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Physiological Studies of Phaseolus vulgaris L. in Medium Irrigated with Different Sources of Water from Otuoke, Bayelsa State, Nigeria

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Abstract

Physiological studies on *Phaseolus vulgaris* L. in medium irrigated with different sources of water obtained from Otuoke, Bayelsa State, Nigeria were conducted in the laboratory. Three (3) sources of water; stream water, rain water and tap water were used alongside a control (distilled water). Analysis of water samples for physico-chemical characteristics was conducted using standard procedures. 10 seeds of the test crop were sown in sterilized Petri dishes containing two sterile What-Man's filter paper per treatment and replicated five (5) times. The experimental set up was maintained in a growth chamber under light condition at 28±1^{o}C for two (2) weeks. Coefficient of velocity of germination, germination percentage, shoot length, root length, fresh weight and dry weight of the seedlings were determined. There were marked variations ($P < 0.05$) in pH value, contents of dissolved oxygen, biological oxygen demand, chemical oxygen demand, total dissolved solids, and total suspended solids as well as mineral elements contents of the three water samples. Similarly, the coefficient of velocity of germination, germination percentage and growth parameters such as shoot length, root length, fresh weight and dry weight of *P. vulgaris* varied significantly ($P < 0.05$) among the three treatments, although in most cases the germination and growth responses were comparatively lower than that of the control treatment. This study suggests that both nutrients and non- nutrients composition of irrigation water can influence the growth performance of the test crop.

Keywords: Physiological studies; *Phaseolus vulgaris;* water sources; Otuoke.

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1. Introduction

Incidents of water contamination may now become emergent, most especially in areas where industrial pollution and indiscriminate dumping of hazardous waste are prevalent [1, 2]. Water, as a major constituent of plant, serves as cheap structural material and biochemical reaction medium as well as an exchange for the needed carbon IV oxide in photosynthesis [3]. However, deterioration in water quality may be harmful to plant growth and development. The resultant deterioration in water quality may affect the homeostatic capacity of the aquatic ecosystem resulting in biological magnification problems. Similarly, most of these contaminated systems are irrigation water sources and are intensely utilized for crop production by local farmers [4, 5]. Certain growth stages have been shown to be particularly sensitive to water stress with the overall effects leading to functional decline on ultimate yield [3, 6]. Certain nutrients in soil and water are needed for optimum growth of plants, however, it functionality concentration increases from zero, deficiency, adequacy and finally toxicity [7, 8, 9]. *Phaseolus vulgaris* L. (Fabaceae) commonly called common beans has edible leaves often used in soups preparation with high protein content of the seeds, which makes it a valuable food for domestic consumption and as export crop [10, 11]. Otuoke is a local community with less or no efficient waste disposal systems with its attendants erosion of materials either into open land or nearby aquatic ecosystems both lotic and lentic. Therefore, this research was properly designed to assess the germination and growth response of *Phaseolus vulgaris* in medium irrigated with different water samples from the study area.

2. Materials and Methods

2.1. Collection and Analysis of Water Samples

Water samples (stream, rain and tap) were obtained from Otuoke, Bayelsa State, Nigeria. Analysis of water samples for physico-chemical characteristics was conducted using standard procedures [12]. Physico-chemical characteristics (pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand, total dissolved solids, total suspended solids, total nitrogen, phosphorus, calcium, magnesium, potassium, sodium, zinc, copper, iron, manganese and lead) of the water samples were examined. Distilled water was used as control.

2.2. Germination and Growth Studies

Seeds of *Phaseolus vulgaris* were obtained from local farmers in Yenagoa, Bayelsa State, Nigeria. Viable seeds were surface sterilized with 5% sodium hypochloride solution for 5 minutes. Surface sterilized seeds were washed several times with sterile distilled water and air-dried. 10 seeds of the test crop were sown in sterilized Petri dishes containing two sterile What-Man’s filter paper per treatment. The research design used was completely randomized design with five (5) replications for each treatment. The experimental set up was maintained in a growth chamber under light condition at $28\pm1^{o}C$ for two (2) weeks. Coefficient of velocity of germination, germination percentage, shoot length, root length, fresh weight and dry weight of the seedlings were determined at the end of the study (2 weeks).

2.3. Statistical Analysis

The mean values were obtained from the replicate readings and used to calculate standard errors. This was subjected to analysis of variance (ANOVA). The differences in the means were tested using Least Significant Difference (LSD) at 0.05 level of probability [13].

3. Results

The physico-chemical properties of water samples used for this study are presented (Table 1). The value for pH, and contents of dissolved oxygen, biological oxygen demand, chemical oxygen demand, total dissolved solids, and total suspended solids, as well as contents of mineral elements in the water samples are indicated in table 1. The highest value ($P < 0.05$) of coefficient of velocity of germination of the test crop was recorded in treatment containing rain water (0.23), relative to the control treatment with a value of 0.22. In addition, the values of 0.19 and 0.18 were recorded in treatment containing stream water and tap water, respectively, for coefficient of velocity of germination of the crop (Table 2). The germination percentage of the test crop indicated the highest value (80.40%) in treatment containing rain water, while treatment with stream water and tap water had the values of 79.25 and 68.25 %, respectively. These values were comparatively ($P < 0.05$) lower than that of the control treatment (82.30%) (Table 2). The shoot length of the crop indicated the values of 27.50, 25.40, 24.20 and 27.40cm in the control, stream water, tap water and rain water treatments, respectively (Table 3). Similarly, the root length of the crop recorded the values of 10.60, 8.80, 8.60 and 10.42 cm in the control, stream water, tap water and rain water treatments, respectively (Table 3). The highest value of fresh weight (2.10 g) of the crop was recorded in stream water treatment while the lowest value (2.06 g) was recorded in tap water treatment. These values were comparatively ($P < 0.05$) lower than that of the control treatment (2.14 g) (Table 3). In addition, the highest value of dry weight (0.44 g) of the crop was recorded in stream water treatment while the lowest value (0.40 g) was recorded in tap water treatment. The value of dry weight recorded in stream water was comparatively ($P < 0.05$) higher than that of the control treatment (0.43 g) (Table 3).

Table 1: Physiological Characteristics of water samples

Parameters	Stream water	Tap water	Rain water
pH	5.77±0.42	5.86± 0.30	6.30±0.23
Dissolved oxygen (mg/l)	6.60±0.33	6.82±0.65	5.92±0.17
Biological oxygen demand (mg/l)	19.82± 0.14	21.32±0.21	13.61±0.15
Chemical oxygen demand (mg/l)	40.09±1.20	42.16± 0.73	24.10±0.12
Total dissolved solids (mg/l)	130.07± 1.50	134.02±1.22	16.30±0.30
Total suspended solids (mg/l)	1.52±0.40	1.70±0.21	0.00±0.00
Total nitrogen (mg/l)	0.29±0.03	0.36±0.01	0.17±0.02
Phosphorus (mg/l)	0.52±0.01	0.68±0.04	0.03±0.01
Calcium (mg/l)	37.73±0.30	42.21±1.22	8.20±0.34
Magnesium (mg/l)	7.24±0.45	9.30±0.67	3.12±0.21
Potassium (mg/l)	4.21±0.32	6.72±0.54	1.33±0.32
Sodium (mg/l)	14.26±1.34	18.34±1.32	5.20±0.26
Zinc (mg/l)	0.05±0.01	0.06±0.02	-0.01±0.00
Copper (mg/l)	0.03±0.01	0.02±0.01	-0.01±0.00
Iron (mg/l)	0.22±0.02	0.29±0.06	0.02±0.01
Manganese (mg/l)	0.02±0.01	0.04±0.02	0.01±0.00
Lead (mg/l)	0.003±0.01	0.00±0.00	0.01±0.00

Mean ± Standard Error from 3 replicates

Table 2: Germination Parameters of *Phaseolus vulgaris* as affected by different water sources

Paramaters	Control(Distill water)	Stream water	Tap water	Rain water
Coefficient of velocity of Germination	0.22±0.01	0.19±0.02	0.18±0.01	0.23±0.03
Germination percentage (%)	82.30±0.46	79.25±0.70	68.23±0.32	80.40±0.57

Mean ± Standard Error from 3 replicates

Table 3: Growth Parameters of *Phaseolus vulgaris* as affected by different water sources

Paramaters	Control(Distill water)	Stream water	Tap water	Rain water
Shoot length (cm)	27.50±0.44	25.40±0.27	24.20±0.43	27.40±0.32
Root length (cm)	10.60±0.63	8.80±0.22	8.60±0.49	10.42±0.55
Fresh weight (g)	2.14±0.33	2.10±0.21	2.06±0.45	2.07±0.10
Dry weight (g)	0.43±0.03	0.44±0.08	0.40±0.02	0.42±0.03

Mean ± Standard Error from 3 replicates

4. Discussion

Germination studies indicated that the seeds of the test plant exhibited varying germination responses to different sources of water used. There were significant reductions in germination percentages and coefficient of velocity of germination in treatments containing stream and tap water relative the control treatment. This may be due to osmotic or ionic effects of soluble salts in the water samples [14, 15]. These soluble salts accumulation in seeds grown in medium containing contaminated water may also account for the reduction and variations in the germination parameters of the test crop. This result agrees with the work of [16] that water containing NaCl, $CaCl_2$, KCl and $MgCl_2$ at lower concentration increased the germination rate, while at higher concentrations, the germination rate and germination percentages were inhibited. Irrigation water containing soluble salts has been shown to adversely affect crops by delaying or preventing germination and seedling growth [17]. Similarly, the pH differences due to effect of soluble salts in the water samples may also contribute significantly to the reduction in seed germination. pH, which is the measure of acidity or alkalinity of a medium directly affects nutrient availability. Thus, the pH value of a medium is one of the environmental conditions that affects the quality of plant growth. The solubility, biological availability of mineral nutrients for plant growth and development may be influenced by pH of the growth medium [3, 18, 19, 20, 21].

The slight increase in the plant growth parameters in treatments containing rain water and stream water may be due to the rapid utilization of mineral nutrients in the water samples. Lower concentrations of some salt in growth medium has been shown to enhance rapid absorption of such salt ions, and its utilization in metabolic processes in plants thereby causing an increase in growth of the seedlings. Growth stimulations due to the presence of some essential organic compounds in waste water have been reported [22, 23, 24]. However, the reductions in the test crop growth parameters may be attributed to the non-nutrients composition of the medium. Several non-nutrients in waste waters have been reported to have significant effects on the germination and growth of seed and seedling of various species [25]. Similarly, pollutants in water due to industrial wastes affect seed germination [26, 27]. Seedling growth has been reported to be negatively affected by the presence of higher concentration of salts in polluted water, while at low concentration, seedling growth was not affected [28]. Toxic non-nutrient mineral in soil and water have been shown to affect plant functions [5, 8, 29]. Polluted water and soils contain numerous non-nutrients such as heavy metals, semi metals, non-metal ion and simple salinity which impact toxicity to specific metabolic processes [30, 31, 32]. Therefore, this clearly shows that excess of non-nutrients may distort both physiological and biochemical processes leading to reduction in growth, net tissue death or whole plant death.

5. Conclusion

This study shows that irrigation water is one of the environmental factors that influence the growth of the test plant. Irrigation water may contain both nutrient and non-nutrients depending on the prevailing environmental and cultural influences around the water source. Therefore, appropriate assessment of water sample is necessary prior to its utilization for irrigation purposes.

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