EFFECT OF PHOSPHORUS FERTILIZER ON PEA (*PISUM SATIVUM* L.) UNDER DROUGHT CONDITIONS

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Abstract

The aim of this research was to see how *Pisum sativum* responded to various simulated watering regimes in terms of morpho-physiological parameters. To test the morphological responses of *Pisum sativum*, a randomised experimental design was used to examine the effects of two stages of irrigation (well-watered and drought-stressed) and phosphorous (P) fertilisation treatment (with and without P). Even at the seedling level, taking into account these criteria are a quick and effective approach for selecting drought-tolerant plants. Phosphorus greatly decreased the detrimental effects of drought in pea seedlings, according to the findings. More physiological characteristics should be studied in the future. In order to devise effective conservation and management methods for this species, it is critical to investigate the fundamental metabolic pathways and effects of various stages of P fertilisation on *P. sativum* under drought conditions.

Key words: Pea (*Pisum sativum*), Water Stress, Leaf Biomass, Root Biomass, Stem Biomass

Introduction

In the current scenario, where drastic shifts in environmental factors are normal, identifying alternative solutions for rising crop production is a key field that must be prioritised in order to feed the world's growing population and ensure food security (Haggag *et al*., 2015). Stress is a neurological state that is changed as a result of conditions that cause an imbalance to be disrupted. Every physical and/or chemical alteration caused by a stress is referred to as strain (Gaspar *et al*., 2002). Drought is one of the most significant constraints to crop production around the world. Crop growth forecasts indicate that this problem will worsen in the future. Drought impedes natural growth, disrupts water interactions, and decreases the efficiency with which plants use water (Zlatev and Lidon, 2012). Following a cycle of water tension, the activity of indoleacetic acid oxidase was found to increase. While endogenous plant growth regulators regulate plant growth and morphogenesis through their action and interaction, the impact of water stress on these compounds has not been thoroughly investigated (Darbyshire, 1971). In the last two decades, the impact of drought on crop growth and yield has become more widespread across the world. Drought stress during crop growth is most severe during the reproductive period, and has a significant effect on yield and seed quality. Plant breeding's main aim is to improve crop growth and yield in drought conditions (Alqudah *et al*., 2011).

Many experiments in a variety of plant species have shown the value of having a sufficient supply of P during early crop growth and have illustrated plant adaptations for getting early season P. The importance of early season P for crop production was also addressed, as well as the consequences of developing management practices to maximise p supply for crop production. In *Pisum sativum* L. cv Sprite, the effects of nitrogen and phosphorus on seed yield and seed nutrient content were investigated. Increased plant nitrogen and phosphorus supply resulted in higher concentrations of the respective ingredient in the seed in both tests

(Browning & George, 1981). Plant populations of 50, 100, and 200 plants/m^2 had no impact on cvs seed generation in garden pea (*Pisum sativum* L.) grown for seed. Pania and Princess are a couple. In both cultivars, however, the prevalence of hollow heart increased as population density increased (Castillo *et al*., 1993). Significant variations in the amount of water ingested by whole seeds and seeds without their seed coats were found among four faba bean (*Vicia faba* L.) and four pea (*Pisum sativum* L.) cultivars (Rowland &and Gusta, 1977). Seed number, the most variable yield component of legumes is strongly affected by heat stress (HS) and water deficit (WD).

The pea (*Pisum sativum* L.) is an effective pulse crop, but due to its low yield stability, its growing area is small. The most important abiotic factor restricting plant survival and yield in many parts of the world is a lack of water, and crop production can only be improved by improving drought tolerance. One of the main tasks in breeding programs has been the creation of pea cultivars that are well suited to dry conditions. Breeding new cultivars for dry conditions in the traditional way involved intensive selection and testing for yield production in a variety of environments using different biometrical approaches. Drought tolerance has been linked to a number of morphological and biochemical characteristics, and approaches dependent on physiological attributes can be used to produce better varieties. The conservation of turgor pressure under water stress is aided by osmoregulation, and knowledge on genotype activity under osmotic stress can aid selection for drought resistance. In vitro tests, genetic transformation, and the use of molecular markers and mutations are all biotechnological techniques that may be helpful in pea breeding. In a minireview scientists summarized the present status of different approaches related to drought stress improvement in the pea (Magyar-Tabori *et al*., 2011). When drought conditions were removed, the internal water state improved quickly, as did most, though not all, plant growth parameters (Paez *et al*., 1983). Keeping all these facts in view, the objectives of the present research were to investigate the drought stress tolerance of *Pisum sativum* and to find out the effect of phosphorus fertilizer (SSP) in improving this tolerance.

Materials and Method

Soil analysis: The same amount of soil was collected from four treatments for testing the pH, Nitrogen, Potassium, Phosphorus, (N, P, and K) in the laboratory of Department of Biological Sciences, University of Veterinary and Animal Sciences, Ravi Campus, Pattoki.

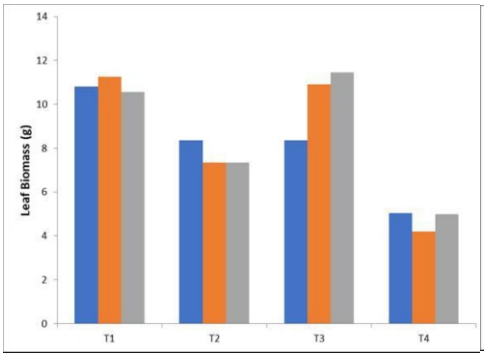
Experimental Design: Experiment on *Pisum Sativum* was conducted in the Department of Biological Sciences of University of Veterinary and Animal Sciences, Lahore, Pakistan. Twelve healthy plants of *Pisum sativum* were collected from Pattoki agriculture farm (Kacha Pakka) and transferred to pots. 800 grams of topsoil were filled in the pots and then placed the plants in it. Pots were irrigated and left for acclimatization for few days.

After 20 days, the plants were labeled with the name of T1a, T1b, T1c, T2a, T2b, T2c, T3a, T3b, T3c, T4a, T4b, T4c. The plants were given to three replicates of four treatments (3 replicates of each) for a month. In which, two treatments given to plants were well watered and watered stressed and other two were with fertilization levels (Phosphorus and without Phosphorous). 22 gram of phosphorus/treatment was weighed. Treatment of fertilizer (Single Super Phosphate) was repeated after few days in 35 mL water, for which the fertilizer was dissolved into water through vigorous shaking. To avoid the Environmental effect on the experiment, the position of pots was changed according to weather conditions. Following parameters were measured at the end of experiment;

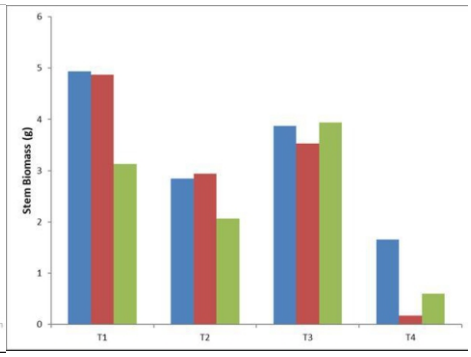
Leaf Biomass (gm): The leaves collected from each plant were weighed on weighing balance to obtain the fresh weight (FW). After that these were allowed to dry for few days. Leaf biomass was determined by using following formula;
Leaf Biomass (LB) = FW – DW

Root Biomass (gm): The roots collected from the plants then immediately weighed to obtain the fresh weight of roots and then allowed to dry for almost 40 days and again weighed to obtain the dry weight (DW) to measure the root biomass.
Root Biomass (RB) = FW- DW

Stem Biomass (gm): Stem were also weighed immediately after removing from the plants to find out the fresh weight of stems and then let them dry for 37-40 days and weighed again to determine the dry weight (DW) of stems to measure the stem biomass.

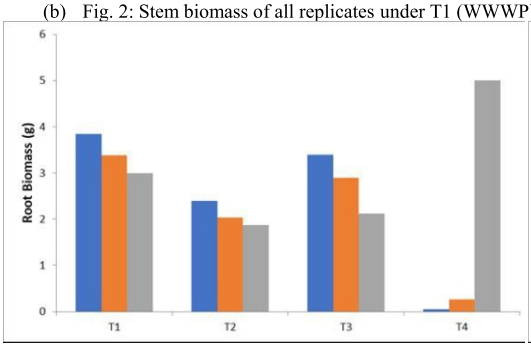


(a)



(b)

(a) Fig. 1: Leaf Biomass of all replicates under T1 (WWWP), T2 (WWNP), T3 (WSWP) and T4(WSNP).
(b) Fig. 2: Stem biomass of all replicates under T1 (WWWP), T2 (WWNP), T3 (WSWP) and T4(WSNP).



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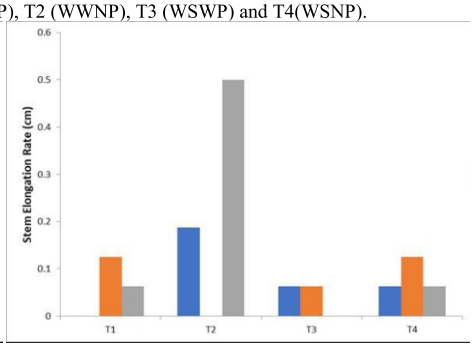
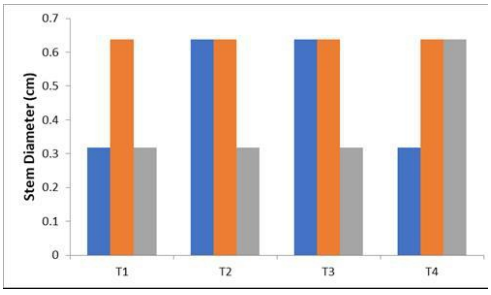


(d)

(a) Fig. 3: Root Biomass of all replicates under T1 (WWWP), T2 (WWNP), T3 (WSWP) and T4(WSNP)..
(b) Fig. 4: Stem Elongation Rate under T1 (WWWP), T2 (WWNP), T3 (WSWP) and T4(WSNP).



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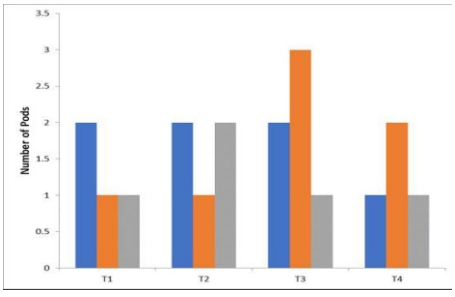
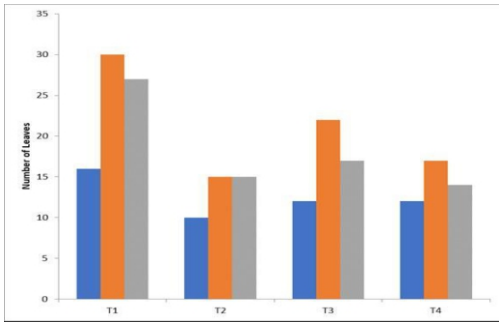


(f)

(e) Fig. 5: Stem diameter of all plants under T1 (WWWP), T2 (WWNP), T3 (WSWP) and T4(WSNP).
(f) Fig. 6: No. of pods in all pea plants under T1 (WWWP), T2 (WWNP), T3 (WSWP) and T4(WSNP).



(g)

Fig. 7: No. of leaves of all replicates under T1 (WWWP), T2 (WWNP), T3 (WSWP) and T4(WSNP).

Shoot Biomass (SB) = FW- DW

Plant Height and Stem Elongation Rate (SER): Height of 12 plants was measured before starting the treatment and after the treatment by using measuring tape. Duration of the total treatments was also part of this calculation. SER was calculated as follows;
Difference of the total height = Final height (H_2) – Initial height (H_1)
SER = Difference of the total height / t

Stem Diameter (cm): Circumference of 12 plants was measured at the end of treatment by using measuring tape. The diameter of 12 plants was found by using following formula;
Total diameter = Final reading – Initial reading

Number of Pods: No. of pods were counted at the end of the treatment as at the start seedlings do not have any pods.

Number of Leaves: The no. of leaves was calculated in the whole experiment and their readings are as follows:
Difference = Final reading – Initial Reading

Results

Soil analysis: The table 1 shows that the range of soil pH in the four treatments (twelve replicates) T1 to T4 is between 7.4 to 7.8 that means the soil is more basic. The soil of treatments T3 is more basic as compared to the rest of treatments. The level of Phosphorus and nitrogen in the soil of all the treatments (T1 to T4) is "trace" and the level of potassium is low in T1, T3 and medium in the T2 and T4.

Leaf Biomass (gm): The average weight of all treatments is 7.53 gram. Leaf biomass for individual replicates is given in Table 2.

The mean values of leaf biomasses of all treatments are not same and phosphorus has significant effect on Leaf biomasses ($P<0.05$). ANOVA also shows that Water and Phosphorus fertilizer have combined effect on Leaf biomasses of *Pisum sativum*.

Stem Biomass: The average stem biomass of all treatments was 2.87 gram. Stem biomass for individual replicates is given in Table 4.

Mean values of stem biomass of all treatments are not same and Phosphorus has significant effect on stem biomass ($P < 0.05$). ANOVA also shows that Water and Phosphorus fertilizer have combined effect on stem biomass of *Pisum sativum*.

Root Biomass (gm): The average weight of all treatments is 2.14 gram. Root biomass for individual replicates is given in Table 6.

Mean values of root biomass of all treatments are not same and Phosphorus has significant effect on stem biomass ($P<0.05$). ANOVA also shows that Water and Phosphorus fertilizer have combined effect on root biomass of *Pisum sativum*.

Table 1: Soil analysis of soil used in drought stress experiment.

Sr. No.	Parameter	T1			T2			T3			T4		
		A	B	c	a	B	C	A	b	C	A	B	c
01	pH	7.4	7.4	7.4	7.4	7.4	7.4	7.8	7.8	7.8	7.5	7.5	7.5
02	Phosphorus (P)	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
03	Nitrogen (N)	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
04	Potassium (K)	Low	Low	Low	Medium	Medium	Medium	Low	Low	Low	Medium	Medium	Medium

Table 2: Changes in leaf biomass, stem biomass, root biomass, stem elongation rate, stem diameter, no. of pods and no. of leaves of *Pisum sativum* for non-fertilized and fertilized treatments with and without water stress.

S. No.	Treatments	Replicates	Leaf Biomass (g)	Stem Biomass (g)	Root Biomass (g)	Stem Elongation Rate (cm)	Stem Diameter (cm)	No. of Pods	No. of Leaves
1	WWWP	T1a	10.82	4.94	3.84	0	0.3184	2	16
2		T1b	11.26	4.87	3.38	0.125	0.6369	1	30
3		T1c	10.55	3.13	3	0.0625	0.3184	1	27
4	WWNP	T2a	8.35	2.84	2.4	0.1875	0.6369	2	10
5		T2b	7.34	2.94	2.04	0	0.6369	1	15
6		T2c	7.35	2.06	1.87	0.5	0.3184	2	15
7	WSWP	T3a	8.35	3.87	3.39	0.0625	0.6369	2	12
8		T3b	10.91	3.53	2.9	0.0625	0.6369	3	22
9		T3c	11.46	3.94	2.12	0	0.3184	1	17
10	WSNP	T4a	5.05	1.66	0.05	0.0625	0.3184	1	12
11		T4b	4.2	0.17	0.26	0.125	0.6369	2	17
12		T4c	4.8	0.6	0.47	0.0625	0.6369	1	14

Note: WWWP stands for with water with phosphorus treatment; WWNP stands for with water no phosphorus treatment; WSWP stands for water stressed with phosphorus treatment; WSNP stands for water stressed no phosphorus treatment

Stem height and Stem Elongation Rate: The table 8 shows that the Stem elongation rate in the four treatments (Twelve replicates) was changed from T1 to T4. The average rate of stem elongation was calculated 0.5 cm.

Mean values of stem elongation rates of all treatment are not same and Phosphorus has significant effect on stem elongation rate ($P<0.05$). ANOVA also shows that Water and Phosphorus fertilizer have combined effect on stem elongation rate of *Pisum sativum*.

Stem Diameter (cm): Table 10 shows that as the quantity of phosphorus was changed, the diameter of stem was also changed. The average stem diameter is

0.504cm. A minor change was found throughout the whole experiment.

Mean values of stem diameter of all treatments are not same and Phosphorus has significant effect on stem diameter ($P<0.05$). ANOVA also shows that Water and Phosphorus fertilizer have combined effect on stem diameter of *Pisum sativum*.

Number of Pods: The table 12 shows the number of pods at the end of treatments.

Mean values of No. of Pods of all treatments are not same and Phosphorus has no significant effect on No. of Pods ($P>0.05$). ANOVA also shows that Water and Phosphorus fertilizer have combined effect on No. of Pods of *Pisum sativum*.

Number of leaves: No. of leaves was also changed after the whole experiment. The average number of leaves was increased from starting to end. Number of leaves was found in the WWWP plants (Table 14).
Mean values of No. of Leaves of all treatments are not same and Phosphorus has no significant effect on No. of Leaves ($P>0.05$). ANOVA also shows that Water and Phosphorus fertilizer have combined effect on No. of Leaves of *Pisum sativum*.

Discussion

In comparison to other treatments, the total minimum weight of WSNP is 4.68 g, which is a very small amount. The leaf masses are reduced due to a lack of water and phosphorus. WWWP and WSWP had masses that were very similar to each other, about 10 g. The WWNP value is in the middle of previous treatments. Phosphorus is an essential component in plant energy reactions. Deficiencies can affect nearly all energy-intensive processes in plant metabolism. Early in the growing season, phosphorus stress will limit crop output, resulting in a lower final crop yield. Deficiencies that occur early in the growth cycle have a greater negative impact on crop production than p constraints that occur later in the growth cycle (Grant *et al*., 2001). Water stress, whether applied during flowering or seed filling, resulted in a substantial decrease in pea DW and N accumulation. During these times, specific effects on yield were observed due to water stress. The duration of flowering was reduced and several flowers were aborted in the SF treatment as observed by Gallegos & Shibata (1989). Except for WSNP, there were no major shifts in the amount of pods during water stress in our Experiment. Pea seed yield was linked to the number of pods per unit area, which was also linked to water tension. Water tension has little impact on the number of peas per pod. (Martin & Jamieson, 1996). But for T1, the stem diameter was greatly increased. The diameter of the plant was influenced by water and fertilizer. In T2 treatments where plants were exposed to WWWP, the incidence of stem elongation was also high. The WSNP therapy has a significant impact on stem biomass. During this time, developing seeds exposed to high temperatures aborted, resulting in a decrease in pea seed production. We propose relevant parameters to diagnose an effect of high temperature where decreased yields are obtained by extrapolating these results to field conditions (Jeffery *et al*., 1990).

Conclusion

Drought stress has a significant impact on *P. sativum*'s development and metabolism. Under well-watered conditions, P application had little to no impact on morphological traits. However, P application has a significant positive effect on these characteristics, indicating that *P. sativum* is more droughts tolerant. These findings provide a foundation for further research into the morphological responses of *P. sativum* to drought stress and the beneficial effects of P fertilization on drought-stressed plants. If there are regular drought events, balanced P fertilization can help *P. sativum* seedlings in agriculture systems because P has a positive effect on drought tolerance. We recommend further research into the fundamental biochemical and molecular processes of drought stress, as well as the potential role of different levels of P fertilization in reducing the negative effects of drought or improving drought resistance in *P. sativum*.

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