



## Allelopathic Effect of Aqueous Extract of *Poa Annua* on Seed Germination and Seedling Growth of Selected Wheat Varieties

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### ABSTRACT

Weed interference with crop growth and development is major challenge in modern agriculture. Weeds' capability to adapt, evolve, and extent rapidly allows them to outcompete crops for resources, decreasing yields and impacting productivity. Thus, we aimed to explore at examining the allelopathic potential of a weed rapid *Poa annua* against the selected wheat varieties *Nifa Aman*, *Nifa Nijat* and *Zargoan* at seedling growth and germination. In order to estimate the allelopathic potential of weeds, a laboratory experiment was conducted at Shaheed Benazir Bhutto Women University Peshawar in the year 2024. *Poa annua* hot water extract (10 g, 15 g and 20 g) were applied to test the seed germination and seedling growth of the tested varieties. The extracts of *Poa annua* caused a broad phytotoxic effect on the seedling growth and seed germination of all the tested varieties at all concentrations. Extracts of *Poa annua* showed significant reduction in seedling growth and germination of tested *Triticum aestivum* varieties. The seed germination, root length and shoot length were significantly affected at higher concentration of the extract. Maximum inhibition of seed germination was observed in variety *Zargoan* (60%) at 20 g as comparison to control condition. Radical, plumule growths, fresh weight, dry weights were lowest at high extract concentration (20 g). These findings confirm that aqueous extract from *Poa annua* display allelopathic effects, leading a risk to crop plant development by suppressing seedling establishment and seed germination.

### INTRODUCTION

Allelopathy, a process first termed by Theophrastus in 300 BC states to the chemical interactions between plants, which can either stimulate or inhibit or growth (Narwal, 2012). This chemical inhibition signifies a form of competition between neighboring plants for partial resources like light, nutrients and water. Allelopathy plays a consequential role in modeling plant communities in both influenced ecosystems and natural, influencing plant invasion, evolution and replant failure (Shupert, 2016). Several biotic and abiotic factors might affect crop productivity in agriculture (Balasubramanian & Karthickumar, 2017). Weeds are the most crucial biotic factor aiding to the deterioration of food crops quantity and quality. They release a number of allelochemicals, which can inhibit the nutrients application, production of cultivation crops, germination and growth development (Hayat et al., 2020). Researchers has revealed that specific weed species yield phytotoxins that possess inhibitory effects both heterospecific and conspecific weeds. Furthermore, various plant species release allelochemicals that impart significant threats to both the environment and crops (Ali et al., 2009). The allelopathic effect of weeds on crop seed germination and seedling growth shows interspecific variability, with various quantities of allelochemicals being discharged (Palanivel et al., 2021). Furthermore, weeds involve in competitive communications with crops for vigorous resources like, light, space, water and

nutrients resulting in destroying of crop production. Research has been evaluated that weed competition can consequence in major nutrient losses for crops, including 42% of phosphorous, 24% of magnesium, 47% of applied nitrogen, 50% of potassium and 39% of calcium (Kumar et al., 2024). Although weeds are known as an important consideration in the management of land and water resources, their effects on agricultural yield are absolutely more prominent (Rao et al., 2020). Many studies have documented the impact of allelopathic weeds, which can disturb crop plants throughout their life cycle, from development to maturity, consequential in considerable economic losses (Zohaib et al., 2014). *Poa annua* L is a well-known species within turfgrass systems, displaying dual roles as both a weed and a valuable component. The *Poa* genus, including 575 species, represents the most widespread grass genus (Gillespie & Soreng, 2005). Wheat (*Triticum aestivum* L.) is a vital crop worldwide, aiding as a primary food source for over 40% of the world's population, making it the primary cereal crop (Kaur et al., 2021). According to STATISTA (2020), wheat cultivation covers an area of 215 million hectares, resulting in a production of 765.41 million tons and a yield of 3.56 tons/ha. Nevertheless, wheat production is frequently delayed by various factors, including abiotic stresses (heat, salinity, drought etc) and biotic factors include (pathogens, insects, weeds etc). Amongst these, weeds are a major concern. Research proposes that weed infestation is accountable for a 13.1% reduction in global wheat yield (Mahlein et al., 2012).

Weeds are acknowledged as desired vegetation that employ detrimental effects on crop production characteristics, predominantly over competition for resources such as nutrients, space and water (Sindhu, 2008). Allelochemicals released by these weeds can severely disrupt the development of roots and shoots in evolving crop seedling, leading to further harm. Weeds are substantial biotic factor influencing wheat yield, and the economic losses they impose on agricultural production are considerable (Zimdahl, 2018).

## MATERIAL AND METHODS

### Plant Collection and Extract Preparation of *Poa annua*:

The plants of *Poa annua* were collected from District Charsadda. The collected plants were cleaned and shed dried. They were then grinded collectively to make a fine powder. To prepare aqueous extract of *Poa annua* the powdered plant was weighed using a digital balance. 10g, 15g and 20g of grinded shed dried *Poa annua* powder was soaked separately in 250 ml of hot water to obtain the aqueous extract. These samples were labelled and kept in room temperature for 96 hours. Then each of the extract (10g, 15g, 20g) was filtered by using Whatman filter paper.

### Research Design

The petri dishes at a diameter of 15 cm were prepared, cleaned and sterilized with 70% alcohol solution, and a filter paper was placed in each petri dish. 10 randomly selected seeds of different wheat varieties i.e. *Nifa aman*, *Nifa Nijat* and *Zargoona* were placed on filter paper, and 10 mL of different concentrations of plant extract were added to each dish along with the control condition. For control, seeds were grown in filter paper soaked with distilled water. The petri dishes were placed in the laboratory temperature for a period of 96 hrs. in triplicate experiment. The following parameters were analysed during the experiment.

### Germination percentage (%):

The percent seed germination was recorded after 96 hrs of seed soaking in control and different concentrations of plants extracts. The percent germination was recorded by using the following formula;

Germination percentage (%) = No of seedlings/ No. of total seeds x 100

### Radicle and plumule length (cm):

The plumule and radicle was detached from their point of attachment with the seed, and then with the help of ruler lengths of the radicle and plumule was measured distinctly.

### Fresh weight determination (g):

The seedlings from control and plant extracts applied plates were taken and their fresh weights were determined using a digital balance.

### Dry weight Determination (g):

The seedlings were taken from the plates and placed in holed papers and dried by using an electric oven and then their weight was taken by using digital balance.

### Moisture content Determination (%):

Moisture contents of the control and extracts applied plants were measured using the following formula;

Moisture content (%) = (Fw-Dw)/Fw x100

Where Fw= Fresh weight, Dw= Dry weight

### Statistical analysis:

The data were statistically analyzed for all the studied traits using M.Stat-C software for the least significant difference (L.S.D) test was used to compare between means at a level of probability 0.05.

## RESULTS AND DISCUSSION

### Germination (%):

The examination of variance (ANOVA) for germination percentage revealed statistically highly significant differences with a p-value of 0.000 between treatment (Conc.), varieties (V).

However, non-significant Combined effect i.e. Var. x treatments as indicated by p value of 0.237.

*Poa annua* aqueous solutions considerably inhibited seed germination percentage of all three tested varieties *Nifa Aman*, *Nifa Nijat* and *Zargoona*. The results in the (Table 1) shows that there was significant effect of hot water extract on the germination percentage of tested varieties. Among different varieties maximum mean germination (38.33%) was recorded in variety *Zargoona*, followed by variety *Nifa Aman* and *Nifa Nijat* (35.00 %). In case of concentration mean the maximum % germination was observed at control (80 %), followed by 15 g (48.89%) and 10 g (13.33%) concentration while lowest germination was occurred at 20g (2.22%). In case of concentration mean the maximum % germination was observed at control level in all varieties. profound reduction in concentration mean was observed at 10 g of the extract (13.33%) as compared to 15 g of the extract (48.89%). However, significant reduction (2.22 %) was recorded at 20 g of the extract. Seed germination is essential for the establishment of a stable plant population and is structured by plentiful environmental (Bewley *et al* 1994). Allelochemicals released by the donor plants may be the cause of the concentration-dependent decline in seed germination and seedling growth in recipient plants (Wang *et al* 2019; Xing *et al* 2020). Water is a natural solvent for plants and may extract compounds from them when they are in their natural state (Wang *et al*. 2018). The current study exposed that hot water extracts of different concentration of *Poa annua* had different germination percentage. Seed germination of the tested wheat varieties *Nifa Aman*, *Nifa Nijat* and *Zargoona* reduced with the increase concentration of *Poa annua* hot water extracts (10g, 15g and 20 g). Our results are also supported by Katoch *et al*. (2012) Katoch *et al*. (2012) have revealed that seedling development and seed germination inhibition are dependent on concentration, with quantitatively greater inhibition observed at higher concentrations. Our Findings are in accordance with (Bora *et al*.1999). The suppressive effect on seed germination might be attributed to the release of allelochemicals that inhibited the seed germination at higher concentration (Sharma & Devkota 2018). The maximum inhibition in germination percentage observed in *Zargoona* at 20g of the extract suggests the release of profound amount of allelochemicals that reduced the germination percentage of the tested variety.

**Table 1. Effect of various concentrations of hot water extracts of *Poa Annua* on seed germination (%) after 96 hrs.**

GERMINATION PERCENTAGE				
	<i>Nifa Aman</i>	<i>Nifa Nijat</i>	<i>Zargoona</i>	Conc mean
Control	70.000	96.667	73.333	80.000 <sup>A</sup>
10 mg	13.333	6.667	20.000	13.333 <sup>C</sup>
15 mg	56.000	50.000	40.000	48.889 <sup>B</sup>
20 mg	0.000	0.000	6.667	2.222 <sup>C</sup>
Variety Mean	35.000 <sup>B</sup>	38.333 <sup>A</sup>	35.000 <sup>B</sup>	

LSD value for Concentration=22.50; LSD value for Variety=26.35 at  $\alpha$  0.050

### Radicle Length (cm):

Radical length exposed substantial alterations among the mean value of different V, C and their interaction at  $p < 0.05$  (Table 2). Among several varieties maximum means radical length (0.970 cm) was recorded in (*Nifa Aman*), followed by *Nifa Nijat* (0.500 cm) However, the lowest radical length (0.397cm) was recorded for *Zargoona*. In case of concentration mean the highest concentration mean (2.161 cm) was observed in control condition, while the lowest concentration mean was observed in 20 g (0.006 cm). The concentration mean of 0.159 cm was observed for 10 g extract while 5 g showed 0.164cm

concentration mean. The hot water extract of *Poa annua* showed greatest inhibition rate on 20 g of the extract applied. The maximum reduction in radicle length was observed in *Nifa Aman* at 20 g (0.000 cm) while the extract concentration i.e., 15 g has minimum effect on the radicle length. The maximum reduction in radicle length was observed in *Zargoan* at 20 g (0.017 cm). Abu Roman *et al.* (2010) have shown similar results regarding decreased radicle length. These results also support the findings of Hussain (1985), who found that the leaf extract of *Azadirachta indica* lowered the generation of radicals in wheat, millet, maize, lettuce, and mustard. According to Hussain and Reigosa (2011), the inhibition may be caused by inhibitors found in fresh leaves, which alter macromolecules like proteins, lipids, and nucleic acids. The reduction in root length might be caused by the synthesis of high inhibitory allelochemicals in aerial parts of the plants which may interfere with plant growth processes (Gill *et al.* 1996). These allelochemicals may be decreasing cell division or auxin prompted growth of roots (Gholami *et al.* 2011).

**Table 2. Effect of various concentrations of hot water extracts of *Poa Annua* on radicle length (cm) after 96 hrs.**

Radical length				
	<i>Nifa Aman</i>	<i>Nifa Nijat</i>	<i>Zargoan</i>	Conc Mean
Control	3.463 <sup>A</sup>	1.857 <sup>B</sup>	1.162 <sup>BC</sup>	2.161 <sup>A</sup>
10 mg	0.227 <sup>C</sup>	0.017 <sup>C</sup>	0.233 <sup>C</sup>	0.159 <sup>B</sup>
15 mg	0.190 <sup>C</sup>	0.127 <sup>C</sup>	0.177 <sup>C</sup>	0.164 <sup>B</sup>
20 mg	0.000 <sup>C</sup>	0.000 <sup>C</sup>	0.017 <sup>C</sup>	0.006 <sup>B</sup>
Variety Mean	0.970	0.500	0.397	

LSD value for Concentration=0.8913; Interaction A×B=1.187 at  $\alpha$  0.050.

#### Plumule length (cm):

Significant differences among the mean value of different V, C and their interaction were observed at  $p < 0.05$  for plumule length (Table 3). Among the tested varieties highest plumule length (0.788 cm) was observed in *Nifa Aman*, followed by *Nifa Nijat* (0.462 cm) while the lowest plumule length (0.411 cm) was recorded for *Zargoan*. However, when it comes to concentration mean the highest percentage germination (1.596 cm) was noted in control condition. The hot water extract of *Poa Annua* revealed varying effect on the plumule length. Significant reduction in plumule length was noted at 20 g (0.033 cm) followed by 10 g (0.184 cm). However, at a concentration 15 g of extract the plumule length was recorded as (0.401 cm). The reduction in % germination due to the hot water extract of *Poa annua* inhibited root and shoot length on all concentrations 10g, 15g and, 20g of the extract applied. Comparable outcomes from Barkatullah *et al.* (2010) were noted, who used *Dodonaea viscosa* water extracts from bark, leaves, and flowers, considerably reducing the formation of plumules and radicles in several plants. However, they linked an increase in extract concentration to the reduction of growth in seedling plumule. In present study significant reduction of shoot and root length occurred in all extract concentrations, which were also noted by several earlier researchers although working on other weeds. The previously reported findings of Kapoor *et al.* (2019), who quantified that the water-soluble leaf extract of *Artimisia absinthium* and *P. guajava* had a major impact on seed germination and seedling growth of shoot and root length, corroborate our results. Rajangam *et al.* (1999) concluded that, applying aqueous extracts of *Excoecaria Agallocha* leaves suppressed rice plumule and radicle elongation as well as seed germination. The current findings support the previous studies of (Bora *et al.* 1999) who observed that, the inhibitory effect of leaves extracts of *Acacia auriculiformis* on propagation of some agronomic crops was correlated with extract content. Moreover, Jadhar *et al.* 1992 reported that when

the concentration of *Acacia auriculiformis* leaf leachates increased, the percentage of germination, radicle length, and plumule length of rice and cowpea reduced.

**Table 3. Effect of various concentrations of hot water extracts of *Poa Annua* on plumule length (cm) after 96 hrs.**

PLUMULE LENGTH				
	<i>Nifa Aman</i>	<i>Nifa Nijat</i>	<i>Zargoan</i>	Conc Mean
Control	2.520 <sup>A</sup>	1.263 <sup>B</sup>	1.003 <sup>BC</sup>	1.596 <sup>A</sup>
10 mg	0.100 <sup>D</sup>	0.167 <sup>D</sup>	0.287 <sup>D</sup>	0.184 <sup>B</sup>
15 mg	0.533 <sup>CD</sup>	0.417 <sup>CD</sup>	0.253 <sup>D</sup>	0.401 <sup>B</sup>
20 mg	0.000 <sup>D</sup>	0.000 <sup>D</sup>	0.100 <sup>D</sup>	0.033 <sup>B</sup>
Variety Mean	0.788 <sup>A</sup>	0.462 <sup>B</sup>	0.411 <sup>B</sup>	

LSD value for Concentration=0.4476; LSD value for Variety=0.5240; Interaction A×B=0.5960; at  $\alpha$  0.050

#### Fresh weight (g):

Fresh weight determination revealed substantial differences among the mean value of different V, C and their interaction at  $p < 0.05$  (Table 4). Among three tested wheat varieties maximum fresh weight of (0.338 g) was recorded in *Nifa Aman*, followed by *Nifa Nijat* (0.311 g). Although the lowest fresh weight (0.272 g) was observed for *Zargoan*. In case of concentration mean the highest fresh weight (0.777 g) was recorded in control condition, while 0.324 g was recorded for 15 g of the extract, for 10 g of extract showed an average concentration mean of 0.109 g. However, the lowest value of (0.018 g) was recorded for 20 g. In all the aqueous concentration of *Poa annua* extracts, more inhibition was observed at 10 g of the extract as compared to 15 g of the extract applied. However, highest inhibition was observed at 20 g of the extract. This tends to propose that the effects of the extracts on fresh weight of the tested varieties are more profound at higher concentration of the extract. The water soluble phenolics found in weed water extracts may be the cause of the inhibition of germinability and biomass formation (Zohaib *et al.*, 2014).

**Table 4. Effect of various concentrations of hot water extracts of *Poa Annua* on fresh weight (g) after 96 hrs.**

FRESH WEIGHT				
	<i>Nifa Aman</i>	<i>Nifa Nijat</i>	<i>Zargoan</i>	Conc Mean
Control	0.880	0.797	0.653	0.777 <sup>A</sup>
10 mg	0.090	0.090	0.147	0.109 <sup>C</sup>
15 mg	0.383	0.357	0.233	0.324 <sup>B</sup>
20 mg	0.000	0.000	0.053	0.018 <sup>C</sup>
Variety Mean	0.338	0.311	0.272	

LSD value for Concentration=0.1711; at  $\alpha$  0.050

#### Dry weight (g):

Dry weight determination revealed substantial changes among the mean value of different V, C and their interaction at  $p < 0.05$  (Table 5). Among different varieties maximum mean dry weight (0.186 g) was recorded in *Nifa Aman*, then in *nifa Nijat* (0.152g). The lowest dry weight was recorded for the variety *Zargoan* (0.138g). In case of concentration mean the highest concentration means (0.381 g) was observed in control condition, while 15g extract showed (0.186 g), for 10 g of extract (0.058 g) however, the lowest value of (0.010 g) was recorded at 20 g. The decrease in dry weight might be because of the presence of allelochemicals existing in the plant which disturb

many physiological processes of the other nearby plants. The current findings concur with those of Verma *et al.* (2002), who discovered that the extracts of *Cyperus rotundus* unpleasantly decreased the biomass yield, seed germination, and seedling growth of Brassica and tomato. Our results suggests that the 10 g of the extract has more inhibitory effect than 15 g of the extract and the variety *Nifa Nijat* was the most susceptible variety affected by higher concentration of the extract.

**Table 5. Effect of various concentrations of hot water extracts of *Poa Annua* on dry weight (%) after 96 hrs.**

DRY WEIGHT				
	<i>Nifa Aman</i>	<i>Nifa Nijat</i>	<i>Zargoona</i>	Conc Mean
Control	0.467 <sup>A</sup>	0.373 <sup>AB</sup>	0.303 <sup>ABC</sup>	0.381 <sup>A</sup>
10 mg	0.067 <sup>DE</sup>	0.033 <sup>DE</sup>	0.073 <sup>DE</sup>	0.058 <sup>BC</sup>
15 mg	0.210 <sup>BCD</sup>	0.200 <sup>BCD</sup>	0.147 <sup>CDE</sup>	0.186 <sup>B</sup>
20 mg	0.000 <sup>E</sup>	0.000 <sup>E</sup>	0.030 <sup>DE</sup>	0.010 <sup>C</sup>
<b>Variety Mean</b>	0.186 <sup>A</sup>	0.152 <sup>A</sup>	0.138 <sup>B</sup>	

LSD value for Concentration=0.1500; LSD value for Variety=0.1757; Interaction A×B=0.1998; at  $\alpha$  0.050

#### Moisture Content (%):

Moisture content revealed varied differences amongst the mean value of different V, C and their interaction at  $p < 0.05$  (Table 6). Among three different varieties of *wheat* maximum moisture content (35.50%) was observed in *Zargoona*, then in *Nifa Aman* (26.33%) and the lowest (25.50 %) moisture content was recorded for *Nifa Nijat*. In case of concentration mean the highest concentration mean (47.67 %) was observed in control condition, (22.33%) in 10g, (41.67 %) in 15g and (4.78 %) in 20g. The above table indicates that increased concentration of *Poa annua* in hot water extract results in decrease of moisture content 4.48 % at 20 g of the extract. The lowest value is recorded for the variety *zarghoon* at 20 g. Our results are supported by the findings of (Oyun, 2006) who stated that with increase in concentration mean decreases gradually. Alike findings were obtained by (Femina *et al.* 2012) who applied aqueous extract of leaves of *Tridax procumbens L.* and found that it had inhibitory effect on germination of root and shoot elongation, dry as well as fresh weight of leguminous.

**Table 6. Effect of various concentrations of hot water extracts of *Poa Annua* on moisture content (%) after 96 hrs.**

MOISTURE CONTENT				
	<i>Nifa Aman</i>	<i>Nifa Nijat</i>	<i>Zargoona</i>	Conc Mean
Control	46.667	52.667	43.667	47.6667 <sup>A</sup>
10 mg	14.333	6.667	46.000	22.333 <sup>AB</sup>
15 mg	44.333	43.667	37.000	41.667 <sup>A</sup>
20 mg	0.000	0.000	14.333	4.778 <sup>B</sup>
<b>Variety Mean</b>	26.333 <sup>B</sup>	25.750 <sup>B</sup>	35.250 <sup>A</sup>	

LSD value for Concentration=30.93; LSD value for Variety=36.21 at  $\alpha$  0.050

## CONCLUSION AND RECOMMENDATIONS

Plants are negatively impacted by the well-known phenomena known as allelopathy. The current study revealed that the weed *Poa annua* pose threat to seed germination and seedlings growth of wheat varieties *Nifa nijat*, *Nifa aman* and *Zargoona*. From the present investigation, we observed that all the tested parameters i.e. seed germination, seedling growth, moisture contents, dry

weight, fresh weight of test crops were decreased with increasing concentration (20 g) of extract. The variety *Nifa Nijat* was the most susceptible variety therefore this variety should be restricted to grow by the farmers. The results of this study recommend that targeted management practices are required to limit weed growth in crops and neutralize their inhibitory effects on growth and germination. Furthermore, breeding crop varieties with enhanced tolerance to allelopathic effects is essential for mitigating these adverse effects.

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**APPENDICES****Appendix 1:**ANOVA table for germination  
ANALYSIS OF VARIANCE TABLE

K	Degrees of	Sum of	Mean	F		
Value	Source	Freedom	Squares	Square	Value	Prob
2	Factor A	3	33811.111	11270.370	50.0905	0.0000
4	Factor B	2	88.889	44.444	0.1975	
6	AB	6	1955.556	325.926	1.4486	0.2378
-7	Error	24	5400.000	225.000		
Total		35	41255.556			

**Appendix 2:**ANOVA table for radicle length  
ANALYSIS OF VARIANCE TABLE

K	Degrees of	Sum of	Mean	F		
Value	Source	Freedom	Squares	Square	Value	Prob
2	Factor A	3	28.542	9.514	26.9370	0.0000
4	Factor B	2	2.238	1.119	3.1689	0.0601
6	AB	6	6.220	1.037	2.9351	0.0272
-7	Error	24	8.477	0.353		
Total		35	45.477			

**Appendix 3:** ANOVA table for plumule length

ANALYSIS OF VARIANCE TABLE

K	Degrees of	Sum of	Mean	F		
Value	Source	Freedom	Squares	Square	Value	Prob
2	Factor A	3	13.643	4.548	50.8242	0.0000
4	Factor B	2	1.007	0.504	5.6282	0.0099
6	AB	6	3.132	0.522	5.8343	0.0007
-7	Error	24	2.147	0.089		
Total		35	19.930			

**Appendix 4** ANOVA table for fresh weight

ANALYSIS OF VARIANCE TABLE

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	3.094	1.031	81.9990	0.0000
4	Factor B	2	0.027	0.013	1.0709	0.3585
6	AB	6	0.102	0.017	1.3577	0.2714
-7	Error	24	0.302	0.013		
Total		35	3.525			

**Appendix 5:** ANOVA table for Dry weight

## ANALYSIS OF VARIANCE TABLE

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	0.742	0.247	24.7799	0.0000
4	Factor B	2	0.014	0.007	0.7213	
6	AB	6	0.037	0.006	0.6241	
-7	Error	24	0.240	0.010		
Total		35	1.034			

**Appendix 6**

## ANOVA table for Moisture content

## ANALYSIS OF VARIANCE TABLE

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	10260.000	3420.000	8.0460	0.0007
4	Factor B	2	680.389	340.194	0.8004	
6	AB	6	2563.833	427.306	1.0053	0.4449
-7	Error	24	10201.333	425.056		
Total		35	23705.556			