**WHEAT RESPONSE TO WATER STRESS UNDER HUMIC ACID LEVELS**

**BY**

**MUHAMMAD BILAL**

*An internship report submitted to The University of Agriculture Peshawar in partial fulfillment of the requirements for the degree of*

**BACHELORS OF SCIENCE (HONS) IN AGRICULTURE**

**(AGRONOMY)**



**DEPARTMENT OF AGRONOMY**

**FACULTY OF CROP PRODUCTION SCIENCES**

**THE UNIVERSITY OF AGRICULTURE, PESHAWAR**

**KHYBER PAKHTUNKHWA-PAKISTAN**

**JULY, 2023**

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DEDICATION

Above and beyond all else, I extend my most sincere gratitude to the ALMIGHTY ALLAH for granting me the inquisitive spirit and essential capabilities to diligently accomplish this research endeavor. I offer special recognition to the Revered Prophet Muhammad (Peace be upon him), a perpetual source of enlightenment for humanity as a whole.My heartfelt appreciation and indebtedness go to my academic mentor, Dr. Zahir Afridi, the esteemed head of the Department of Agronomy at the University of Agriculture Peshawar, Khyber Pakhtunkhwa. His kindness, cooperation, constructive criticism, and unwavering support during the entirety of my academic and research journey have been invaluable. I hold his insightful guidance and supervision in high regard.Additionally, I cannot overlook the invaluable encouragement and prayers bestowed upon me by my mother. I wish to extend my heartfelt gratitude to all my family members who, at every challenging juncture of my educational and personal voyage, provided me with resolute moral, ethical, and financial support, as well as unwavering guidance.I deeply express my sincere thanks to my father, who stands as the cornerstone of my academic advancement.

(MUHAMMAD BILAL)

**WHEAT RESPONSE TO WATER STRESS UNDER HUMIC ACID LEVELS**

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**ABSTRACT:**

The study titled "WHEAT RESPONSE TO WATER STRESS UNDER HUMIC ACID LEVELS” was conducted in pots at the Amir Muhammad Khan Campus in Mardan during the period of 2022-23. The experimental design employed a complete randomized layout with three replications. The study encompassed three levels of humic acid application: 5 kg ha-1, 15 kg ha-1, and 20 kg ha-1, combined with four water levels (40%, 60%, 80%, and 100%). Numerous parameters were investigated, including days to germination, days to booting, days to anthesis, tillers per pot, spikes per pot, grain yield, biological yield, 100-grain weight, 1000-grain weight, and harvest index.The outcomes of the research highlighted significant effects on all parameters, with the exception of germination rate and root weight, which showed no statistical significance. The findings underscored that both humic acid application and water levels significantly influenced a wide range of parameters, including thousand-grain weight, grain yield, spike weight, total grains, grain weight, spikes, shoot weight, biological yield, grains per spike, days to booting, days to anthesis, tillers per pot, and spikes per pot. Notably, the treated pots reached maturity earlier than the control group. The onset of booting was observed at 10 kg ha-1 humic acid application and a field capacity of 40%, while early anthesis occurred at 10 kg ha-1 humic acid application and 80% field capacity. Enhanced spike weight was recorded at 20 kg ha-1 humic acid application and 80% field capacity. Furthermore, increased shoot weight was observed with both 10 kg ha-1 and 20 kg ha-1 humic acid applications, particularly at an 80% field capacity. Elevated biological yield was noted with 10 kg ha-1 humic acid application and an 80% field capacity. Moreover, higher spike density per pot was documented with 20 kg ha-1 humic acid application and 80% field capacity. Additionally, a greater number of grains per spike were found at 10 kg ha-1 humic acid application and 80% field capacity, while higher grain numbers were observed at 20 kg ha-1 humic acid application and 100% field capacity. Notably, increased grain weight was recorded at 20 kg ha-1 humic acid application and 100% field capacity.In contrast, pots without humic acid application and under lower water regimes exhibited reduced values across the measured variables. In conclusion, the application of humic acid and adjustment of water levels demonstrated a positive influence on various growth parameters, ultimately enhancing grain and biological yields. These findings suggest the potential of humic acid and water management strategies in improving wheat performance, particularly under conditions of drought stress.

I INTRODUCTION

Wheat (Triticumaestivum L.) has been playing an important role in devolepment of civilization since immorial time and is the serial of choice in many countries of the world.it is a chief source of food for a great deal of population and is known as king of cereals .It is staple food for the people of Pakistan and meats the major dietry requirements and supplies about 73% of calories and protein of average diet. In 2020, wheat production for Pakistan was 24,946 thousand tonnes. Wheat production of Pakistan increased from 6,476 thousand tonnes in 1971 to 24,946thousand tonnes in 2020 growing at an average annual rate of 3.11% (Govt of Pakistan). Wheat is nutritious food rich in proteins, minerals, vitamins and dietary fiber (Afzal et al., 2013; Kumar et al., 2011). It is being used as staple food in Pakistan and fulfils the 60% of total calories and protein needed for the daily life and about 65% of the wheat grain is used by humans worldwide (Khan et al., 2009). According to Ayaz (2016), there is a direct relationship between biological yield and 100 grain weight and also between 100 grains weight with grains yield among various wheat genotypes. The genotypes developed and adapted in a particular agroecological zone usually remain sufficiently stable for the expression of morpho-physiological characters but occasionally behave differently when exposed to other zones with different growing conditions. Changing crop phenology is considered an important bio-indicator of climate change, with the recent warming trend causing advancement in crop phenology. The effects of climate change on crop phenology have interacted with the effects of changes in crop management, such as modified sowing dates and changing genotypes (Liu et al., 2009). Wheat research in Pakistan has been a success story.

Abiotic stress like deficient for crop growth and development might influence the quantity and quality of seed (Younasi and Moradi, 2009).Water stress reduce crop yield and hence a considerable importance for agriculture research (Zhang et al., 2008).Crop adopted to stresses modify its metabolic and morphological processes in response to water stress (Tohidi-Moghadam et al., 2009).Water stress during grain formation stage interferes development and hence result poor seed formation (Cruz-Aguado et al.,2000).The reduction in seed size is mainly due to reduction grain filling period compared to inhibition of seed growth rate (Younasi and Moradi,2009).ater stress decrease dry matter production and grain yield and yield related traits and phonological traits(Ramirez et al.,2006.

Physiological proceses like photosynthesis,cell turgidity and cells growth are substainly influenced by water stresses (Tahir et al.,2007).photosynthesis decrease (Huxet et al., 1997) under dought stress conditions.High electron leakage in photosynthetic and respiratory processes in drought stress induced oxidative stress in the plant cell.Enhance of the reactive oxygen species(ROS) generations takes place(Tauhedi-monghadam et al., 2009).(Gumasekara et al., 2006) in flower formation and pod intiation.Supplimental irrigation applied at grain filling stage increased the grain yield(Wang et al., 2005).(Hang et al.,2008)indicated that irrigation during stem elongation increased grain yield in non irrigating conditions.(Gutteri et al., 2001) also evaluated the determental effect of water stress on grain yield by reducing kernel growth rate,whereas (Altenbach et al., 2003) reported reduced grain size and yield by shortening of grain filling stage.

Humic acid is orgainic fertalizer comprised of essential nutrients involving in increasing in fertility of soil and availability of nutrients hence increases crop growth and yield by mitigating water stress condition (Tufencki et al ., 2006).Humic acid consist of 51 to 57% Carbon,4 to 6%Nitrogen,and 0.1 to 2%P that might inhances crop growth and production through its addition to crop (Sharif et al.,2002).Humic substance have considerable impact on growth and devolpment of crop plants roots.Application of humic acid to soil inhanced root growth and devolpment (Koopal et al.,2005).The application of humic acid due to its orgainic nature may increase orgainic matter yield as compared to control. (Delfineet et al.,2005).Its also improve nitrogen us efficiency and enhances shoot and root growth of crop by improving oil physic-chemical traits i.e.water holding capacity,PH and thermal insulation(schnitzer,2001).It also fixes macro and micro nutrients,enzyme activation and inhibition variation in membrane permeability ultimately enhance crop growth and yield and protein synthesis (Steveson,2009).Inamullah and Ali(2014) reported that application of humic acid improved crop growth traits i.e.spikes m-2,grain spike-1and biological yield respectively when compared to control.An increase in photosynthetic pigments ,total carbohydrates ,polysaccharides,proline and straw yield of the crop occurred due to application of humic acid.

**OBJECTIVES:**

Hence the current study is initiated with the aim to determine the influence of humic acid to incounter effect of drought stress

**II REVIEW OF LITERATURE**

Sharif et al.,(2002) studied the effect of different levels of humic acid on growth of maize plants. humic acid (HA) derived from lignitic coal on the growth of maize (*Zea mays*L. Kissan). HA was sprayed on soil at the rate of 0, 50, 100, 150, 200, 250, and 300 mg kg−1 soil along with uniform dose of nitrogen–phosphorus–potassium (NPK) (120–90–60 kg ha−1). The addition of 50 and 100 mg kg−1 HA caused significant  increase of 20 and 23% in shoot and 39 and 32% in root dry weight of maize plants as compared to control. The increasing levels of HA above 50 and 100 mg kg−1 produced no significant effect on maize yield. Soil organic matter content was improved slightly (7 to 14%) and pH values were decreased by 0.2 to 0.3 unit by the HA treatments.

Delfinee et al.,(2003) conductecd an experiment in order to study the effect of foliar application of humic acid and nitrogen on durum wheat in mediterian type environment. This effect has significantly effect on grain yield, spike fertility and grain protein content during the two years of the study. Humic acid never affected photosynthesis or stomatal conductance, while Rubisco activity and leaf protein content showed intermediate responses between unfertilized control and split soil N application. We conclude that humic acid had limited promoting effects on plant growth, grain yield and quality, and photosynthetic metabolism of durum wheat crops grown in a typical Mediterranean-type agro-ecosystem of southern Italy, with respect to split soil N application..

Gumasekara et.,al(2006) study the effect of drought stress at different growth stages on qualitative and quantitative traits and some agronomic traits of four canola cultivars. The results indicated that drought stress treatments had significant affect on seed yield, number of seeds.pod-1, number pod per plant, number of branches per plant, 1000-seed weight, plant height and oil content. In this experiment, stress at flowering stage had the most effect on pod number per plant, number of seeds per pod, number of branches per plant and plant height. Seed forming stage was the most sensitive stage, so that 1000-seed weight and oil content were decreased in this stage. The highest (3151.25 kg.ha-1) and lowest (2377.08 kg.ha-1) seed yield belonged to full irrigation and stress at flowering stage, respectively. Cultivar factors had significant effect on seed yield, yield components, number of branches per plant, plant height and oil content. The highest (2925 kg. ha-1) and lowest (2523.7 kg.ha-1) seed yield belonged to Hyola401 and Zarfam, respectively. Interaction effects of drought stress×cultivar had an effect on seed yield, yield components and hadn’t significant effect on other traits. Also, results of this experiment indicated that stress at flowering stage is more sensitive to water deficit due to pod number per plant and number of seeds per pod. So, Hyola401 cultivar is recommended due to having higher seed yield and yield components in western Iran

MOHAMMAD et al.,(2009)In order to study the effect of different levels of humic acid on yield and yield components of Results showed that different levels of humic acid imposed a significant effect on the yield parameters such as grain yield, biomass, leaf area index, leaf area duration, height, row number and ear length, but there were no significant effects on harvest index, 1000-grain weight, ear diagonal, and grain number per row did not have significant effect. According to the results, the highest and lowest grain yield belonged to 3500 g.ha-1 humic acid and control treatments respectively. The highest biomass production observed to 4500 g.ha-1 humic acid treatment. While the highest row number and ear length belonged to 3500 gha-1 humic acid treatments. Generally, it seems that application of humic acid due to having nutritional ingredients and different physiological effects improves corn performance and reduces environmental pollution and it could be used as a natural material to increase and stabilize field crop production.

Inamulllah and ali (2011) studied impact of sulphur and humic acid on wheat. More spikes m-2 (502), grains per spike (55) and biological yield (11380 kg ha-1)with humic acid @ 1, 6 and 3 kg ha-1 as compared with 416, 51 and 9614 kg ha-1 with 0 kg HA ha-1 respectively Similarly, higher 1000 grains weight (44.72 g) and grain yield (4325 kg ha-1) were produced with HA 2 kg ha-1 as compared with 42.01 g and 3208 kg ha-1 from control. Based on the results, it is recommended that humic acid 1 kg ha-1 in combination with sulfur 30 kg ha-1 may be applied to get higher grain yield of wheat in the agro-climatic conditions of Peshawar.

Zia ul islam et al.(2011) evaluated the effect of humic acid on growth and oil content of brassica compestris. The growth, yield and oil content of three mustard varieties viz., S-9, P-78 and AH-2001 were observed under varying levels of humic acid application to a poorly fertile and alkaline-calcareous soil. The humic acid was applied to soil at the time of sowing 0, 3.17, 6.35, and 9.35 kg acre-1. Overall varieties, compared to control, the application of humic acid 6.35 kg acre-1 positively affected almost all the growth and yield parameters. The variety S-9 responded comparatively better to all application rates of humic acid than its other two counterparts.Malik et al.,(1985) studied the effect of humic acid on seedling growth of wheat. Small concentrations (54 mg/l) of humic acid in the water medium resulted in a 500% increase in root length. Fresh and dry weight of roots also increased significantly due to humic acid. Dry matter yield of shoots increased by 22% in the presence of 54 mg/l humic acid. Moisture uptake and N content increased significantly. n N-free medium, humic acid caused a significant increase in the growth of roots and shoots as well as moisture uptake and N content of the seedlings. A maximum growth effect was obtained at 54 mg/l humic acid. In the presence of N, root and shoot growth was retarded. However, N uptake by the seedlings was enhanced by 22% in the presence of 54 mg/l humic acid.

Mohammadi et al.,(2011)study the effect of nitrogen fertilizer and foliar spraying of humic acid on yield and yield components of cowpea. Results showed that, the effect of humic acid spraying and also nitrogen fertilizer on all studied traits had significant differences in 1% significance level. Interaction effect of humic acid and nitrogen fertilizer on seed yield, plant height, number of pods per plant and number of seed per pod was significant in 5% level and on other traits was non significant. Among humic acid treatments, the highest seed yield was recorded from use of 50 mg/L humic acid spraying with 1486 kg/ha. Among nitrogen fertilizer treatments, the maximum seed yield was recorded from use of 45 kg/ha pure nitrogen with 1566 kg/ha. The highest seed yield between interaction effect levels was recorded from h3n4 (50 mg/L humic acid spraying along with 45 kg/ha pure nitrogen) treatment.

Tahir et al.,( 2011) studied the effect of lignite derived humic acid on two different types of soil. wheat grown in earthen pots under greenhouse conditions. On an average of both soils, the largest increases in plant height and shoot fresh and dry weights were found with HA2 (60 mg kg−1 soil), being 10%, 25%, and 18%, respectively, as compared to the control without HA (HA0). Both soils responded positively towards HA application. The HA application significantly improved K concentration of the non-calcareous soil and P and NO3-N of the calcareous soil. The highest rate of HA (90 mg kg−1 soil) had a negative effect on growth and nutrient uptake of wheat as well as nutrient accumulation in soil, whereas the medium dose of HA (60 mg kg−1 soil) was more efficient in promoting wheat growth.

Anas et.,al (2015) conducted an experiment in order To investigate the response of wheat to different levels of nitrogen (N), zinc (Zn) and humic acid (HA).Results showed that N application at the rate of 160 kg ha-1 manifested maximum days to physiological maturity (164 days), productive tillers m-2 (248), spikes m-2(258), leaf area tiller-1 (113.6 cm2), spike length (10.4 cm), grains spike-1(52), 1000-grain weight (47.5 g), biological yield (9260 kg ha-1), grain yield (3723 kg ha-1) and harvest index (40%). Zn treated plots at the rate of 12 kg ha-1showed maximum days to physiological maturity (162 days), productive tillers m-2 (241), spikes m-2(252), grains spike-1(51), 1000-grain weight (45.2 g), biological yield (8843 kg ha-1), grain yield (3375 kg ha-1) and harvest index (39 %). Similarly, HA treated plots at the rate of 12 kg ha-1revealed maximum days to physiological maturity (162 days), productive tillers m-2 (238), spikes m-2(249), spike length (9.7 cm), 1000-grain weight (45.00 g), biological yield (8649 kg ha-1), grain yield (3342 kg ha-1) and harvest index (39%). The combined application of N, Zn, and HA had significantly affected wheat yield and yield components. It was concluded that N at the rate of 160 kg ha-1, Zn 12 kg ha-1 and HA 10 kg ha-1 significantly increased yield and yield components of wheat.

Naik et al.,(2016) conducted an experiment in order to study the impact of humic acid on root growth and yield component of redgramm. he effectiveness of humic acid was studied with different levels as T1 - Humic acid liquid 15% @ 1.0 ml/l of water, T2 - Humic acid liquid 15% @ 1.5 ml/l of water, T3 - Humic acid liquid 15% @ 2.5 ml/l of water, T4 - Humic acid liquid 15% @ 4.0 ml/l of water, T5 - Planofix 4.5 % @ 20ppm and T6 - as a control. Redgram root growth including root length, shoot length, root dry weight , shoot dry weight , leaf area, dry matter production, flower drops, minerals content (quality), and yield components were measured at 60,90 DAS and at harvest, respectively. Significant differences (p<0.05) were observed for all the above mentioned parameters across the humic acid levels. Based on this study, the foliar application T4-Humic acid liquid 15% @ 4.0 ml/l of water might be recommended to improve growth physiology, quality and yield components of Redgram in similar environmental condition

Naeem etal conducted an experiment in order to study different levels of water on wheat. Wheat cultivar AS-2002 recorded highest grain yield (4821.5 kg ha-1) which was significantly higher than the other two cultivars. Wheat crop supplied with five irrigations at crown root + tillering + booting + earing + milking recorded the highest grain yield (5696.8 kg ha-1) which was significantly higher than all the other irrigation levels. At highest irrigation level I5, cultivars AS-2002 and SH-2002 produced grain yield at par but significantly higher than Aqab-2000. At all the other irrigation levels, cultivar AS2002 recorded significantly higher grain yield than the other two cultivars.

Khan et.,al (2016)Conducted an experiment to study the effect plant derived humic acid (PDHA) and coal derived humic acid (CDHA) on wheat growth was tested on two alkaline calcareous soils in pots. Data was collected on plant growth parameters such as spike weight, grain and straw weight, and plant nutrients (macronutrients and micronutrients). Results showed that spike weight increased by 19, 15, and 26, and 11% with application of PDHA at the rate of 50 and 100 mg/kg in clayey loam and sandy loam soil respectively. Grain yield show an increase of 21, and 11% over control with application of PDHA and CDHA at the rate of 50 mg/kg on both soils respectively, and 10, 22% with application of PDHA and CDHA at the rate of 100 mg/kg on both soils.

Finekher (2016) studied the effect of foliar application of humic acid on its component on grain yield of sorghum.. The highest grain yield in both season was 4.395 and 5.213 ton.ha-1 respectively when plants were sprayed at the concentration of 3 cm3 L -1 . Foliar application at the stage of vegetative growth gave highest mean in plant height, leaf area, biological yield, grain weight head-1 , number of grain.head-1 and grain yield (ton.ha-1 ). The highest grain yield in spring and autumn seasons was 4.120 and 4.928 ton.ha-1 respectively by foliar application at vegetative growth. The results showed a significant interaction between application stages and humic acid concentrations in means of grain yield. The higher grain yield of 6.070 and 5.380 ton.ha-1 were obtained when Sorghum plants were sprayed with humic acid at the concentration of 3 cm3 .L-1 in vegetative growth stage in spring and autumn seasons respectively.

KAHRAMAN ALI(2017)) conducted A experiment in order to study the effect the effect of humic acid (HA) on the yield and nutritional characteristics of cowpea varieties to provide an alternative crop for sustainable agricultural systems... Results showed that, 1000 seed weight, seed yield, protein yield, potassium and manganese showed an increasing tendency by increased dose of humic acid. Furthermore, 70 kg ha−1 dose of humicacid recorded higher stomatal conductance and first pod height, while applicationof 110 kg ha-1 of humic acid recorded higher plant height and protein ratio

Abbas and Gholinzad (2017) studied the effect of soil application of humic acid on grain yield and yield components. The results showed that drought stress reduced dry weight of leaf, number of grains and pods, total dry weight and grain yield. Application of humic acid in two years increased the value of all studied traits under full irrigation. In the first year, application of 2.5 and 5 mg humic acid increased 1000-grain weight, and total and leaf dry weight under drought stress conditions, respectively. In the second year, with higher consumption of humic acid, grain yield, total dry weight and harvest index increased significantly under drought stress conditions. Application of 7.5 mg humic acid in the second year, produced the highest proline under optimum irrigation (393.10 mg kg-1 DW) and drought stress (507.90 mg kg-1 DW) conditions.

Ahmad et.,al.(2019) conducted a pot experiment in order to see the effect of plant derived humic substances (PDHS) on chickpea crop grown in 5.50 kg soil container, consisting seven treatments. Three seeds of chickpea variety *Dhasht* was sown in each pot which was thinned to one plant. Results show that highest plant height of 45cm was obtained when HS applied at the rate of 30 mg l-1as followed by 44.67cm where HS was applied @ 45mg l-1. The highest number of pods/plant-1 (22) were obtained in HS applied at the rate of 30 mg l-1 followed by 22.00 at the rate of 45 mg l-1. The maximum biomass wt. 14.24 g was received in 15 mg l-1followed by 30 mg l-1 having weight of 14 g. The highest straw weight of 8.78 g was obtained in 30 mg l-1 treatment. The highest seed weight of 5.64g was received in 15 mg l-1The highest pod length of 11.86 mm was obtained in 45 mg l-1, while the highest pod diameter 17.57 mm was obtained in 45 mg l-1. The highest pod weight of 8.27 g was received in 45mg l-1.

Jihad et .,al(2019) conducted an experiment in order to investigate, to investigate the impact of humic acid and organic and inorganic nitrogen sources on maize crop. Humic acid, organic manures and basal dose of P2O5 and K2O were applied at sowing time while N was applied in two splits. Results showed that humic acid application significantly increased days to tasseling (53.80), silking (58.66), maturity (98.66), leaf area (526.86 cm2), plant height (209.13 cm), cob length (17.18 cm), grains cob-1 (398.87), 1000-grains weight (328.80 g), biological yield (12725 kg ha-1), grain yield (4616.7 kg ha-1) and harvest index (36.17 %) over control. In case of N sources, late tasseling (55.66) days, silking (60.33) days, maturity (98.66) days, highest leaf area (555.44 cm2) and plant height (213.50 cm) were observed in case of Poultry manure treatment. Whereas, maximum cob length (18.30 cm), grains cob-1 (431.33), 1000-grains weight (344.17 g), biological yield (13671 kg ha-1), grain yield (5169.7 kg ha-1) and harvest index (37.77 %) were recorded in plots receiving N from compost. Hence, the results concluded that compost and poultry manure as N sources with integration of humic acid were found most suitable for maximum values of growth and yield attributes, particularly grain yield (5169.7 kg ha-1).

Maruf.et al (2019)conducted an experiment in order to evaluate the impact of adding various levels of Humic Acid and Sulfur rates on maize yield and yield components.. The results showed that the effect was significant at (P < 0.05) on the reproductive growth criteria of a maize plant. The number of kernels per ear, the weight of 100 kernels (g), kernel yield (ton ha-1 ), biological yield (ton ha-1 ), harvest index and relative yield maize plant from both of locations. While the results showed that the humic acid and sulfur application significantly affected of the number of kernels per raw from Kanipanka and of the ear diameter (cm) from Qlyasan, it did not affect the number of kernels per raw from Qlyasan location and by the ear diameter (cm) from Kanipanka location.

**Taiba Walayat et. al(2023)**conducted to determine the best dose and potential of humic acid (HA) in combination with synthetic fertilizers. to find the effect of humic acid on yield and yield components of wheat crop (Triticum aestivum L. cv. Juahar-16).  The results obtained showed that maximum yield of 5781 kgha-1, 1000 grain weight (g) and spike length (cm) were obtained from T5 (16 kgha-1 HA) that was at par with T4 (12 kg ha-1 HA) and T3(8 Kg ha-1 HA). Hence the best dose of humic acid for wheat is T3 (8 kgha-1 HA) that showed an increased yield by 3.63 times over the control under Bahawalpur conditions. Results suggested that effect of applied HA on plant growth with chemical fertilizers to soil increased grain yield of wheat from 1.5 to 5.45 times over the control. It was found that the highest yield was obtained in T5 treatment and the second-best results were obtained with T4 treatment, but it has a high cost, while treatment T3 was the most significant economically and yielded high income when compared to other treatments. Hence, it has been concluded that HA has a great potential to increase grain yield production and to improve the soil fertility on a sustainable basis.

# Sobhi et.,al(2023) conducted an experiment in order to study the effect ofDifferent physiological and agronomic traits were significantly affected by humic acid doses and growth stages. Overall, the lowest values of CC, FSA, PC, PH and GY were noted for H0, whereas H4 resulted in the highest values of these traits. Grain yield was 3882.82 kg ha−1 in H0 and increased to 4988.14 kg ha−1 (28 %) in H4 dose of humic acid. The GY was decreased, whereas PC and PR increased in the second year of the experiment due to warmer and drier weather conditions. The highest PC values were noted in H0, and the PC values decreased with the increase in humic acid doses. The biological and biochemical composition of wheat (*Triticum aestivum*) as affected by the bio and organic fertilizers.

**III MATERIAL AND METHODS**

The experimented was conducted in order to study the effect of humic acid along with water on yield and quality of wheat under drought stress condition at AMK CAMPUS MARDAN during 2022. Five drought levels i.e.,100%field capacity(FC),80%(FC),60%(FC),40%(FC) were maintained on gravimetric basis. Mitigation of drought and humic acid was applied to the crop.Three levels of humic acid(10,15,20 kg hac¹).The crop was subjected to drought stress after complete emergence when the crop reached three to five leaves stage.a control plot where no humic acid used was included.The experiment was conducted in pots with three replications.The humic acid was applied in sowing time.

**TREATMENT COMBINATION**:

FACTOR A: WATER STRESS

1. 100%FC1
2. 80%FC2
3. 60%FC3
4. 40%FC4

FACTOR B: HUMIC ACID

1. H1 =10Kghac-1
2. H2 =15 Kghac-1
3. H3=20Kghac-1

CONTROLS:No humic is applid only water to maintain 20% moisture

**Paramaeters:**

The following parameter was study was study during this research.

**1.Days to germination stage**

**2.Days to booting stage**

**3.Days to anthesis s**

**4.Tellers per pot**

**5.Spikes per pot**

**6.Grain yield**

**7.Biological yield**

**8:100grain weight**

**9:1000grain weight**

**10:Harvest index**

**Procedure for collecting data**

**Days to germination stage**:

Seedling in each pot was counted.And counted from the days of sowing to germination date.This process was repeated second time

**Days to booting stage:**

The days to boot were counted from data of sowing till the swelling of flag leaf of 70% plant in each pot

**Days to anthesis:**

The anthesis stage lasts from the begging to the end of the flowering period. Pollination and fertilization occur during this period. All heads of a properly synchronized wheat plant flower within a few days and the embryo and endosperm begin to form immediately after fertilization. Numbers of days after sowing were counted when plants reached to anthesis stage.

**Tellers per pot:**

Tellers was counted after harvesting wheat.The number of tellers counted in plants per pot.And average does the work.

**Spike weight(g):**

Five samples from each pot were taken and then were weighed. The sample weight were averaged then

**Root and Stem weight(g):**

After harvesting each plant were converted to three pieces stem,root and spikes.And all are weighted separately with balance and averged them.

**1000-grain weight (g):**

After threshing, 1000-grains weight, by counting the grains of collected at random from each sub plot, was recorded and the counted grains were weighed to record 1000-grains weight.

**Biological yield:**

Biological yield was found out by harvesting the crop and was sun-dried for 10 days. The harvested crop was weighed using the balance

**Number of grain per pot:**

Five spikes of sample was taken from each pot and threshed them.And the grains was counted

**Harvest index (%)**

To calculate the harvest index the seed yield was divided by biological yield and was then multiplied by 100 to show the data as a percentage.

Harvest index (%) =

**Statiscal Analysis:**

The statistical analysis was performed for the collected data using appropriate procedure of analysis of variance (ANOVA) using RCB design in Statistix 8.1 software.

**IV RESULT AND DISCUSSION**

**Germinnation:**

The data regarding germination is presented in Fig 1.statiscal analysis revealed that the germination rate is decreased in treated pots as ccompared to control. The control group (untreated) has the highest germination rate with a value of (11.67), The treated group shows a lower germination rate of 10.48 compared to the control Among the Humic Acid treatments, HA 10 has the highest germination rate (11.17), while HA 20 has the lowest (10.58).The data regarding water levels. Field capacity 80% has the highest germination rate (12.00), while Field capacity 60% has the lowest (10.00).

**Days to Booting**:

The data regarding days to booting was presented in fig 2.statistical analysis revealed that the treated pots reached early to booting stage as compared to control.Average of the data revealed that treated pots taken(99.67) days as compared to control which take (100.67) days.Among humic acid levels HA20 reached to early booting(99.67) .while HA15 reached late to booting(100.17).The data regarding water levels. feild capacity 40% taken (99.11) days while field capacity 100% taken( 101.11 )days.our result is supported by anas et.,al(2015) who reported that application of humic acid increased the physiological maturity

**Days to anthesis:**

The data regarding days to Anthesis was presented in fig 3.statistical analysis revealed that the treated pots reached early to anthesis stage as compared to control.Average of the data revealed that treated pots taken(122.89) days as compared to control which take (124.0) days. .Among humic acid levels HA10 reached to early booting (122.17days).while HA20 reached late to booting(123.08) days.Among water levels feild capacity 40% taken 99.11 days while field capacity 100% taken 101.11 days.ou result is supported by jihad et al(2019) who reported tha humic acid appication significantly affect days to physiological maturity.

**Root weight**

The data regarding root weight of wheat presented in fig 4, studied analysis revealed that treated pots significantly Improved as compare to control. Simply water levels and humic acid means significantly affected. The root weight (1.50 g) obtained from treated pot and control (1.47g). More root weight (1.80g) obtained with 10kgha-1 humic acid while lower (1.36 g) with 15kgha-1, higher root weight (2.20g) produced with 80% field capacity while lower (1.76 g) produced with 40% field capacity.same result was reported by naik et al(2016) that different doses of humic acid increase dry weight of root

**Shoot Weight**

The data regarding shoot weight of wheat presented in fig 4, studied analysis revealed treated pots significant improved as compare to control. The water levels and humic acid means significantly affected.Higher shoot weight (2.03g) was recorded at treated pots as compared to control. More shoot weight (2.08g) was obtained from H1 while lower (1.87g) was obtained from H2, similarly high shoot weight (1.93g) was obtained at Field capacity 80% and lower (1.2g) was obtained from field capacity 60%. Contrary to Sharif et al.,(2002) who reported that foliar spray of humic acid increases shoot weight as compare to control.our result is also supported by naeem et al (2012) who reported that humic acid application increse weight of shoot.

**Spike weight (g)**

The data regarding spikes weight of wheat presented in fig 4, studied analysis revealed that treated pots significantly improved as compare to control. The water levels and humic acid means significantly affected. The higher spike weight 2.77g was recorded in treated pots as compared to control 2.51g. The humic acid treated pots with 20 kg HA ha-1 improved spikes weight 3.03g while lower 2.91g spike weight was obtained from 15 kg HA ha-1, similarly high spike weight 3.22g was obtained at field capacity 80 % and lower spike weight 2.66 g was obtained with FC 40 % . our result is supported by khan et .,al (2015) who reporte that due to humic acid application the spike weight is increased.

**Biological yield**

Biological yield of wheat is influenced by humic acid and water levels are presented in fig 4. Statistical analysis of the data showed that treated pots had significant effect on biological yield of wheat. Humic acid has significant effect on biological effect. Higher biological yield (6.40g) was recoded at treated pots and lower (6.28g) recorded at control pots. In treated pots of humic acid higher biological yield (6.85g) was recoded at H1 10kghac-1  while lower (6.24g) was obtained from H2 15kghac-1.While biological yield (7.33g) obtained from field capacity 80% water levels and lower (5.61g) was obtained from field capacity 40% .our result supported by finekher et a(2016)l who reported that application of humic acid increase the biological yeild

**Total grains**

The data regarding total grains of wheat presented in fig 5, studied analysis revealed treated pots significant improved as compare to control. Simply water levels and humic acid means significantly affected. The higher grains (228.39) recorded at treated while lower grains data (144.21) was recoded at control. In case of humic acid high grains data (258.14) was recoded at HA20 applied at the rate of 20kghac-1 and lower (240.83) was recoded at HA15 applied at the rate of 10kghac-1. Similarly, high grains data (289.22) was recoded at field capacity 100% and lower (216.78) was recoded at field capacity 60%

**Grains yield:**

. The data regarding grains weight of wheat presented in fig 5, studied analysis revealed treated pots significant improved as compare to control. Simply water levels and humic acid means significantly affected. The higher grains weight (11.67g) recorded at treated while lower grains data (9.25g) was recoded at control. In case of humic acid high grains weight (14.19g) was recoded at H3 applied at the rate of 20kghac-1 and lower (12.16g) was recoded at H2 applied at the rate of 15kghac-1. Similarly, high grains weight (15.17g) was recoded at field capacity 100% and lower (12.14g) was recoded at W1 field capacity 40% .contrary to result of Taiba walayat et.,al(2023) who reported that different doses of humic acid with fertalize(NPK)r increase grain yield.Inamullah and Ali(2011) also reported that different doses of humic acid increases gran yield.Abbas and Gohinzad(2017) also reported increase in grain yield due to humic acid

**Spikes Weight**

The data regarding spikes weight of wheat presented in fig 5 studied analysis revealed that control pots significantly improved as compared to treated pots. High spikes weight (2.77g) was recoded at treated pots as compared to control(2.51g). In case of humic acid more spikes weight (3.03g) was obtained from HA20 treated pots which was applied as 20kg/hac and lower spikes weight (2.82g) was obtained from H3 applied at rate of 25Kg/hac. In case of water levels high spikes weight (3.22g) was obtained from field capacity 80% and lower (2.66g) was obtained from Field capacity40%The same result was reported by .Inamullah and Ali (2011) who reported that application of humic acid increases weight of spikes.

**Spikes per pot**:

The data regarding spikes per pot of wheat presented in fig 5, studied analysis revealed treated pots significant improved as compare to control. Simply water levels and humic acid means significantly affected. The higher number of spike (5.7) data was recorded in treated pots while lower (4.33) was recoded in control. In treated pots of humic acid more spike are (5.9) was obtained from HA20kghac-1 and lower (5.7) was obtained from HA10 and in case of water levels high number of spikes (6.3) was obtained from Field capacity80% while lower (5.6) was recorded at Field capacity60% and 40%.

**Grains/spike**

The data regarding grains/spikes of wheat presented in fig 5, studied analysis revealed treated pots significant improved as compare to control. Simply water levels and humic acid means significantly affected. The higher grains/spike (32.56) data was recorded in treated pots while lower (20.90) was recoded in control. In treated pots of humic acid more grains/spike are (36.48) was obtained from HA10and lower (31.53) was obtained from HA15 and in case of water levels high grains/spike data (37.07) was obtained from Field capacity80% while lower (30.83) was recorded at Field capacity60%..our result is supported jihad et al (2019) reported that due to humic acid application grain per spikes is significantly increased.

**Summary**

An experiment was carried out in the agronomy department at Amir Muhammad Khan Campus Mardan involving a potted study. The primary objective of this study, conducted during the period 2022-2023, was to investigate the impact of humic acid and varying water levels on wheat growth.The experiment was designed using a complete randomized layout, with each treatment replicated three times. Several parameters were measured, including the time taken for germination, days to reach the booting stage, days to anthesis, the number of tillers and spikes per pot, grain yield (in grams), biological yield (in grams per hectare), 100-grain weight, 1000-grain weight (in grams), and harvest index (expressed as a percentage).

Results indicated that the application of humic acid and different water levels significantly influenced certain aspects of wheat growth. Notably, there were significant effects on the duration of the booting stage and anthesis, as well as on the weight of a thousand grains, grain yield (in grams per hectare), root weight (1.50g), shoot weight (2.10 g), spike weight (2.77 g), biological yield (6.36g), total grains (228.47g), individual grain weight (11.67g), number of spikes (5.70), and grains per spike (32.56g). These favorable outcomes were observed in pots treated with humic acid and adjusted water levels.

In contrast, pots that did not receive humic acid or specific water level adjustments (control group) exhibited lower values for root weight (1.47 g), shoot weight (1.87 g), spike weight (2.51 g), biological yield (6.11g), total grain count (144.21), individual grain weight (9.25g), number of spikes (4.33), and grains per spike (20.90).

Additionally, the application of methanol and humic acid did not show any significant impact on germination percentage or biological yield (in grams per hectare). Analyzing the data, it was evident that the pots treated with humic acid and optimized water levels displayed shorter germination times, faster progression to the booting stage, and quicker anthesis. Conversely, pots without humic acid and adjusted water levels took longer for germination, booting, and anthesis processes to occur.

**CITATION**

Ali, I.N., 2014. Assessment of various humic acid and sulfur levels for higher yields in wheat (Triticum aestivum L.). *Sarhad Journal of Agriculture*, *30*(1). Ali, I.N., 2014. Assessment of various humic acid and sulfur levels for higher yields in wheat (Triticum aestivum L.). *Sarhad Journal of Agriculture*, *30*(1).

Rajpar, I., Bhatti, M.B., Zia-ul-Hassan, A.N. and Tunio, S.D., 2011. Humic acid improves growth, yield and oil content of Brassica compestris L. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences*, *27*(2), pp.125-133

Hartwigsen, J.A. and Evans, M.R., 2000. Humic acid seed and substrate treatments promote seedling root development. *HortScience*, *35*(7), pp.1231-1233.

Delfine, S., Tognetti, R., Desiderio, E. and Alvino, A., 2005. Effect of foliar application of N and humic acids on growth and yield of durum wheat. *Agronomy for sustainable Development*, *25*(2), pp.183-191

Sharif, M., Khattak, R.A. and Sarir, M.S., 2002. Effect of different levels of lignitic coal derived humic acid on growth of maize plants. *Communications in soil science and plant analysis*, *33*(19-20), pp.3567**-**3580.

Tohidi-Moghadam, H.R., Shirani-Rad, A.H., Nour-Mohammadi, G., Habibi, D., Modarres-Sanavy, S.A.M., Mashhadi-Akbar-Boojar, M. and Dolatabadian, A., 2009. Response of six oilseed rape genotypes to water stress and hydrogel application. *Pesquisa Agropecuária Tropical*, *39*(3), pp.243-250

DuPont, F.M. and Altenbach, S.B., 2003. Molecular and biochemical impacts of environmental factors on wheat grain development and protein synthesis. *Journal of cereal science*, *38*(2), pp.133-146.

Wang, C., Yang, A., Yin, H. and Zhang, J., 2008. Influence of water stress on endogenous hormone contents and cell damage of maize seedlings. *Journal of integrative plant biology*, *50*(4), pp.427-434

Cruz-Aguado, J.A., Rodés, R., Pérez, I.P. and Dorado, M., 2000. Morphological characteristics and yield components associated with accumulation and loss of dry mass in the internodes of wheat. *Field Crops Research*, *66*(2), pp.129-139.

Barnabás, B., Jäger, K. and Fehér, A., 2008. The effect of drought and heat stress on reproductive processes in cereals. *Plant, cell & environment*, *31*(1), pp.11-38.

Ostmeyer, T., Parker, N., Jaenisch, B., Alkotami, L., Bustamante, C. and Jagadish, S.K., 2020. Impacts of heat, drought, and their interaction with nutrients on physiology, grain yield, and quality in field crops. *Plant Physiology Reports*, *25*, pp.549-568.

Mirzaei, A., Naseri, R., Moghadam, A. and Esmailpour-Jahromi, M., 2013. The effects of drought stress on seed yield and some agronomic traits of canola cultivars at different growth stages. *Bulletin Environmental Pharmacology Life Science*, *2*, pp.115-121.

Khan, R.U., Khan, M.Z., Khan, A., Saba, S., Hussain, F. and Jan, I.U., 2018. Effect of humic acid on growth and crop nutrient status of wheat on two different soils. *Journal of plant nutrition*, *41*(4), pp.453-460.

Kahraman, A., 2017. Effect of humic acid doses on yield and quality parameters of cowpea [Vigna unguiculata (L.) Walp] cultivars. *Legume Research-An International Journal*, *40*(1), pp.155-159.

Al-Beiruty, R.Z., Finekher, B.M., Khrbeet, H.K. and Al-Beiruty, R.Z., 2018. Foliar application of humic acid, it's components and effect on grain yield in Sorghum. *Journal of Research in Ecology*, *6*(2), pp.2032-2043.

Ghorbani, S., Khazaie, H., Kafi, M. and Bannayan Aval, M., 2010. Effects of humic acid application with irrigation water on yield and yield components of corn (Zea mays L.). *Journal of Agroecology*, *2*(1), pp.11-118.

Abhari, A. and Gholinezhad, E., 2019. Effect of humic acid on grain yield and yield components in chickpea under different irrigation levels. *Journal of Plant Physiology and Breeding*, *9*(2), pp.19-29.

Azarpour, E., Danesh, R.K., Mohammadi, S., Bozorgi, H.R. and Moraditochaee, M., 2011. Effects of nitrogen fertilizer under foliar spraying of humic acid on yield and yield components of cowpea (Vigna unguiculata). *World Applied Sciences Journal*, *13*(6), pp.1445-1449.

Khan, A., Khan, R.U., Khan, S., Khan, M.Z. and Hussain, F., 2020. Effect of plant derived humic substances on the yield of chickpea grown in greenhouse. *Pakistan Journal of Agricultural Research*, *33*(2), pp.321-326.

Walayat, T., 2023. Impact of Humic Acid Application along with Recommended Dose of Chemical Fertilizers (NPK) on Growth and Grain Yield of Wheat (Triticum Aestivum L.) Under Bahawalpur Conditions. *Tobacco Regulatory Science (TRS)*, pp.1674-1683.

Lamlom, S.F., Irshad, A. and Mosa, W.F., 2023. The biological and biochemical composition of wheat (Triticum aestivum) as affected by the bio and organic fertilizers. *BMC Plant Biology*, *23*(1), p.111.

Iqbal, A., Raza, H., Zaman, M., Khan, R., Adnan, M., Khan, A., Gillani, S.W. and Khalil, S.K., 2022. Impact of Nitrogen, Zinc and Humic Acid Application on Wheat Growth, Morphological Traits, Yield and Yield Components. *Journal of Soil, Plant and Environment*, *1*(1), pp.50-71.

Ali, J., Jamal, Y., Ismaeel, M., Ali, M., Dalil, M. and Babar, M., 2023. 11. Impact of humic acid with organic and inorganic nitrogen sources on growth and yield traits of maize (Zea mays L.). *Pure and Applied Biology (PAB)*, *12*(1), pp.103-115.

Maruf, M.T. and Mam-Rasul, G.A., 2019. Effect of humic acid and sulfur fertilizer levels on some physiological traits of maize (Zea mays L.) on calcareous soil. *Applied Ecology & Environmental Research*, *17*(6).

**TABLES**

**TABLE1: GERMINATION BOOTSTAGE AND ANTHESIS**

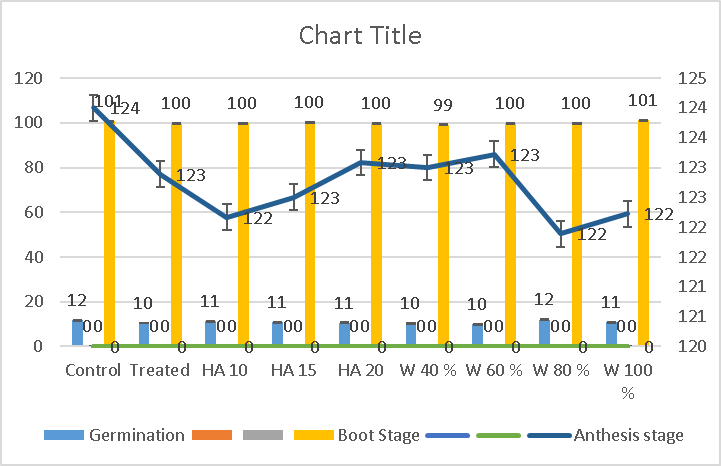
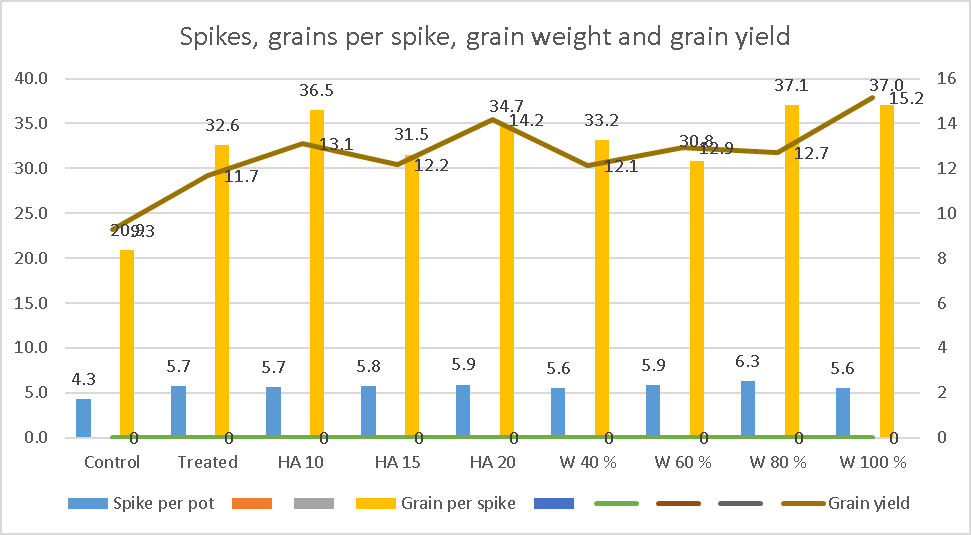
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TABLE 2: **SPIKES,GRAINS PER SPIKE,GRAIN WEIGHT AND GRAIN YIELD**



**APPENDANCIES**

**Analysis of Variance Table for ANTHSIS**

**Source DF SS MS F P**

Rep 2 8.1667 4.08333

Water 3 10.7500 3.58333 1.63 0.2786

Error Rep\*Water 6 13.1667 2.19444

HA 2 5.1667 2.58333 1.22 0.3225

Water\*HA 6 19.5000 3.25000 1.53 0.2314

Error Rep\*Water\*HA 16 34.0000 2.12500

Total 35 90.7500

Grand Mean 122.58

CV(Rep\*Water) 1.21

CV(Rep\*Water\*HA) 1.19

**Analysis of Variance Table for BOOTING STAGE**

**Source DF SS MS F P**

Rep 2 10.8889 5.44444

Water 3 19.0000 6.33333 2.85 0.1273

Error Rep\*Water 6 13.3333 2.22222

HA 2 2.8889 1.44444 0.81 0.4612

Water\*HA 6 19.3333 3.22222 1.81 0.1599

Error Rep\*Water\*HA 16 28.4444 1.77778

Total 35 93.8889

Grand Mean 99.944

CV(Rep\*Water) 1.49

CV(Rep\*Water\*HA) 1.33

**Analysis of Variance Table for GRAIN PER SPIKE**

**Source DF SS MS F P**

Rep 2 172.83 86.4158

Water 3 255.79 85.2626 1.43 0.3236

Error Rep\*Water 6 357.63 59.6051

HA 2 101.36 50.6800 1.34 0.2909

Water\*HA 6 184.79 30.7981 0.81 0.5763

Error Rep\*Water\*HA 16 607.33 37.9582

Total 35 1679.73

Grand Mean 34.517

CV(Rep\*Water) 22.37

CV(Rep\*Water\*HA) 17.85

**Analysis of Variance Table for GRAIN YIELD**

**Source DF SS MS F P**

Rep 2 178.450 89.2252

Water 3 47.946 15.9819 2.42 0.1644

Error Rep\*Water 6 39.634 6.6057

HA 2 19.476 9.7378 1.41 0.2728

Water\*HA 6 44.608 7.4346 1.08 0.4163

Error Rep\*Water\*HA 16 110.457 6.9036

Total 35 440.571

Grand Mean 13.232

CV(Rep\*Water) 19.42

CV(Rep\*Water\*HA) 19.86

**Analysis of Variance Table for GerMINNATION**

**Source DF SS MS F P**

Rep 2 40.500 20.2500

Water 3 19.889 6.6296 2.72 0.1370

Error Rep\*Water 6 14.611 2.4352

HA 2 2.167 1.0833 0.36 0.7002

Water\*HA 6 22.278 3.7130 1.25 0.3337

Error Rep\*Water\*HA 16 47.556 2.9722

Total 35 147.000

Grand Mean 10.833

CV(Rep\*Water) 14.40

CV(Rep\*Water\*HA) 15.91

**Analysis of Variance Table for RW**

**Source DF SS MS F P**

Rep 2 1.7885 0.89424

Water 3 3.2257 1.07523 5.66 0.0349

Error Rep\*Water 6 1.1394 0.18990

HA 2 1.2255 0.61275 2.98 0.0794

Water\*HA 6 5.4918 0.91530 4.45 0.0078

Error Rep\*Water\*HA 16 3.2900 0.20562

Total 35 16.1609

Grand Mean 1.6061

CV(Rep\*Water) 27.13

CV(Rep\*Water\*HA) 28.23

**Analysis of Variance Table for SLW**

**Source DF SS MS F P**

Rep 2 3.64436 1.82218

Water 3 1.15512 0.38504 4.11 0.0667

Error Rep\*Water 6 0.56249 0.09375

HA 2 0.23254 0.11627 1.34 0.2893

Water\*HA 6 1.83424 0.30571 3.53 0.0203

Error Rep\*Water\*HA 16 1.38649 0.08666

Total 35 8.81523

Grand Mean 2.0136

CV(Rep\*Water) 15.21

CV(Rep\*Water\*HA) 14.62

**Analysis of Variance Table for SPP**

**Source DF SS MS F P**

Rep 2 4.6667 2.33333

Water 3 3.6667 1.22222 1.10 0.4191

Error Rep\*Water 6 6.6667 1.11111

HA 2 0.5000 0.25000 0.20 0.8207

Water\*HA 6 9.5000 1.58333 1.27 0.3263

Error Rep\*Water\*HA 16 20.0000 1.25000

Total 35 45.0000

Grand Mean 5.8333

CV(Rep\*Water) 18.07

CV(Rep\*Water\*HA) 19.17