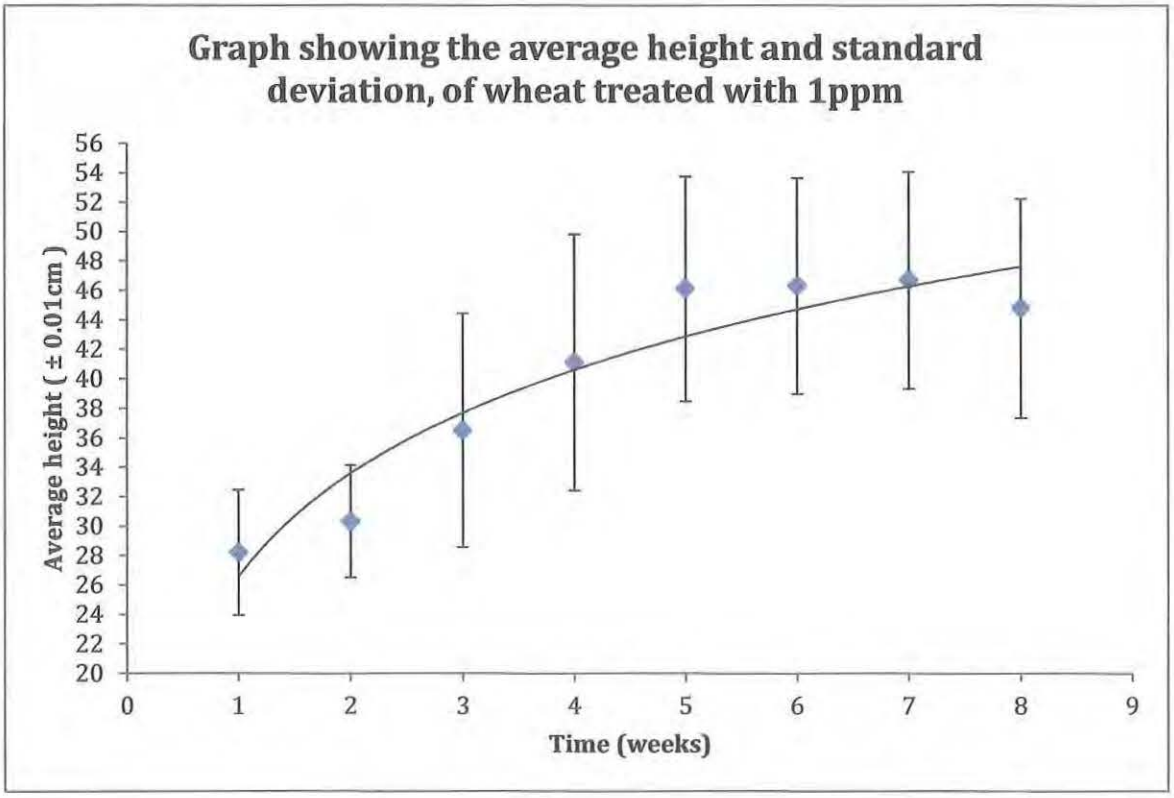
Average height of wheat plants, per week (±0.01cm), and standard deviation	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1 ppm	28.2 ±4.26	30.3 ±3.82	36.5 ±7.94	41.1 ±8.70	46.1 ± 7.26	46.3 ± 7.32	46.7 ± 7.35	44.8 ± 7.42
10^{-2} ppm	27.3 ±5.85	29.6 ±4.96	31.8 ±6.20	37.9 ±6.64	43.0 ±9.20	43.3 ±8.72	42.2 ±10.89	43.1 ±8.55
10^{-4} ppm	28.5 ±4.96	30.0 ±6.30	34.8 ±4.16	38.7 ±8.73	44.5 ±8.13	46.1 ±7.44	44.4 ±8.97	44.7 ±8.72
Control	28.0 ±5.73	29.3 ± 6.68	34.7 ± 5.82	39.4 ±7.92	45.0 ± 7.44	44.4 ±7.34	45.9 ± 6.88	44.5 ±7.07

Figure 6.



From the above graph, it is possible to see the growth rate of wheat. A general growth curve can be identified for all the wheat regardless of treatment. There is a constant growth, between weeks 1-8.

Figure 7.



The results indicate that IAA did not have any significant effect on the height of plants. Wheat treated with 1ppm of IAA grew the tallest up to week 5 with and average of 57.6 cm but this growth could not be maintained due to heavy tropical rains flooding the pots and seriously affecting the growth of seedlings of all treatments. By the time of harvest of the wheat in the 8th week, the height of plants ranged from 43.1 cm to 44.8 cm for all treatments indicating that IAA did not have any significant effect on the height of wheat. Above graphs (Figure 7) supports this claims.

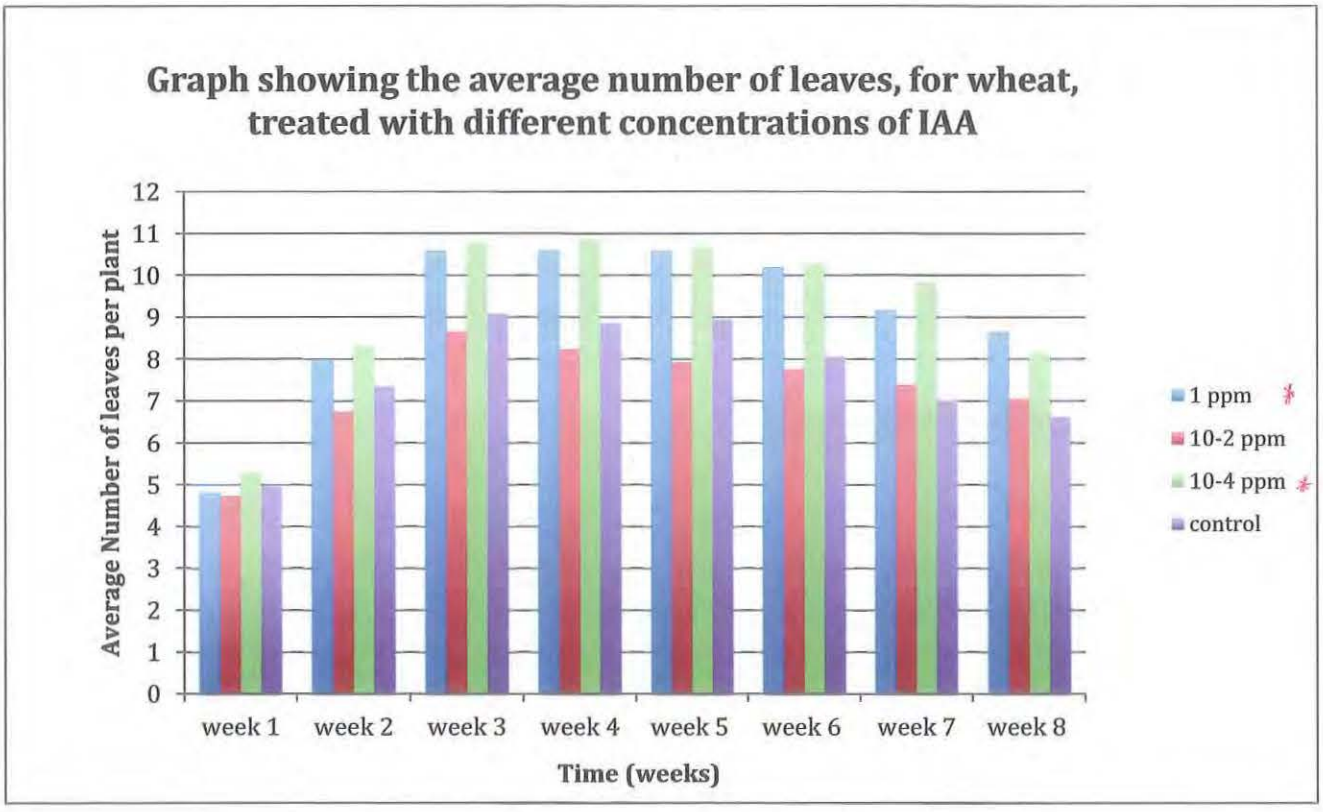
tables well-presented

NUMBER OF LEAVES

Table 3 showing the average number of leaves, for wheat, treated with different concentrations of IAA

Average number of leaves, for wheat plants, per week (±0.01cm), and standard deviation	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1 ppm	4.83 ±1.10	8.0 ±2.86	10.6 ±3.91	10.61 ±4.32	10.6 ± 4.35	10.2 ± 4.04	9.18 ± 4.20	8.66 ± 3.90
10^{-2} ppm	4.74 ±1.04	6.76 ±2.31	8.67 ±2.48	8.24 ±1.79	7.94 ±2.80	7.77 ±2.92	7.40 ±2.40	7.06 ±2.41
10^{-4} ppm	5.32 ±1.47	8.34 ±2.74	10.8 ±3.96	10.87 ±4.51	10.7 ±4.55	10.3 ±5.15	9.87 ±5.96	8.16 ±5.46
Control	4.97 ±1.20	7.37 ±2.31	9.1 ± 2.25	8.87 ±2.20	8.6 ± 2.81	8.07 ±2.54	7.03 ±2.01	6.63 ±1.63

Figure 8.



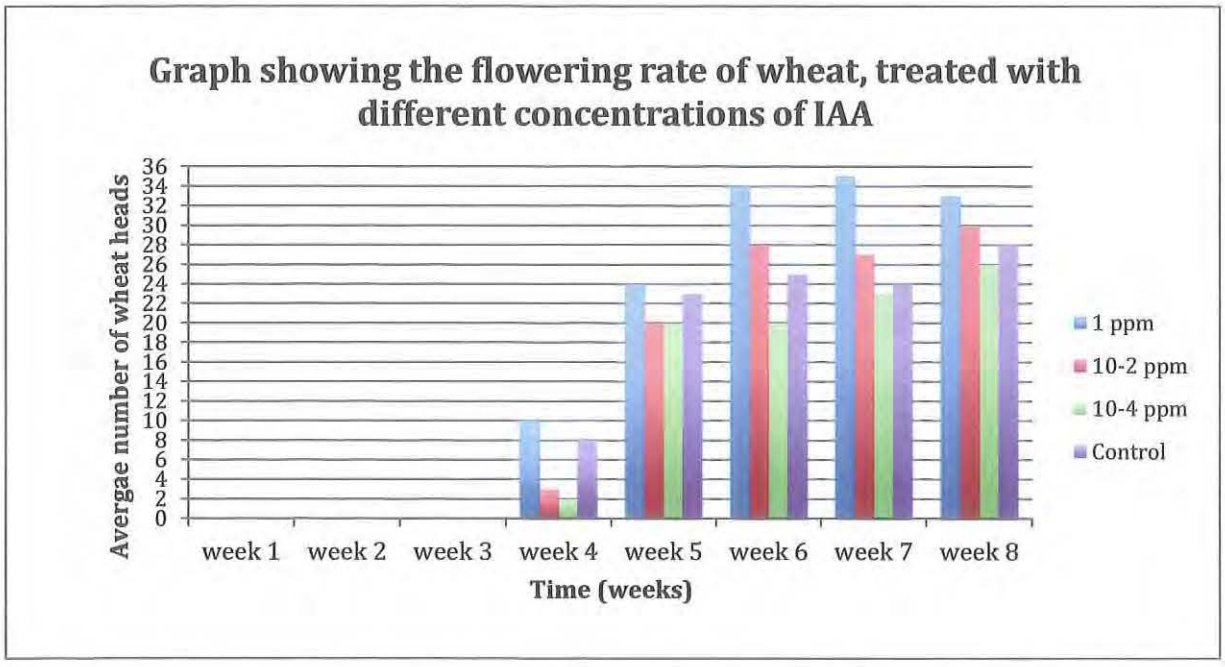
Hormone treatment did not significantly affect the number of leaves produced by wheat seedlings. For the first 3 weeks, seedling in all treatments produced about 7-10 leaves and at the time of harvest, the number of leaves still remained almost the same, once again indicating that IAA does not have any effect on the number of leaves produced by wheat plants.

FLOWERING

Table 4 showing the total number of wheat heads, for wheat treated with different concentrations of IAA.

Total number of wheat heads, per week	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1 ppm	0	0	0	10	24	34	35	33
10^{-2} ppm	0	0	0	3	20	28	27	30
10^{-4} ppm	0	0	0	2	20	20	23	26
Control	0	0	0	8	23	25	24	28

Figure 9.



The flowering of the wheat was monitored closely and there were signs that the different concentrations of IAA, slightly affected flowering. Table 4 shows that wheat treated with 1ppm of IAA flowered earliest with 10 flowering heads while plants treated with more dilute solutions had only 2 or 3 flowering heads produced. Surprisingly the control group plants had 8 flowering heads. At the time of harvest the flowering heads ranged from 33 heads in plants treated with 1 ppm to 26 heads in

those treated with 10^{-4} ppm. It is possible that heavy rain and heavy winds during the growth period affected the final outcome of the treatment. Higher concentrations of hormone if used could possibly increase flowering in wheat as 1 ppm generally had more flowering heads than other treatments. But further research should be conducted for more accurate readings.

The number of seedling initially planned varied for the different groups of concentrations. Therefore it is important to identify the number wheat stems that initially flowered.

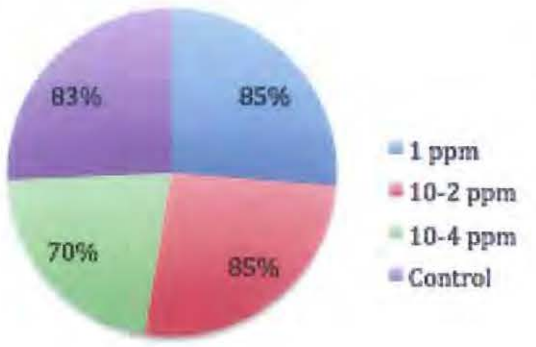
Table 5 showing the percentage of wheat heads compared to the number of stems.

	1ppm	10^{-2} ppm	10^{-4} ppm	Control
Total number of wheat stems	41	35	34	30
Total number of wheat heads	35	30	24	25
Percentage of wheat stems that flowered	85%	85%	70%	83%

Graph showing the percentage of wheat heads compared to the number of stems.

effective way of presenting the data

Figure 10.



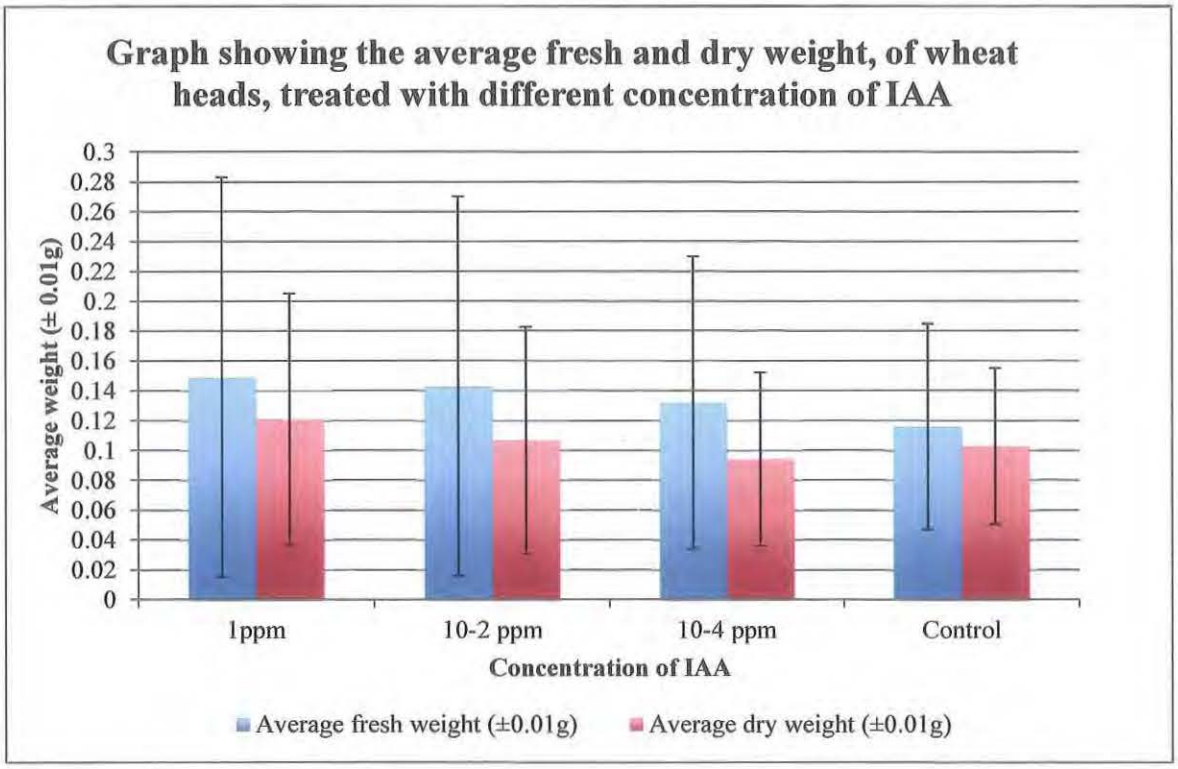
This graph proves that IAA did not affect the flowering of wheat stems in a great manner.

FRESH AND DRY WEIGHT OF WHEAT HEADS

Table 6 showing the average weight of wheat heads, treated with different concentrations of IAA

	1ppm	10^{-2} ppm	10^{-4} ppm	Control
Average fresh weight (±0.01g), and standard deviation	0.149 ±0.134	0.143 ±0.127	0.132 ±0.098	0.116 ±0.069
Average dry weight (±0.01g), and standard deviation	0.121 ±0.084	0.106 ±0.076	0.094 ±0.058	0.103 ±0.0522

Figure 11.



effective figure.

This graph again shows the weight of the wheat heads, both fresh and dry. The greatest average weight was for wheat plants treated with IAA of 1ppm as the weight rose to 0.149 g for the fresh wheat heads and to 0.121 for the dry wheat heads. The lowest fresh weight indicated was for the control group, with an average weight of 0.116 g and the lowest average dry weight of 0.094 was found for wheat treated with a

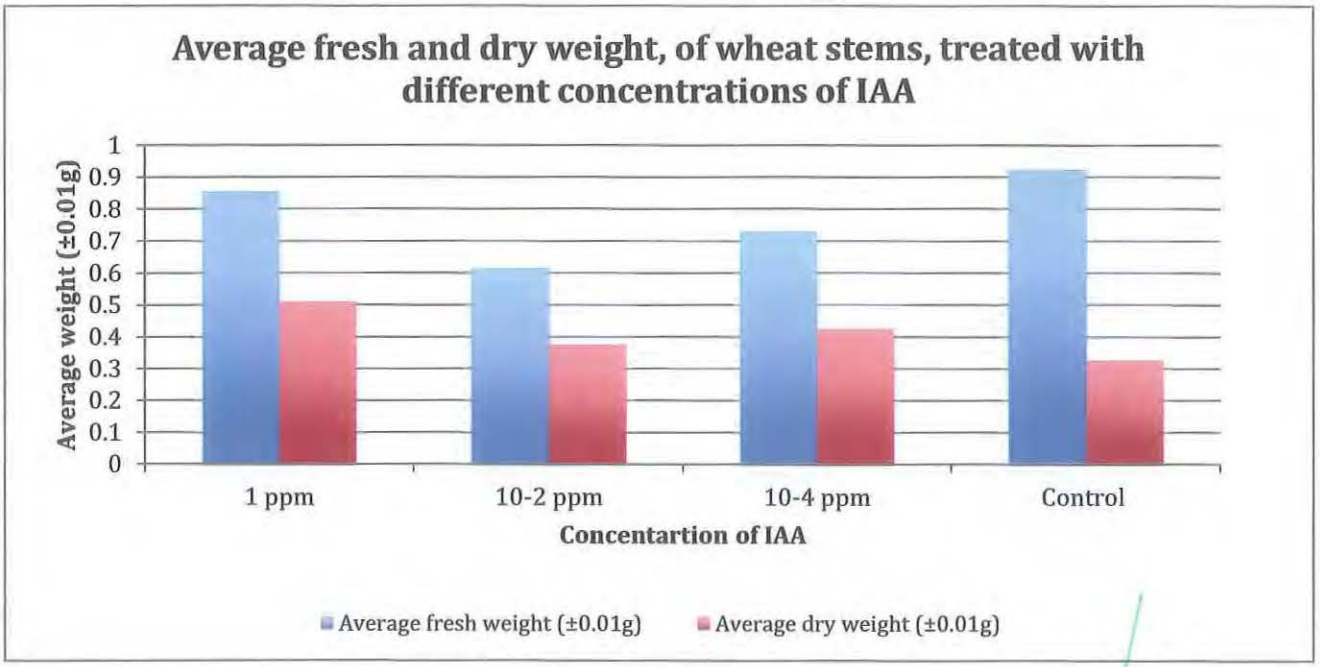
concentration of 10^{-4} ppm of IAA. These results indicate that the more concentrated the solution the heavier the wheat head, both for fresh and for dry wheat heads. However this different is not significant as can be seen in graph (Figure 11.) as the standard deviation is overlapping for the treatments.

However a similar pattern could not be seen in the fresh and dry weight of the wheat stems observed in Table 7 given below.

Table 7 showing the average weight of wheat stems, treated with different concentrations of IAA

	1ppm	10^{-2} ppm	10^{-4} ppm	Control
Average fresh weight (±0.01g), and standard deviation	0.854 ±0.857	0.615 ±0.328	0.730 ±0.632	0.923 ±0.529
Average dry weight (±0.01g), and standard deviation	0.351 ±0.230	0.375 ±0.165	0.436 ±0.318	0.328 ±0.148

Figure 12.

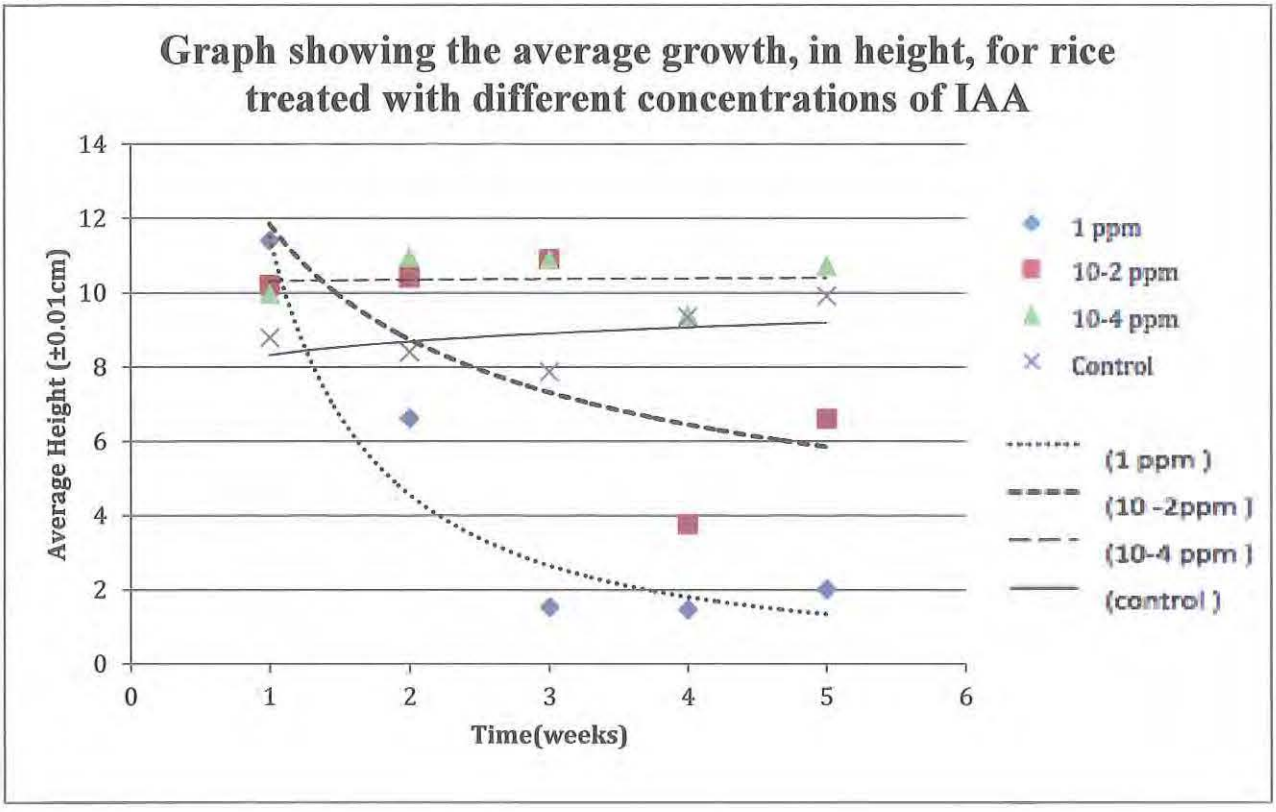


RICE: GROWTH

Table 8 showing the average height of rice plants treated with different concentrations of IAA

Average height of rice plants, per week (±0.01cm), and standard deviation	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
1 ppm	11.4 ±3.17	6.62 ±4.05	1.53 ±1.1	1.46 ±0.61	2 ± 0	0 ± 0
10^{-2} ppm	10.2 ±3.72	10.4 ±2.34	10.9 ±3.93	3.75 ±3.78	6.6 ±4.41	1.7 ±0.95
10^{-4} ppm	9.97 ±4.47	10.94 ±4.13	10.9 ±4.98	9.38 ±6.47	10.7 ±5.88	1.63 ±0.82
Control	8.79 ±3.46	8.4 ±2.57	7.87 ±4.10	9.34 ±3.61	9.9 ±3.28	1.83 ±0.40

Figure 13.



* (The growth is only plotted for 5 weeks, because the average height was under 5 cm during weeks 6, so the data would have interfered with the obtained from the other weeks and given an invalid graph)

This graph shows the growth of the rice for a period of 5 weeks. In the methodology it was stated that the plants would be grown for 8 weeks, however due to the fact that

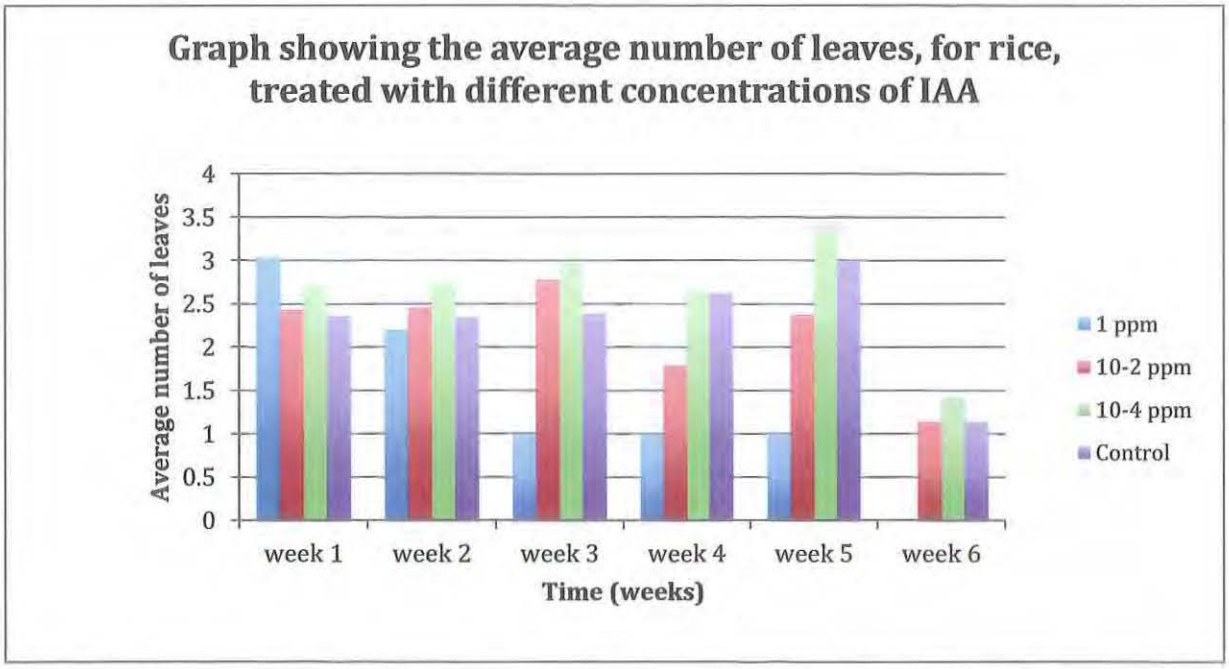
the rice died earlier the experiment had to be cut short. There is no clear growth curve for all of the rice plants, like the one seen for wheat, and this is due to the many limiting factors. Heavy rains killed some of the seedlings and later on a large numbers of plants. Also a lot of birds eat the rice, by ripping the whole plant from the pot or biting it, so that only a few centimeter high plants were left behind. However it can be seen that the height for both the control group and the plants treated with a concentration of 10^{-4} ppm show a small increase in height. The tallest average height of rice plants was seen for the plants receiving treatment with a concentration of 10^{-4} ppm, and the average height at week 5 for these plants were 10.7 cm, and the highest individual height was 23.7 cm. However when looking closely at the graph the greatest increase in average height was for the control group, as their height increased about a total of 1cm, but due to the fact that they were shorter when treatment began their height never exceeded that of 10^{-4} ppm. To try to keep the rice growing for as long as possible, fertilizer was given to all the plants on week 4, however no definite impact on the growth of the rice due to the fertilizer can be seen. The plants treated with a concentration of 1 ppm of IAA suffered the most from the environmental factors and had therefore the lowest average height of all the plants.

NUMBER LEAVES

Table 9 showing the average number of leaves, per rice plant, treated with different concentrations of IAA

Average number of leaves, per rice plant (and standard deviation)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
1 ppm	3.04 ±0.73	2.2 ±1.04	1 ±0	1 ±0	1 ±0	0
10^{-2} ppm	2.43 ±0.76	2.46 ±0.72	2.78 ±0.71	1.79 ±1.10	2.38 ±0.87	1.14 ±0.53
10^{-4} ppm	2.71 ±0.83	2.75 ±0.64	2.98 ±1.03	2.65 ±1.50	3.44 ±1.25	1.43 ±0.53
Control	2.37 ±0.64	2.35 ±0.72	2.39 ±0.77	2.63 ±0.83	3 ±1.0	1.14 ±0.37

Figure 14.



According to my results, the number of leaves would be greatest, when using the lowest concentration of 10^{-4} ppm. As can be seen from the graph the average number of leaves at its greatest was at week 5, namely 3.44, for the rice treated with the concentration of 10^{-4} ppm. When comparing the height of the rice as well as the number of leaves, the rice treated with a concentration of 10-4 ppm gave the best

results overall. The rice sprayed with the concentration of 1ppm gave the shortest plants and least leaves; hence this rice was most affected by the rain as well as the birds.

The results form this investigation indicate that for wheat more concentrated solutions of IAA could enhance the size of the wheat head, the number of leaves and the height of wheat. For rice no correlation between stronger IAA concentrations and growth can be seen, indicating that stronger IAA does not have a positive effect on the growth of rice plants.

do you mean more EJ than in this study?

Chapter 4

Discussion and Conclusion

The affect of IAA on wheat had a positive correlation for growth (in height). Figure.6 shows the growth curve of wheat according to height (cm) and it can be seen that the highest concentration of 1ppm caused the greatest growth in height. It also shows that the height for the plants treated with 1ppm had the greatest height throughout the whole experiment. Plant hormones and specially Gibberellins have been used in a number of studies. Braas *et al,* (2010) conducted a study using Gibberellins and they found that overall a higher dose of hormones gave a greater growth. When they gave a low dose of Gibberellins the plants stem height reached on average of 11.3 cm in a week whereas with a larger dose of Gibberellins the stem height was 20.9 cm. The control group gave a significantly lower height of only 7.9cm. When comparing Braas (2010) results with the present investigation the results are very similar, as the wheat treated with IAA of 1 ppm gave a height of 28.2 cm (see Appendix A1.) after one week. Steven (2009) also had similar findings, however he only used Gibberellins and not other hormones like Braas and his plants treated with hormones grew 88cm during the first week and the control group only 64cm in height. Even though both Braas and Steven.G studies were done using peas, *Patium Sativa*, and this investigation was on wheat, it only indicates that overall plant hormones enhanced growth and that plants overall can be treated with external hormones to enhance their growth.

In Figure 9. It can be seen that the application of IAA did not affect the flowering of the wheat compared to the number of stems in a significant manner, and this can be supported by Misra & Sahu's findings in 1958, when they applied IAA on rice, *Oryza*

sativa and found no effect on grain yield or component of yield. However their findings would indicate that a lower concentration of IAA would speed up the days it takes for rice to grow from a stage from soaking to ear emergent. In average it took up to 113.13 days for the control plants, 112. 99 days for plants treated with IAA of 500 ppm, 112.29 days when treated with 250 ppm and 112.19 days when treated with 100ppm. When in my case it can clearly be seen in figure 9. that a higher concentration of IAA gives a faster flowering rat for wheat, but as seen in figure 13, my results are in some ways similar to Misra & Sahu's, with greater growth for rice plants treated with a lower concentration of IAA. However Misra & Sahu's findings are supported for instant by Thimann & Leopod's (1949), who in Winter Barley observed " both flowering and growth being promoted by relatively low concentrations and inhibited by higher concentrations of auxins." According to figure. 11 the wheat heads would weigh more, as the concentration of IAA increases, indicating a greater yield, which is also in contradiction with Misra & Sahu's (1958) findings.

Even though the study could not be fully continued to the end for the rice, there are still some findings that are similar to does done by other researchers. According to Radi & Maeda (1986) a higher concentration of IAA decreased the growth of rice roots and a relatively low concentration of IAA stimulated root growth. In their study, *Oryza sativa* was used, and a concentration of 10^{-7} ppm gave a root length of 369 cm and for a concentration of 10^{-5} ppm a length of only 296 cm, showing a gradual difference. As there is a strong relationship between the growth of rice roots and the body of a rice plant, which relates to the yield. (Abe & Morita, 1994) According to this and the present results for the rice growth in height, figure.13, a similar phenomena can be seen, as the plants that received the highest concentration of IAA grew least in height

compared to the lower concentrations of IAA. The specific height of rice plants can be seen in the Appendix B. Figure 14. shows the same results when it comes to the number of leaves.

This study clearly shows how different concentrations of IAA have affected the wheat and rice grown. According to the present results a higher concentration of IAA would increase the flowering rate and increase the yields for wheat, however these findings were not supported by other researchers. Then again the findings of increased height due to higher concentrations of IAA and the fact that the flowering itself was not affected by the different concentrations of IAA was supported by other scientists. ✓ However it has to be taken into account that the nature played its role, especially when it came to growing the rice plants. It is also needed to keep in mind that a tropical climate might not be the best conditions for growing wheat, which is often grown in colder and dryer places. ✓

This investigation could have yielded better results if it would have been possible to grow the plants for a longer time and in conditions not affected by the heavy tropical rains or being attacked by birds. In the future, it is advisable to investigate the effect of other hormones on crop plants and also on vegetables such as peas, potatoes, carrots etc. If such research yielded positive results, it would help in solving the problem with scarcity of food for the growing population. ✓

- Perhaps using only one species would have allowed for a more focused investigation?

* Very nice investigation! ✓

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Appendix

A. Raw Data of the height of wheat.

A1. Table showing the height of wheat plants (1ppm)

Date	28.2.2011	7.3.2011	14.3.2011	21.3.2011	28.3.2011	4.4.2011	11.4.2011	18.4.2011
Height of wheat (cm)	23	32	38	47.5	41	41.5	41.5	45
	28	38.5	31.5	30.5	38.3	54	55	50.6
	21	23	35.5	42.5	55	36	36	38.3
	29.5	33.5	30	58	36.4	42	42.2	39.5
	23	31	37	30.5	45	37.5	59.5	59
	31	33.7	31	41	42.9	60	37.6	42.2
	29	27	42	28.5	60	46	46	35.9
	27.5	30	47.5	47	42	50.7	50.5	53
	23	30	39.8	42	42.7	34.2	47.5	49
	21	32	43	30	38.8	50	36	32
	29	27.5	25.5	53.5	50.5	39	51.5	46
	24	30	36	30.5	51	53.5	38.7	55.6
	27.5	28.5	42	47	36.2	34.5	54.5	53.7
	31	27	26	44.3	48.5	51.2	34.5	36.5
	27	31	36	30	54.5	46.5	50.5	51
	28	30.5	44.4	25.7	34.3	36.5	56	39
	25.5	20	39.5	37.5	53	49.2	34.7	52
	33	24.5	36.4	48.5	49.5	46	53.5	39.3
	32	33.5	27	49	45.5	35	46.5	46
	25	27	27.5	28	34.6	53	34.5	35
	21.5	36.5	38.5	26.5	37.5	37.2	37.5	37.3
	29	30.5	32	43	52.5	46.5	37.5	34.3
	26.5	33.5	29	47.5	35	53	46	36.5
	31.5	31	29	32	46.6	34.7	49.2	51.9
	34	26.5	37	34.5	41.3	46.2	54	41.3
	37.5	32	38.7	35.5	55.5	53	41.2	56
	30	31	33.5	43	46.5	40.7	55.6	46.5
	31	33	41.5	44.5	47.2	55.7	46.2	47.3
	19.5	34.5	40.5	50	52.5	47.1	41.8	41.7
	26	27.5	31	47.5	39.8	41.2	46.7	53.5
	30	31.5	44.5	50.3	53.6	49.4	53.1	55
	23.5	31.5	45.5	42.5	55.4	45.4	54.1	42.9
	32.5	37	37	44.5	49.6	53.9	51.5	54.2
	30.5	32	34	52.5	38.6	55.2	49.5	53.4
	30	23.5	43.5	44.5	56	55	45.5	54
	34	31	40	50.7	43.2	52.3	56	45.1
	31	30			56.5	54.5	43.5	49
	35				45.2	43.5	55.2	52
							53.8	
Average height (+/- 0.1cm)	28.2	30.3	36.5	41.1	46.1	46.3	46.7	44.8

A2. Table showing the height of wheat plants (10^{-2} ppm)

Date	28.2.2011	7.3.2011	14.3.2011	21.3.2011	28.3.2011	4.4.2011	11.4.2011	18.4.2011
Height of Wheat (cm)	19	27.5	28.5	28	27.5	45	34	33.7
	26.5	32.5	31.5	46	48.5	32	46	49
	26.5	26	26	30	35.5	45.5	48	35.6
	26.5	26	41	29.2	31.7	39.5	3	28.5
	25	25.5	26	29.7	42	35.7	39.3	39
	25	22	23	43	51	31	35.5	45.1
	21.5	31	25.5	40.1	42.4	49	31.8	46.9
	33	25.5	29.9	46	41.7	31.5	45.1	41.8
	30	31	40	31.5	34	32.7	45.7	47
	31.5	41	31.5	27.3	33	41	32	31
	33	32.5	33	34	31	42.5	35.7	32.8
	34.5	27	24	33.5	48.2	50.5	50	41.5
	21	35	23	47	29.5	42	39.5	42
	36.5	23	35	27	63.4	48	33.6	51
	24	36.5	32.5	44.5	40.5	31.5	45.6	31.5
	22	25	24.5	46.3	53	41.5	63	61
	30.5	33	30	45	52	63	31	42.2
	24.5	32	23	32	33.6	52.5	42	51
	18	30.5	35.5	46	52.5	33.3	53	51
	22.5	33	44.5	40.5	61.5	53	53.5	31
	31.5	27	36	33	49	53	33.3	53
	30	37	27	35	46.2	49	53	61
	22.5	28.5	31.5	48	54	43.5	46.2	48
	36.5	28.5	35.5	45	46.5	46.5	45	45
	26	32	46	43	45	44.9	51.5	53
	30.5	30	41	36.2	51.4	54	46.4	51.4
	29	23	32	41	43	51.5	54	45
	33	33.5	38.5	35.5	37.6	61.5	49.5	47.8
	34	21.5	29	32	42.5	29.5	62	43
	16	33	29.5	39	43.5	42	42.9	38
	31	33	35	41.5	35.5	44.2	38	43.2
	31	34	32	40	44.5	37.9	43.2	43.4
	27	30.5	23.5	37.2	29.4	42.9	30	30
	33	18.5	34.5			42.9	44.2	44.1
	13		35			29.9	43.2	30.5
							30.5	
Average height (+/- 0.1cm)	27.3	29.6	31.8	37.9	43.0	43.3	42.2	43.1

A3. Table showing the height of wheat plants (10^{-6} ppm)

Date	28.2.2011	7.3.2011	14.3.2011	21.3.2011	28.3.2011	4.4.2011	11.4.2011	18.4.2011
Height of wheat (cm)	24	32	35.5	40.3	48.2	59.5	48.7	54
	30.5	29	39.8	47.1	46	46.2	46	49
	28	35.5	38	39	53.3	56	56	53
	32	30	35.5	36	40	52.7	53	44.5
	20.5	31	33	37	56	48.2	60.9	59
	42	30.5	33	41.5	52	50.5	51.6	51
	22.5	33.7	34	37	43	38	42.4	41.7
	22.5	28.7	45	34	40	52	39.9	40
	21	26.3	32.7	51.5	54.5	40	51	35
	27	24	37	31.3	51.3	40.8	29	50.5
	27	35	31.5	46.7	35	51.5	44.5	55
	34	23.5	36.5	46.4	37.7	50.2	40.4	28.5
	31.5	29.5	37	47.5	53.4	37.6	52.8	46
	32	31	41	30.5	55.2	46.6	55.2	36.6
	26	29	30	48.5	54.4	54	46.7	50
	18.5	33.5	37	36.5	50.2	40.8	36.2	54.3
	28.5	22	31.5	41	33.5	55.4	50.5	55.2
	24.5	41	34	38	42.4	36	25.1	53.2
	31	26.5	35.5	32.5	32	34.8	39	53.2
	30.5	33	31.5	31.5	50.1	44.5	35	40.5
	36	38.5	36.5	26	33.5	43	33	34
	29.5	36	36	40	42.5	52.6	41	32.5
	31	35.5	28	31	35	50.5	52	33
	30.5	30	39.5	42.5	31.4	33.5	33	40
	31	32	28	44.5	44	38	44	39
	24	33	37	43	43	43	37	31
	28	34	26	44	51.7	52	53	50
	28	5 3/5	33.5	33	52.2	49	52	42
	29	28		37	32	33	33	51
	35	26		26	49	53	49.5	31
	28	23.5			36.5			48
		34						51
								36
Average height (+/- 0.1cm)	28.5	30.0	34.8	38.7	44.5	46.1	44.4	44.7

A4. Table showing the height of wheat plants (control)

Date	28.2.2011	7.3.2011	14.3.2011	21.3.2011	28.3.2011	4.4.2011	11.4.2011	18.4.2011
Height of wheat (cm)	22	23.5	40.5	41.7	48	52	48	52
	31.5	30	32	47.4	55	29.8	55	30
	33.5	33.5	22	40	53.5	49	43	48
	39.5	34	36.5	23	40.7	41.6	46.5	42.7
	32.5	33.5	38	47.3	30	48	50	48
	36.5	32.5	45.5	43.5	50	36.1	53	55.6
	33	29	34	39.5	48	52	53	50.5
	32	28	37	39.4	34	48	50	47
	23	31.5	25	26.7	36	34.3	47.5	34.5
	31.5	2.5	34.5	46.7	50	50	34.4	35.5
	30	28	38	30.5	33	36	36.1	48
	19	32	35	31	46	33	33	32.5
	34	28	31.5	43.2	52	46	45	45
	24	35.5	39.5	41.3	43	49	43	47.5
	25.5	27.5	36.5	37.6	48	45.5	42.5	43
	30	27.8	26.5	51	37.5	48	51.5	49.5
	29	29.5	33.2	23.3	50	42	33.5	41.5
	20	44	46	33.3	33.5	38	38	36.5
	25.5	26.5	34	46	42	33.3	49	33.5
	29	33.5	36.5	51	47	46	34.3	53
	16.5	32.7	25	43.5	33.56	58	58.5	47.1
	27.5	23.5	34	43	58.5	50.1	46	50.5
	29	31.5	29	52.3	50	54	47	45.3
	29	37	37.5	35.5	46	44.2	50.5	57
	27	31.5	44.5	26.5	54.5	46.5	54	34.6
	37	25.5	36.5	32	41.7	31.1	49	40.7
	27	29.5	34.5	38.2	48	48.5	41	47
	23	27.5	35.5	40.5	46	52	52.5	50
	18	24	30.5	43	51	45	44.5	44.5
	27.5	25	29.5	42	45	44.4	46	44.5
	29							
	22							
Average height (+/- 0.1cm)	26.0	29.3	34.7	39.4	45.0	44.4	45.9	44.5

B. Raw Data of height of Rice

B1. Table showing the height of rice plants (1ppm)

Date	30.3.2011	6 4.2011	13.4.2011	20.4.2011	27.4.2011	4.5.2011
Height of rice (cm)	13	13	4	1.5	2	None
	7.3	6.6	2.8	2.8	2	
	4	11.3	1	1		
	13.5	6.9	1	1.8		
	14.5	5.4	1	1.2		
	15.4	4	1	1.4		
	15.5	3	1	1		
	14.8	8	1	1		
	10.5	9	1			
	15.2	1				
	13.7	3.2				
	12.8	7.4				
	11.4	6.5				
	3.5	4.5				
	2	5.7				
	11.3	8				
	14.1	10				
	12.4	15				
	13	7.6				
	11.7	3				
	8	3.2				
	10.5	1				
	11.0	1				
	12.2	14.6				
	11.3					
	12.5					
	10.0					
	13.5					
	10.9					
	13					
	12.5					
	13.2					
	11.7					
	11.5					
	10					
	12					
	14.3					
	14.5					
	10.5					
	11.5					
	10.3					
	2.5					
	12.5					
	11.5					
	13					
	12.8					
Average height (+/-0.1 cm)	11.4		1.53	1.46	2	

B2. Table showing the height of rice plants (10^{-2} ppm)

Date	30.3.2011	6.4.2011	13.4.2011	20.4.2011	27.4.2011	4.5.2011
Height of rice (cm)	12.1	10.4	5.3	7.6	5.4	1.3
	10	9.6	16.8	5	7.6	1
	11	8	10	1.3	2.9	1
	13.2	6.3	9	1.1	15.1	3.2
	13.2	9.4	15.1	1.2	3	1.5
	11.1	10	12	4	4.9	3.4
	15	7.5	4.6	1.1	1	2.8
	11	11	17.1	0.9	2	2
	10.5	5.9	14.7	6.5	4.2	2.8
	14	15.4	13.3	11.4	13.5	1
	13	9	12.8	7.5	11.2	1
	10	12.5	13.6	3	8	1
	13.6	11	7.5	13.5	6.8	1
	13.9	9.8	8.5	12.9		0.7
	10.8	9	15	2.5		
	6.5	12.5	11.4	3.9		
	10.3	13.3	13.5	2		
	12	11.1	13.3	1.1		
	10.4	13	9.2	1.1		
	12.7	8.7	5	0.5		
	6.5	8.7	11.7	1.2		
	9.6	11.5	11.5	0.5		
	13	12.5	14	1.7		
	13.2	6.9	13.4	4.3		
	9	9.5	13	1.2		
	7.7	7.6	15.2	2		
	11.2	13	7.5	2.3		
	12.1	13	10.4			
	11.5	12.6	4			
	13	11.4	2.1			
	12.4		9			
	10.9					
	5.9					
	14					
	11.7					
	13.6					
	2					
	12.5					
	13					
	2.3					
	2					
	1					
	5					
	3					
Average height (+/- 0.1cm)	10.2	10.4	10.9	3.75	6.6	1.7

B3. Table showing the height of rice plants (10^{-4} ppm)

Date	30.3.2011	6.4.2011	13.4.2011	20.4.2011	27.4.2011	4.5.2011
Height of rice (cm)	13.8	7.9	17.1	2.3	16	1.8
	7	11.2	14.9	1	4	0.7
	14.2	12.6	8.7	16	16.1	1.3
	6	20.3	12	4	12.4	3.2
	10.5	6.7	16.6	16.2	23.7	1.1
	14	5.4	5	23.2	6	2
	11.2	16.3	11.7	3.8	13	1.3
	12	12.3	11.5	4.4	2.1	
	9.4	5.4	12.5	19.7	12	
	22.4	10	15.9	13.5	6.1	
	12	3.5	22.3	4.6	8.8	
	15.4	11	4.5	2.5	5.9	
	4.2	13.2	3.7	6.1	13.5	
	3	8	16.2	11.6	13.2	
	13.6	13.4	13.7	14	19.5	
	12.5	11	6.2	9.3	4.6	
	7.2	8.2	13.5	12.1	12	
	13.4	16.7	19.8	12.5	5	
	16.3	18.9	12	13.6		
	18.5	7	14.1	5.6		
	12.5	19	13.9	1		
	11	12.6	6			
	11	10	12			
	13.5	7.9	12.5			
	7.3	11	17.1			
	10.5	4.6	2.5			
	6	15.2	6			
	5	7.3	2.3			
	3.5	9.7	12.1			
	11.2	11	11.5			
	10.6	13.4	8			
	1.7	15.6	10.2			
	1.2	13.6	11.5			
	6.2	10	6.1			
	9.2	9	7.6			
	7.7	8.9	4.1			
	5	7.1				
	10.5					
	9					
	7					
	10.5					
	12					
Average height (+/- 0.1cm)	9.97	10.94	10.9	9.38	10.7	1.63

B4. Table showing the height of rice plants (control)

Date	30.3.2011	6.4.2011	13.4.2011	20.4.2011	27.4.2011	4.5.2011
Height of rice (cm)	8.5	9.5	13.5	14	13	2.4
	5.5	8.5	10.5	4	6.7	1.4
	9.5	11	14	14.1	10.4	2
	13.5	10.4	8.4	10.8	14.3	1
	11	12.5	11.9	5.6	11	2
	10	4.5	10.1	10.3	13.4	1.9
	6.4	6.8	5.5	8.8	4.3	2.1
	13.2	6	2.2	12.2	9	2.1
	11.6	7.4	5	14.6	3.8	1.8
	9	8	4	6.4	14.5	1.6
	7.5	8.5	8	9.5	6.8	
	14.2	4.7	14.7	4.5	8	
	13.4	5.6	7.3	2	13	
	8	11	9.6	11.1	11.2	
	8.5	10.6	2	13	8.2	
	7.5	13.2	2	8.5	10	
	10.4	7.9	5	10	10.8	
	10	5.5	8	10.6		
	12.4	6.3		7.5		
	14.5	14				
	14	11				
	6.4	6.2				
	4.5	6.5				
	8	7				
	5	8				
	11.5	3.4				
	3.4	7.9				
	2.5	11.7				
	6.5	9.4				
	11.3	12.5				
	12.4	7.3				
	7.7	6.5				
	9.5	9.8				
	7.5	7.2				
	7.2	8				
	2.5	6.5				
	5	9.5				
	9					
	10.3					
	9.1					
	8.7					
	10.5					
	13.1					
	11					
	2					
	1					
Average height (+/- 0.1cm)	8.79	8.4	7.87	9.34	9.9	1.83