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Allelopathic Effect of *Artemisia Persica Boiss.* Aqueous Extract on Seed Germination and Seedling Growth of Selected Brassica Varieties

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Authors' Contribution

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ABSTRACT

An experiment was conducted during 2024 at Shaheed Benazir Bhutto Women University, Peshawar laboratory to find out the allelopathic effect of hot water extracts of *Artemisia persica Boiss.* on seed development and seedling progression of selected varieties of Brassica; Nifa Gold, Sarso T20 and Durr-e-Nifa. Different concentrations (10g, 15g and 20g) of aqueous extract of *Artemisia persica Boiss.* revealed significant reduction in seed development seedling progression of tested brassica varieties. Seeds germination, plumule and radicle lengths, dry and wet weights were expressively reduced in test treatments linked to control. Higher concentration of the extract (20g) had significantly reduced the germination percentage to 10% as compared to control condition. Nifa Gold was the most susceptible variety to higher concentration of the extract which showed minimum seed development. Radicle and plumule lengths, dry and wet weights were lowest at 15g concentration of the applied extract of *Artemisia persica Boiss*. while moisture content was not significantly affected. Allelopathic effects were more obvious at higher concentrations then lower in most conditions. The results showed differences in allelopathic effects on all three varieties at different concentrations.

INTRODUCTION

Allelopathy is the field of chemo ecology which relates to the study of those chemicals that are produced by plants and other microbes which influence the growth, development and dispersal of other microbes and plants(Cheng & Cheng, 2015). Allelopathic relations can be positive or negative. Allelopathy can act as a weed controller, pests hinder and it can also improves the accessibility of nutrients in soil. Eventually the allelopathy affect plants growth(Xie *et al*., 2021). Activity of allelochemicals is mostly dose reliant; higher meditations inhibit the growth of target plants whereas lower concentrations rouse the growth (Rehman *et al.,* 2019).The allelochemicals may be water soluble that are released through the process of leaching, decomposition of plant residues and volatilization. Research of allelopathy are mostly based on the effects of weed species relations(Turk & Tawaha, 2003). On allelopathic effect of probable plants in controlling weeds of vegetables the enquiry data is scarce. Suitable plants identification with herbicidal properties, with their formulation grains distinctive importance in organic agriculture(Cheng & Cheng, 2015). *Artemisia persica*, a perennial herbaceous plant belongs to the asteraceae family. It is one of the diverse and largest genus of family asteraceae that has an extensive range of distribution mostly within temperate climates of land like in southern Europe, North Africa, America and Iran. Almost 34 species of *Artemisia* are found in the form of shrubs in Iran which are named as dermaneh by the local people of Iran. Many species of this genus produce biologically active compounds of terpenes and phenols(Bidgoli, 2021). Many species of *Artemisia* have allelopathic compounds that effect the decline of seed germination and seedling of other plants. Asteraceae family have many identified species containing allelopathic complexes which may decrease seed germination and seedling appearance of other florae. The research on *Artemisia dubia* showed that the seed growth, shoot and root lengths of barnyard grass reduced by the application of different parts extract like leaf, root and shoot of Artemisia but the leaf extract having more obvious effect which might be due to the phytotoxic chemicals present in *Artemisia dubia*(Mallik *et al*., 2014). The water-soluble extracts of *Artemisia argyi* are also reported to exhibit the allelopathic inhibitory effects on various

types of floras. *Artemisia argyi* affect the seed germination and growth of some brassica species due to the allelopathic effect of argyi which has the ability to exhibit both the dicotyledons and monocotyledons not only through seed germination but also by seedling growth due to its allelopathic effect(Li *et al*., 2021). The research on allelopathic effect of *Artemisia annua* also showed that the leaf tissue of plant has conflicting effects on seedling growth of mustard and germination of Amaranth. *Artemisia scoparia* has also been described for its herbicidal activity on several weed species(Ahangar *et al*., 2017). As some other species of Artemisia have been described as growth inhibitors, hence it is assumed that due to allelopathic effects aqueous extract of *Artemisia persica Boiss.* Probably will also reduce seed growth of field crops. Studies on allelopathic effects of *Artemisia persica Boiss* on brassica is rare in literature therefore this study is carried out to evaluate the allelopathic prospective of *Artemisia persica Boiss.* on selected varieties of Brassica; Nifa Gold, Sarso T20 and Durr-e-Nifa.

MATERIALS AND METHODS

Materials and Plant Collection:

This study was carried out to record the allelopathic potential of *Artemisia persica* on seed development and seedling progression of selected varieties of Brassica. The plants of *Artemisia persica* Boiss were collected from madak lasht (35.7737N72.0312E), Chitral, Khyber Pakhtunkhwa Pakistan. The collected plants were cleaned and shed dried. They were then grinded collectively to make a fine powder.

Experimental Design

The experiment was conducted under laboratory conditions in the laboratory of Botany, Shaheed Benazir Bhutto Women University Peshawar during 2024. To prepare aqueous extract of *Artemisia persica* Boiss the powdered plant was weighed using a digital balance. 10g, 15g and 20g of grinded shed dried *Artemisia persica* 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. Petri dishes with a diameter of 15 cm were prepared and subjected to thorough cleaning and sterilization protocol using a 70% ethanol solution. Subsequently, a filter paper was placed in each petri dish, ensuring a sterile environment for further experimentation. 10 seeds of selected varieties (Nifa Gold, Sarso T20 and Durr-e-Nifa) were set on filter paper, and 10 mL of plant extract at varying concentrations were added to each petri dish along with control condition. Seeds soaked with distilled water were germinated on filter paper for control conditions. The petri dishes were placed in the laboratory temperature for a period of 96 hrs. in triplicate 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 analyzed statistically for all the studied characters using M. Stat-C software for the least significant difference test was used for comparison between means at a level of possibility 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) and their Combined effect i.e. Var. x treatments (Appendix. 1).

The outcomes in the (Table 1) revealed major effect of hot water extract on the percentage of germination of tested Brassica varieties. Germination percentage showed major differences among the mean value of different V, C and its relationship at $p<0.05$. Among the various varieties tested, the highest mean Germination rate of 57% was observed in variety *Sarso T20*, observed by variety *Durr-e-Nifa* (43 %). However, the lowest means germination was shown by *Nifa Gold* (30 %). In terms of concentration mean, the highest mean percent germination (100%) was recorded under control Condition. However, the concentration mean Gradually declines with rising Concentration i.e., 10g (45%), 15g (18%), 20g (10%).

Seed germination is the fundamental precursor to plant growth, that directly impact the viability and growth of plants(Khasabulli et al., 2018;Gorai et al., 2014;Wang et al., 2019). In Allelopathic research, One of the most commonly used methods for biological detection is seed germination test (Rice, 2012). In the natural state, water

is the essential medium for plants, able to drain out the chemicals in plants (Wang *et al*., 2018). The present study revealed that hot water extracts of various concentration of *Artemisia Persica* had different germination percentage. Seed germination of the tested Brassica varieties (*Sarso T20, Durr-e-Nifa and Nifa Gold*) decreased gradually with the increase concentration of *Artemisia Persica* hot water extracts (10g, 15g and 20 g). The maximum inhibition in germination percentage was observed in *Sarso T20* at 20g of the extract. Our findings are in parallel to Katoch *et al.* (2012) who also observed that the reduction in seed germination and growth was correlated with the concentration and statistically maximum reduction was recorded at higher concentration. Our findings are also in accordance to the previous published results of Bakšinskaitė *et al*., 2023 who reported that the aqueous extracts of *Artemisia dubia Wall* also pose adverse effect on the development of various weeds and wheat crops in a dose dependent manner.

Table 1. Effect of various concentrations of hot water extracts of Artemisia Persica on seed germination (%) after 96 hrs.

Germination Percentage				
	Nifa Gold	*Sarso T20*	*Durr-e-Nifa*	Conc. Mean
Control	100^{A}	100^{A}	100^{A}	100^{A}
10 g	10^{DE}	86^{A}	40^{B}	45^{B}
15 g	6^{DE}	30^{BC}	20^{CD}	18^{C}
20 g	3^{E}	13^{DE}	13^{DE}	10^{C}
Variety Mean	30^{C}	57^{A}	43^{B}	

LSD value for concentration=13.94; LSD value for Variety=12.07; interaction AxB=0.08935 at α 0.05

Radicle Length (cm):

The present lab experiment of various hot water extract of *Artemisia persica* results in varying radicle length. Data analysis revealed significant differences in radical length among treatment(C), Varieties (V) and their interaction i.e Var.x treatments, as indicated by the p-value of 0.001 (Appendix.2)

Among various varieties tested, highest means radical length 1.077 cm was recorded in *Sarso T20*, followed by gradual reduction *Durr-e-Nifa* (0.878 cm). However, the lowest radical length (0.575 cm) was recorded for *Nifa Gold*. In case of concentration mean the highest concentration mean 2.801 cm was observed in control condition, while in case of *Artemisia Persica* hot water extracts the lowest concentration mean was observed is 15 g (0.050 cm). 10 g extracts showed 0.336 cm and the highest concentration of the extract i.e., 20 g showed 0.184 cm.

The hot water extract of *Artemisia Persica* showed greatest inhibition on 15 g of the extract applied. The maximum reduction in radicle length was observed in *Nifa Gold* at 15 g (0.01 cm) while the maximum extract concentration i.e., 20 g has minimum effect on the radicle length. Same results were attained by Watban and Salama (2012) of *Artemisia monosperma* extract on *Phaseolus vulgaris*. Reduction in root length might be due to the production of high inhibitory allelochemicals in aerial parts of the plants which might interfere with the processes of plant growth (Gill *et al.* 1996). These allelochemicals may be responsible for reduction in cell division or auxin stimulated growth of roots (Gholami *et al.* 2011).

Table 2. Effect of various concentrations of hot water extracts of Artemisia Persica on radicle length (cm) after 96 hrs.

Radical Length				
	Nifa Gold	*Sarso T20*	*Durr-e-Nifa*	Conc. Mean
Control	2.13^{AB}	3.14^{A}	3.13^{A}	2.801^{A}
10g	0.10^{C}	0.65^{BC}	0.25^{BC}	0.336^{B}
15g	0.01^{C}	0.11^{C}	0.01^{C}	0.050^{B}
20g	0.05^{C}	0.39^{BC}	0.11^{C}	0.184^{B}
Variety Mean	0.575^{A}	1.077^{A}	0.878^{A}	

LSD value for concentration=1.430; LSD value for Variety=1.674; interaction AxB=1.904 at α 0.05

Plumule length (cm):

Data analysis for plumule length showed significant differences in treatment(C), Varieties (V) and their Mutual effect i.e Var.x treatments as indicated by the p-value of 0.006 (Appendix.3).

Significant changes between the mean value of different V, C and their interactive effects were observed at $p<0.05$ for plumule length (Table 3). Between the tested varieties highest plumule length (0.599 cm) was observed in *Sarso T20*, followed by *Durr-e-Nifa* (0.506 cm) while the lowest plumule length (0.366 cm) was recorded for *Nifa Gold*. In control condition, the maximum germination percentage 1.736 cm was recorded in case of concentration mean. The hot water extract of *Artemisia Persica* showed varying effect on the plumule length. Significant reduction in plumule length was recorded at 15g (0.050 cm) followed by of 10g (0.071 cm). However, at a concentration 20 g of extract the plumule length was recorded as 0.104 cm.

The reduction in % germination due to the hot water extract of *Artemisia Persica* inhibited root and shoot length on all concentrations 10g, 15g and, 20g. The same inhibition of shoot length in aqueous conc. of *Artemisia Dubia* was also observed by Das Mallik *et al* (2014).

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

Plumule Length				
	Nifa Gold	*Sarso T20*	*Durr-e-Nifa*	Concentration Mean
Control	1.43^{A}	1.99^{A}	1.78^{A}	1.736^{A}
10g	0.00^{B}	0.06^{B}	0.15^{B}	0.071^{B}
15g	0.03^{B}	0.11^{B}	0.00^{B}	0.050^{B}
20g	0.00^{B}	0.22^{B}	0.09^{B}	0.104^{B}
Variety Mean	0.366^{A}	0.599^{A}	0.506^{A}	

LSD value for concentration=0.8134; LSD value for Variety=0.9524; Interaction AxB=1.083 at α 0.05

Fresh Weight (g):

The analysis of data for fresh weight indicated significant ($p<0.05$) differences among treatment (C), Varieties (V) while non-significant interactive effect i.e Var. x treatments as indicated by the p-value of 0.120 (Appendix.4)

Fresh weight determination exposed significant changes between the mean value of different V, C and their relation at $p<0.05$(Figure 4). In three tested Brassica varieties highest fresh weight of (0.474 g) was recorded in *Sarso T20*, followed by *Durr-e-Nifa* (0.395g). While the lowest fresh weight (0.287g) was observed for *Nifa Gold*. In case of concentration mean the highest fresh weight 0.678 g was recorded in control condition, however the concentration mean with increasing concentration gradually reduces i.e 10g (0.394 g), 15g (0.249 g), 20g (0.226 g)

Allelochemicals are well known inhibitors of germination and plant Growth. From the above table it is concluded that seed germination reduced by the increase of aqueous hot water extract of *Artemisia persica*. From these results we conclude that concentration mean decreases gradually with increasing Concentration. *Nifa Gold* was the most susceptible variety observed to be affected by the higher concentration of the extract. Our findings are strengthened by the previous published results of (Li *et al*., 2021) who also reported that the water-soluble extract of A. argyi powder displayed extremely inhibition of the biomass of the three tested plants. The decrease in biomass of the plants is attributed to the down regulation of a number of genes linked to pathways of chlorophyll synthesis including HEMA, HEML, CHLD, CHLH, CRD and CHLG were substantially decreased after treatment with *Artemisia argyi* extract (Li *et al.,* 2021).

Table 4. Effect of various concentrations of hot water extracts of Artemisia Persica on fresh weight (g) after 96 hrs.

Fresh Weight				
	Nifa Gold	*Sarso T20*	*Durr-e-Nifa*	Conc.Mean
Control	0.607^{A}	0.680^{A}	0.747^{A}	0.678^{A}
10 g	0.287^{A}	0.557^{A}	0.340^{A}	0.394^{A}
15 g	0.090^{A}	0.397^{A}	0.247^{A}	0.244^{A}
20 g	0.167^{A}	0.263^{A}	0.247^{A}	0.226^{A}
Variety Mean	0.287^{A}	0.474^{A}	0.395^{A}	

LSD value for Concentration=0.6809; LSD value for Variety =0.7972; Interaction AxB=0.9068 at α 0.05

Dry weight (g):

The study of variance (ANOVA) for dry weight revealed highly significant differences between treatment(C), Varieties(V) their interaction i.e Var.x treatments as indicated by a p-value of 0.001(appendix.5).

Dry weight determination exposed significant differences between the mean value of distinct V, C and their relation at $p<0.05$(Table 5). Between tested varieties highest mean dry weight (0.201g) was recorded in *Sarso T20*, then (0.185 g) in *Durr-e-Nifa*. The lowest dry weight was recorded for *Nifa Gold* (0.051g). In case of concentration mean the highest concentration means 0.236 g was observed in control condition, while a gradual reduction was observed at 10 g of extract (0.162 g), for 20 g of extract (0.113g) however, the lowest value of (0.071 g) was recorded for 15g.

The decrease in dry weight might be the presence of phytochemicals in plant which disturb many physiological processes of the other nearby plants. *Artimisia annua L.* extract contains the allelochemicals that deter the growth and germination of *Lactuca sativa L.* by interferring with physiological processes (Keshavarzi *et al.*, 2014). From this, we conclude that allelochemicals present in the hot water extract of *Artemisia persica* might be responsible for the reduction of seed growth and development. Khoursheed & Hassan, 2022 also reported that the presence of allelochemicals in *Artemisia* extract are responsible for reduction in shoot dry weight and root dry weight.

Table 4. Effect of various concentrations of hot water extracts of Artemisia Persica on dry weight (g) after 96 hrs.

Dry weight				
	Nifa Gold	*Sarso T20*	*Durr-e-Nifa*	Conc. Mean
Control	0.047^{E}	0.290^{AB}	0.370^{A}	0.236^{A}
10mg	0.077^{DE}	0.217^{BC}	0.193^{C}	0.162^{B}
15mg	0.040^{E}	0.153^{CD}	0.020^{E}	0.071^{C}
20mg	0.040^{E}	0.143^{CD}	0.157^{CD}	0.113^{BC}
Variety Mean	0.051^{A}	0.201^{B}	0.185^{A}	

LSD value for concentration=0.06709; LSD value for variety=0.07856; Interaction AxB=0.08935 at α 0.05.

Moisture Content (%):

The data study of variance (ANOVA) for moisture content exposed non- significant ($p \leq 0.05$) differences between treatment (C), varieties (V) but highly significant interactive effect i.e. Var. x treatments as indicated by p- value of 0.00 (Appendix. 6).

Moisture content revealed varied differences between the mean value of different varieties, treatments and their relation at $p<0.05$ (Table 6). Between three different varieties of Brassica highest moisture content (68.917 %) was observed in *Nifa Gold*, then in *Durr-e-Nifa* (54.917 %) and the lowest (54.883%) moisture content was recorded for *Sarso T20*. In case of concentration mean the highest concentration mean 66.67 % was observed in control condition, 45.889 % in 10g, 62.889 % in 15g and 51.778 % in 20g.

The below table indicates that increased concentration of *Artemisia persica* in hot water extract results in decrease of moisture content. The lowest value is recorded for *Nifa Gold* at 15g. Anwar *et al.,* 2021 concluded that Artemisia extract of different concentrations significantly decreases seed development and seedling growth of several weed species also discussing the moisture content in relation to the inhibitory effects of the extracts on the weed seeds.

Table 5. Effect of various concentrations of hot water extracts of Artemisia Persica on moisture content (%) after 96 hrs.

Moisture Content				
	Nifa Gold	*Sarso T20*	*Durr-e-Nifa*	Conc. Mean
Control	92.333^{A}	57.333^{BCD}	50.333^{BCD}	66.67
10 mg	73.00^{ABC}	56.00^{BCD}	41.667^{CD}	45.889
15 mg	34.00^{D}	63.00^{ABCD}	91.333^{A}	62.889
20 mg	76.333^{AB}	42.667^{CD}	36.33^{D}	51.778
Variety Mean	68.917	54.883	54.917	

LSD value for interaction AxB=32.73 at α 0.05

CONCLUSIONS

In the light of results, it is concluded that *Artemisia persica Boiss* extract inhibited seed germination of tested three varieties of Brassica. The present study revealed differences in germination percentage at various concentrations of *Artemisia persica Boiss.* Among all three varieties maximum inhibition was resulted by *Nifa Gold* (30%). Extract concentration of 15g showed significant reduction in plumule radicle lengths, fresh and dry weights in Brassica varieties. The present study revealed that the weed *Artemisia persica Boiss* affected the seed development and seedling growth of all the tested Brassica varieties, therefore an appropriate management is essential. Furthermore, due to its phytotoxic effect, *Artemisia persica Boiss* growth should be discouraged in the fields of Brassica varieties by weed manager.

REFRENCES

Ahangar, M., Dehdari, S., Kouhanestani, Z., & Noedoost, F. (2017). Investigating allelopathic effects of Artemisia sieberi on seed germination and seedling growth indices of three alfalfa species. *Journal of Rangeland Science*, *7*(2), 172-182.

Bidgoli, R. D. (2021). Chemical composition of essential oil and antifungal activity of Artemisia persica Boiss. from Iran. *Journal of Food Science and Technology*, *58*(4), 1313.

Cheng, F., & Cheng, Z. (2015). Research progress on the use of plant allelopathy in agriculture and the physiological and ecological mechanisms of allelopathy. *Frontiers in plant science*, *6*, 1020.

Gorai, M., El Aloui, W., Yang, X., & Neffati, M. (2014). Toward understanding the ecological role of mucilage in seed germination of a desert shrub Henophyton deserti: interactive effects of temperature, salinity and osmotic stress. *Plant and Soil*, *374*, 727-738.

Keshavarzi, M., Nooralvandi, T., & Omidnia, P. (2014). Consideration of allelopathic effects of Artemisia annua L. on morphological characteristics of Lactura sativa L.

Khasabulli, B. D., Musyimi, D. M., George, O., & Gichuhi, M. N. (2018). Allelopathic effect of Bidens pilosa on seed germination and growth of Amaranthus dubius. *Journal of Asian Scientific Research*, *8*(3), 103.

Khoursheed, R. M., & Hassan, D. S. (2022). Effect of Artemisia vulgaris l. aqueous extract on some germination properties and seedling growth of linseed. *Iraqi Journal of Market Research and Consumer Protection*, *14*(2), 82-89.

Li, J., Chen, L., Chen, Q., Miao, Y., Peng, Z., Huang, B., Guo, L., Liu, D., & Du, H. (2021). Allelopathic effect of Artemisia argyi on the germination and growth of various weeds. *Scientific reports*, *11*(1), 4303.

Mallik, B. B. D., Acharya, B., Saquib, M., & Chettri, M. (2014). Allelopathic effect of Artemisia dubia extracts on seed germination and seedling growth of some weeds and winter crops. *Ecoprint: An International Journal of Ecology*, *21*, 23-30.

Rehman, S., Shahzad, B., Bajwa, A. A., Hussain, S., Rehman, A., Cheema, S. A., Abbas, T., Ali, A., Shah, L., & Adkins, S. (2019). Utilizing the allelopathic potential of Brassica species for sustainable crop production: a review. *Journal of plant growth regulation*, *38*, 343-356.

Turk, M., & Tawaha, A. (2003). Allelopathic effect of black mustard (Brassica nigra L.) on germination and growth of wild oat (Avena fatua L.). *Crop protection*, *22*(4), 673-677.

Wang, C., Wu, B., & Jiang, K. (2019). Allelopathic effects of Canada goldenrod leaf extracts on the seed germination and seedling growth of lettuce reinforced under salt stress. *Ecotoxicology*, *28*, 103-116.

Wang, X.-L., Zhou, L., & Lu, C.-Y. (2018). Allelopathic effects of exotic mangrove species Laguncularia racemosa on three native mangrove species in China.

Xie, Y., Tian, L., Han, X., & Yang, Y. (2021). Research advances in allelopathy of volatile organic compounds (VOCs) of plants. *Horticulturae*, *7*(9), 278.

Appendix 1:

ANOVA table for germination

A N A L Y S I S O F V A R I A N C E T A B L E

K	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	46.388	15.463	408.8566	0.0000*
4	Factor B	2	1.537	0.768	20.3168	0.0000*
6	AB	6	1.202	0.200	5.2959	0.0013*
-7	Error	24	0.908	0.038		
	Total	35	50.034			

*= Significant results, NS= Non significant results

Appendix 2:

ANOVA table for radicle length

A N A L Y S I S O F V A R I A N C E T A B L E

K	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	46.388	15.463	408.8566	0.0000*
4	Factor B	2	1.537	0.768	20.3168	0.0000*
6	AB	6	1.202	0.200	5.2959	0.0013*
-7	Error	24	0.908	0.038		
	Total	35	50.034			

*= Significant results, NS= Non significant results

Appendix 3:

ANOVA table for plumule length

A N A L Y S I S O F V A R I A N C E T A B L E

K	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	18.622	6.207	506.4959	0.0000*
4	Factor B	2	0.331	0.166	13.5050	0.0001*
6	AB	6	0.293	0.049	3.9816	0.0066*
-7	Error	24	0.294	0.012		
	Total	35	19.540			

*= Significant results, NS= Non significant results

Appendix 4:

ANOVA table for fresh weight

ANALYSIS OF VARIANCE TABLE

K	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	1.179	0.393	45.7368	0.0000*
4	Factor B	2	0.211	0.105	12.2603	0.0002*
6	AB	6	0.099	0.016	1.9117	0.1200NS
-7	Error	24	0.206	0.009		
	Total	35	1.694			

*= Significant results, NS= Non significant results

Appendix 5:

ANOVA table for dry weight

ANALYSIS OF VARIANCE TABLE

K	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	0.135	0.045	23.4806	0.0000*
4	Factor B	2	0.163	0.082	42.6468	0.0000*
6	AB	6	0.096	0.016	8.4065	0.0001*
-7	Error	24	0.046	0.002		
	Total	35	0.440			

*= Significant results, NS= Non significant results

Appendix 6:

ANOVA for moisture content

ANALYSIS OF VARIANCE TABLE

K	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	1163.556	387.852	1.4454	0.2544NS
4	Factor B	2	1577.389	788.694	2.9392	0.0721
6	AB	6	10641.944	1773.657	6.6099	0.0003*
-7	Error	24	6440.000	268.333		
	Total	35	19822.889			

*= Significant results, NS= Non significant results