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Determination of the Critical Phosphorus Concentration for Corn (*Zea mays* L.) Using the EBB and Flow System

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Abstract

An experiment was conducted to evaluate and assess the suitability of ebb and flow system in determining the critical concentration of phosphorus in plant tissue. There were five treatments consisting of different levels of P added in the form of $NaH_2PO_4*H_2O$ arranged in a Completely Randomized Design. Parameters such as plant dry matter yield and biomass were gathered at the end of the experiment. Results showed that the critical P concentration of corn at the early stage of growth using the ebb and flow hydroponic system was 0.29 % wherein the dry matter yield highly correlates with the P concentration of corn (r = 0.98). The result was nearly within the range of critical P levels obtained using different methods. It is concluded that ebb and flow hydroponic system is very useful for plant nutrition studies and the use of the method is highly recommended in any studies involving plant CNC determination.

Keywords: Critical P concentration, corn, ebb and flow system

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INTRODUCTION

Critical nutrient concentration (CNC) refers to the nutrient concentration where plant growth first begins to decrease. It is located at the boundary between the deficiency and adequacy zone (Alsaeedi and Elprince, 2000). Determination of CNC serves as basis for fertilizer recommendation in any crops. Critical nutrient levels of plants differ from maturity plant part. As the plant matures, nutrient composition in different parts changes. In CNC determination, the plant part to be selected for the analysis must have the following characteristics: it should be comparable for all plants at all sample dates; it must have a sharp transition zone between deficiency and adequacy zone; should have a broad range of nutrient concentrations between the deficiency and abundance; and must contain constant critical concentration and should be easy to sample (Alsaeedi and Elprince, 2000).

Phosphorus (P), which is present in plant tissue in small amount, is one of the macro nutrients needed by the plants for proper growth and development. It highly influences plant metabolism through its role in respiration and in making food for plants (Rosen, et al., 2014). It is a part of amino acids and the main component of ATP which is the energy carrier in the plant. Deficiency of P in the plant tissue may result to purple coloration due to anthocyanin production. Crops which are deficient with P delay maturity and develop stems that are slender affecting the overall performance of crops. Plants required P at high amount during early stage of growth. Unlike N and K, the concentration of P in the plant tissue is relatively lower.

Ebb and Flow or the Flood and Drain system is a form of soilless system in growing crops. The system consists of a nutrient solution, submersible pump, container for both solution and plant, timer, tubes and a growing medium enough to anchor the plant. In the process, the solution from the container is being pumped up into the plant roots through tubes connecting the system. The solution is allowed to stay for a specified time before it is drained back into the reservoir. The pumping and draining of solution work with a timer for a specific period of time which allows the solution to be aerated and the nutrients to be continuously supplied for the plant (Niekerk, 2015). In the case of corn, information on its critical phosphorus concentration is already available, hence this study is to evaluate and assess the suitability of ebb and flow system in determining the critical concentration of phosphorus in plant tissue.

MATERIALS and METHODS

Preparation of Nutrient Solution

Nutrient solution was prepared using Hoagland culture solution as described by Taiz And Zeiger (2002). Slight modification on the composition was made (Table 1). Phosphorus application was varied for each treatment.

Table 1. Composition of a Modified Hoagland Nutrient Solution*

Salts	Stock solution (g 100 ml^{-1})	Volume of stock solution (ml L^{-1})
Macronutrient		
KNO_3	10.10	6
$Ca(NO_3)_2 \cdot 4H_2O$	23.62	4
$MgSO_4 \cdot 7H_2O$	24.65	2
Micronutrient	**(g 20 ml^{-1})**	
H_3BO_3	0.286	1
$MnCl_2 * 4H_2O$	0.181	
$ZnSO_4 * 5H_2O$	0.022	
$(NH_4)_2MoO_4 * 4H_2O$	0.080	
$CuSO_4 * 5H_2O$	0.002	
$FeCl_2 * 4H_2O$	0.178	10
Na_2EDTA	0.373	

* Source of P = ($NaH_2PO_4 * H_2O$)

Nutrient Solution Management and Plant Set-up

Carefully selected two-week old corn seedlings were grown hydroponically in a soilless medium employing the flood and drain (ebb and flow) system. Plant roots were flooded every after 3 hours during the day (5 hours during the night) with nutrient solution from the reservoir using a submersible pump. The solution was allowed to drain from the roots by gravity every after 15 minutes of submergence. The nutrient solution was kept aerated until harvest. For the application, 8 liters of nutrient solution was placed for each container. The level of solution in the container was maintained up until harvest (weekly addition of nutrient solution was made).

Experimental Design and Pot Layout

The experiment was conducted at the screenhouse of the National Abaca Research Center (NARC), Visca, Baybay City, Leyte. It was carried out in a Completely Randomized Design (CRD) with 5 nutrient solution containers containing different levels of P as treatments having 4 pots each as replicates. The different treatments were designated as follows:

T_1 = 0 mg P L^{-1} solution
T_2 = 8 mg P L^{-1} solution
T_3 = 16 mg P L^{-1} solution
T_4 = 24 mg P L^{-1} solution
T_5 = 32 mg P L^{-1} solution

Biomass Determination

Dry matter yield (g $plant^{-1}$) – This was determined by weighing the fresh plant parts composed of roots and shoots. Samples were oven-dried at 70 ^oC until constant weight was attained. The dry matter yield was calculated as follows:

Dry matter yield (g $plant^{-1}$) = Total dry weight of leaves + Total dry weight of stalk + Total dry weight of roots

Plant Tissue Analysis

At the end of the experimental period, plant samples were thoroughly cleaned with distilled water along with drying for the determination of total P (%) content. Tissue samples were mixed and a replicate was gathered out of the composite sample and was used for the analysis. After that, plant materials (leaves) were placed in a properly labeled paper bags and were placed in a forced draft oven set at 70 ^oC until constant weight was attained. The oven-dried samples were weighed and were ground to a particle size of 1.0 mm using a stainless Wiley Mill grinder. The ground samples were stored in a properly labeled coin-envelops until analysis of nutrient was done.

Total P was analyzed by dry ashing. For each sample, a 0.5 g oven-dried sample was placed in a crucible and was transferred into a muffle furnace at 550 ^oC for 6-8 hours. The white ash for each sample was soaked in a concentrated HCl solution, filtered and was used for the analysis of total P. The result was quantified using spectrophotometer with ascorbic acid as reducing agent (Murphy and Riley, 1962) and the absorbance was measured using the spectrophotomer.

Data Analysis

The data gathered was analyzed using the STAR software version 2.0.1. Analysis of variance (ANOVA) was used to test the significant effects among treatments and was separated following the Duncan's Multiple Range Test at 5 % level of significance.

RESULTS and DISCUSSION

Dry Matter Production

Total plant dry matter, which is the result of the integration of all plant processes, is the most important parameter in the study of plant canopies. Mineral elements which include phosphorus (P) affect growth and development and subsequently dry matter accumulation of plants if altered (Lauron, 2002). In the study, varying levels of P applied did not significantly affect the dry matter production of corn seedlings (Table 2). Highest dry matter yield (19.06 g plant^{-1}) was obtained from the control group, the one without P application. On the otherhand, lowest dry matter yield (14.00 g plant^{-1}) was obtained from seedlings treated with 32 mg P L^{-1}. The result did not conform on the findings of Li et al., 2010; Temegne et al., 2015 that increased P application significantly increased total dry biomass of celery and a decrease P concentration significantly decreased the total biomass of three voandzou varieties studied, respectively. Under P deficient environment there is a preferential allocation of plant biomass into the roots causing it to expand and enlarge. Plants react to P deficiency by allocating more resources on the production of roots up to the point that increased above ground biomass is suppressed (Temegne et al., 2015).

Figure 1. Two week old corn seedlings hydroponically grown using ebb and flow system with varying levels of P (*levels were 24, 32, 8, 0 and 16 ppm arranged from right to left*)

Table 2. Average dry matter yield (g plant^{-1}) of corn hydroponically grown using ebb and flow system with varying levels of P (mg L^{-1}) at early stage of growth

P levels	Dry matter yield
T_1 – 0	9.53
T_2 – 8	7.19
T_3 – 16	8.60
T_4 – 24	8.12
T_5 – 32	7.00
LSD Value	
CV (%)	23.10

P Uptake of Corn Seedlings

Essential elements are nutrients required by the plants for proper growth and development. The uptake rate of these nutrients is dependent on the rate of plant growth (Marschner, 2012). Roy, 2006 added that the nutrient uptake of plant is low at early stage which increases rapidly until maximum dry matter is attained and declines towards crop maturity. In the study, control group has the lowest uptake (16.06 mg P plant^{-1}) among treatments involved. The highest value (36.56 mg P plant^{-1}) was observed in the samples treated with 16 mg P L^{-1}. P uptake of corn seedlings increased as the concentration of P in the solution was increased (0-16 mg P L^{-1}) and falls down as P concentration was further increased (16-32 mg P L^{-1}). However, statistical analysis revealed that varying levels of P applied did not significantly influenced the P uptake of corn seedlings at early stage of growth (Table 3). The result was in contrast on the findings of others that P application has a significant effect on P uptake of plants. According to Bargaz et al., 2012, low P application has significantly reduced the P uptake and subsequently the growth of *Phaseolus vulgaris*, regardless of its genotype.

Table 3. P uptake (mg P plant^{-1}) of corn hydroponically grown using ebb and flow system with varying levels of P (mg L^{-1}) at early stage of growth*

P levels	P uptake
T_1 – 0	16.06
T_2 – 8	19.36
T_3 – 16	36.56
T_4 – 24	32.46
T_5 – 32	27.59
LSD Value	
CV (%)	25.71

***** mean values from different treatments

Critical Phosphorus Concentration

Critical nutrient concentration (CNC) is defined as the concentration of which the plant needs to produce near maximal growth. It is the concentration at which plant weight is reduced to 90% of the maximum (Burns, 1992). It is based on the relationship between the nutrient concentration and the plant yield which changes with the age of plant (Bates, 1970). In the study, it was found out that the critical P of corn at early stage of growth was 0.29 % (Figure 2).

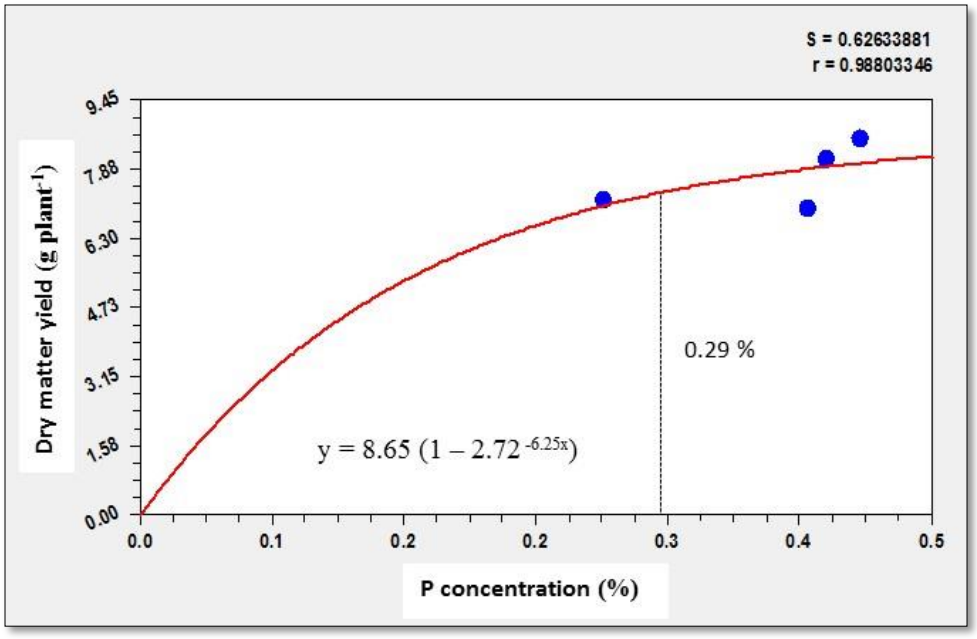

Figure 2. Critical P concentration of corn at early stage of growth

Percent P levels in the tissue highly correlates with the dry matter production of corn with a very high r value of 0.98 (i.e. exponential association). According to Cox and Barnes (2006), the critical P concentration of corn was 23 %.

Regardless of the flaws in the analysis and the actual conduct of the study, the result was nearly within the range from several studies employing different techniques in the determination process.

CONCLUSIONS and RECOMMENDATIONS

Based on the result, it can be concluded that P affects growth of plants however, variations greatly depends on the kind of environment they were in. The study revealed that the critical P concentration of corn which is 0.29 % is nearly within the range of levels obtained using other methods. This implies the suitability and the usefulness of the ebb and flow hydroponic system in CNC determination of plants. For further improvement, similar studies should be conducted to verify the results obtained from the experiment. It would be better if studies related to CNC will be conducted in a tight or highly controlled environment to avoid unnecessary deviations from the expected results. Moreover, responses of the varying P levels applied on the growth parameters (i.e. plant height, leaf width, length and area, base diameter and root length) should be included to support possible results on the biomass and uptake of plant samples. Based on the result, the use of flood and drain hydroponic system is highly recommended in any plant nutrition studies focusing on plant CNC determination.

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Yield and Nitrogen Uptake of Lettuce (*Lactuca Sativa* L.) as Influenced by Different Rates of Vermicast Grown in Sandy Soil

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Abstract

The study was conducted to evaluate the different rates of vemicast on the yield and N uptake of lettuce grown in sandy soil (1) and to determine the best rate of vermicast on the yield and N uptake of lettuce grown in sandy soil (2). Lettuce grown in sandy soil incorporated with vermicast was more vigorous than control especially plants treated with the highest level of vermicast which is 7.5 g/kg soil while control plants have yellowish leaves. Treatments with lower rates of vermicast (5.0 and 2.5 g/kg soil) as well as the control were not successful in developing head of lettuce while the highest rate of vermicast (7.5 g/kg soil) clearly produced head. Incorporating 7.5 g vermicast/kg soil obtained the heaviest fresh weight and total dry matter yield of 88.20 g/plant and 7.86 g/plant respectively. Moreover, application of vermicast regardless of varying rates evidently improved sandy soil pH.

Keywords: nitrogen uptake, lettuce, vermicast, sandy soil

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INTRODUCTION

Lettuce (*Lactuca sativa* L.) which belongs to the *Asteracae family* is considered one of the most important high value vegetables in the Philippines. It can either be leaf or head type salad vegetable that is commonly grown in temperate countries and in some favored localities particularly in elevated part of the country. It is an important component of Filipino diets because it contains high quantities of vitamins, especially vitamin C (Kapoor, 2010).

Increasing lettuce production due to increase in demand tend to source out additional land area. Thus, sandy soils can be a good area to venture lettuce production since alluvial sandy soils (Tropepts suborder) found to be 46.7 % among all other soil types in the Philippines (BSWM).

Although sandy soils are chemically exhausted and highly sensitive to erosion and demand cautious management if used for crop production due to its course texture a low water holding capacity and high infiltration rate (Bationo, 2005), one and very popular practice to mitigate this main production constraint is amending the soil with organic materials.

Organic amendments are regarded as an alternative practice to improve soil moisture and nutrient retention, lowers soil bulk density, and improves overall soil structure and increasing the efficiency of crop production and irrigation (Haynes, 2008). Additionally, soil amendments can not only change the characters of sandy soil, but enhance yield, quality (Chen *et al*., 2005) and stress resistance (Giri *et al*., 2003), promote the growth of horticultural plants. And one of the potential organic amendments are now being promoted is the vermicompost or vermicast.

Vermicast improves water retention capacity of soil due to its high organic matter content. It also promotes better root growth and nutrient absorption and improves nutrient status of soil, both macro-nutrients and micro-nutrients (Punjab State Council for Science and Technology, 2010). Moreover, vermicast has been used in sustainable agriculture and was found to stimulate plant growth (Lazcano, 2011). Vermicast has been applied to several plants including strawberries (Lazcano, 2011), tomato (Manyuchi et al., 2012), rice (Ramasamy, 2011) and maize (Arancon, 2006). At present, there is limited information about the application of vermicast on the growth and yield of lettuce in sandy soil. The study aims to evaluate the different rates of vemicast on the yield and N uptake of lettuce grown in sandy soil and to determine the best rate of vermicast on the yield and N uptake of lettuce grown in sandy soil.

MATERIALS and METHODS

Soil Sampling, Collection, and Analyses

Bulk samples of alluvial sandy soils from a depth of 0-20 cm were collected randomly from an agricultural farm in Lilo-an, Ormoc City. The bulk soil samples were air-dried for 4 days, pulverized and were passed through a 4-mm sieve. Subsamples were subsequently taken for initial chemical analyses and the rest were prepared for bagging. The subsamples for initial chemical properties were passed through a 2-mm sieve for the following analyses:

Soil pH

This was determined using potentiometric method (PCARR, 1980). A 10g air dried soils that passed through a 2 mm sieve or no. 10 mesh screen was placed into a 50 ml beaker. The soil was added with 10 ml distilled water, stirred thoroughly and allowed to stand 15 minutes after mixing. Immediately before placing the electrode of calibrated pH, the soil suspension was again stirred thoroughly.

The pH meter was calibrated using the standard buffer solution of pH 4.0 and 7.0 and soil pH was determined to the nearest 0.1 unit. The electrode was rinsed with distilled water and blot dried with tissue paper before proceeding to the next sample.

Organic Matter (OM)

This was determined using modified Walkley and Black Method (Nelson and Sommers, 1982) a 0.5g air-dried soil that passed through a 0.425mm sieve was weighed and then transferred into a 500 mL Erlenmeyer flask. Subsequently, 10 mL of 1N $K_2Cr_2O_7$ was added to the soil in the flask after which the flask was swirled gently to dispense the soil in the solution. Under the hood, 10mL of concentrated H_2SO_4 was added to soil $K_2Cr_2O_7$ mixture and mix rapidly. The mixture is allowed to stand for 1 hour after which, 200 mL of distilled water was added. Four drops of O-phenanthroline indicator was then be added to the mixture. It was stirred using magnetic stirrer and titrated with 0.5N $FeSO_47H_2O$ until the color of the solution changes from greenish to dark green. A blank solution was prepared and determination was done in the same manner. The %OM was calculated using the formula:

$$\%OM = 1 - \frac{S}{B} \text{ x } 0.69 \text{ x } \frac{1}{w}$$

Where;
OM = organic matter
S = mL of $FeSO_47H_2O$ in soil sample titration
B = mL of $FeSO_47H_2O$ in blank titration
W = weight of soil sample (g)

Total N

This was determined using the Kjeldahl method (USDA, 2004). One soil sample that was passed through a 0.425 mm sieve was weighed and placed into 100 mL digestion flasks. Then 1 g of selenium reagent mixture was added to the soil and mixed thoroughly by swirling. Under the fume hood, 6mL of concentrated H*2SO4* was added to the soil selenium mixture. The flask was placed onto the buchi digestion unit inside the hood and heated. Heating was regulated and the flask was rotated at 20 minutes interval to facilitate the digestion of the sample. The digestion was stopped when frothing or charring ceased leaving a white precipitate. Then the flask was removed from the digester and was allowed to cool. Prior to distillation, approximately 30 mL distilled water was slowly added to the digest and the flask was swirled. The digest was transferred into Buchi distilling flask after which 50 mL of 40% NaOH was added while holding the flask at about 45^o angle. The flask was attached to the distillation set up. For the receiver of the distillate, a 125mL Erlenmeyer flask with 25 mL of 2% H3BO3 and three drops of mixed indicator was placed on the stand beneath the condenser tip. Distillate was collected up to the 75 mL mark of the Erlenmeyer flask.

The distillate was titrated with 0.05 N H_2SO_4 until the color of the solution mixture changed to pink. The total N was determined using the formula:

$$\%N = \frac{(a-b)xNx0.014}{W}\ x\ 100$$

Where:
N = normality of H_2SO_4
a = mL of H_2SO_4 in soil sample
b = mL of H_2SO_4 in the blank
W = weight of soil

Vermicast Collection, Preparation, and Analyses

Vermicast was collected from the vermicomposting site of VSU near Molave Hills, Visca, Baybay City, Leyte. The moisture content was determined by oven drying 100 g sample of vermicast in forced drat oven set at 105^{o}C for five days. After oven drying, the percent moisture content (%MC) was calculated using the following formula:

$$\%\, MC = \frac{FW - ODW}{FW}\ x100$$

Where: FW = fresh weight of Vermicast

ODW = oven dry weight of Vermicast
MC = moisture content

The actual amount of vermicast that was applied per bag was adjusted to its moisture content (%MC) using the formula below:

$$FW = \frac{RR}{1 - \frac{\%MC}{100}}$$

Where: FW = fresh weight of fresh vermicast incorporated per pot
RR = application rate of vermicast per bag (g/kg soil)
MC = moisture content

For the analysis of manure, a sub sample was air dried and set aside for pH, OM, and total N, content determination. The pH, OM, and total N were determined following the methods used for determining pH, OM, and total N of soil.

Experimental Design and Layout

A total of 80 pots were used and placed in shed house structure located at the GULAYAN NG MASA demo area of the Department of Horticulture. These were laid out in Randomized Complete Block Design (RCBD) having 5 sample pots per treatment with 4 replications. The following treatments were used: T_0 – Control, T_1 – 2.5 g Vermicast/ kg soil (5 t/ha), T_2 - 5 g Vermicast/ kg soil (10 t/ha), and T_3 – 7.5 g Vermicast/ kg soil (15 t/ha).

Vermicast Application

The amendment was mixed thoroughly with the soil prior to bagging at one week before planting. On the other hand, Urea as source of inorganic N was applied after two, three and 4 weeks after sowing through drenching at the rate of 10 g dissolved in a gallon of water in all treatment pots.

Care and Maintenance

Weeds were removed regularly to avoid competitions for nutrient and moisture. Watering was done regularly to maintain needed moist condition. Manual picking was done to prevent spread leaf-borers attacking the plant.

Harvesting, Preparation and Analysis of Plant samples

Harvesting was done at 45 days from planting. The head was cut close to the soil surface and roots was uprooted. The soil adhering to the roots was removed carefully. The different plant parts were washed with tap water and rinsed with distilled water. The shoot and roots were separately placed in properly labeled paper bags and placed in a forced drafts oven set at 70°C for four days. The oven dried samples were weighed and ground in Wiley Mill grinder to a particle size less than 1 mm. prior to weighing plant samples for analysis, the ground shoot and roots were placed overnight in a forced draft oven set at 70°C.

Data Gathered

The following parameters were gathered: Fresh weight (g) – this was determined by weighing each lettuce plant at harvest, Dry matter yield (g) – This was obtained by taking the dry weight of the shoots and roots after drying them in forced draft oven set at 70°C for four days. The dry weight of each plant was combined to obtain the total dry weight, and N uptake (mg/kg) – this was quantified by taking the product of total N contents of the shoots and roots multiplied with their total dry matter yield.

RESULTS and DISCUSSION

General Observation

Lettuce seedlings with uniform growth were transplanted two weeks after emergence from seedling trays. One week after transplanting, lettuce looper/worm infestation was observed but controlled through manual picking and chemical spraying with a carbaryl insecticide (Sevin). After 2 weeks from transplanting, visible difference on the growth was observed. Lettuce grown in sandy soil incorporated with vermicast was more vigorous than control especially plants treated with the highest level of vermicast which is 7.5 g/kg soil while control plants have yellowish leaves.

Initial soil chemical properties

Table 1 shows the initial sandy soil and vermicast chemical properties used in the experiment. The soil used in the experiment was slightly acidic and had low amount of OM and total N compared to vermicast with neutral pH and very high OM but lower Total N. Organic matter values of <2% and total N values of <0.2% are low (PCARR, 2000).

The low content of OM and N on the other hand, could partly explain the observed yellowing of control lettuce leaves.

Effects of vermicast on horticultural attributes, yield, N concentration and N uptake

Vermicast application significantly affected the horticultural attributes, yield, N concentration and N uptake of lettuce grown in sandy soil (Table 2 and 3). Treatments with lower rates of vermicast (5.0 and 2.5 g/kg soil) as well as the control were not successful in developing head of lettuce while highest rate of vermicast (7.5 g/kg soil) clearly

Table 1. Initial chemical properties of soil and vermicast used in pot experiment

Soil Property	Soil	Vermicast
pH	5.57	7.00*
OM (%)	0.86	39.39
Total N (%)	0.08	1.63

*- ratio 1:5

Table 2. Means of horticultural attributes of lettuce var. General grown in sandy soil with varying vermicast application

Treatment (g/kg soil)	Number of Days to Head Formation	Head Size (cm)	
		Polar	Equatorial
T_0 - Control	0.00b	0.00b	0.00b
T_1 – 2.5	0.00b	0.00b	0.00b
T_2 – 5.0	0.00b	0.00b	0.00b
T_3 – 7.5	12.67a	11.37a	12.97a
CV%	3.17	2.84	3.24

Means in a column followed by a common letter and those without letters are not significantly different from each other based on 5% level of significance, using FPLSD.

Table 3. Means of yield, N concentration and total N uptake of lettuce var. general grown in sandy soil with varying vermicast application

Treatment (g/kg soil)	Yield (g)		Plant N	
	Fresh weight	Total dry matter	Concentration (%)	Uptake (mg/kg)
T_0 - Control	65.83c	5.23c	2.90a	151.67b
T_1 – 2.5	68.87bc	5.84bc	2.52ab	147.17.99b
T_2 – 5.0	85.83ab	7.13ab	2.24b	159.07a
T_3 – 7.5	88.20a	7.86a	2.10b	165.06a
CV%	77.18	6.51	2.45	6.65

Means in a column followed by a common letter and those without letters are not significantly different from each other based on 5% level of significance, using FPLSD.

produced head (Figure 1). These results suggest that lower doses of vermicast (5.0 and 2.5 g/kg soil) are not suitable for the formation of lettuce head if grown in sandy soil. Moreover, lettuce yield was significantly affected by vermicast application. Increasing rate of vermicast obtained considerable increase in yield. The highest rate of 7.5 g vermicast/kg soil obtained the heaviest fresh weight and total dry matter yield of 88.20 g/plant and 7.86 g/plant respectively. Similarly, this observation supports the claim of Ouda and Mahadeen (2008) that application of the highest dose of organic fertilizer (60 kg ha-1) with the highest dose of organic manure (80 t ha-1) produced the highest yield of broccoli main heads (3.16 t ha^{-1}).

On the other hand, contrasting trend was observed on plant N concentration. Increasing rate of vermicast resulted to decreasing plant N concentration with the highest is on the control. This observation was actually caused by dilution effect during the process of digestion in determining N.

Higher N concentration in control plants is due to lower dry matter yield which had more concentrated N per unit mass than with vermicast having considerably high dry matter yield and less concentrated N or more diluted N per unit mass. N uptake however resulted to have significantly increasing trend as rate of vermicast increases. This result agreed to Murmu et al., 2013 that tomato-sweet corn applied with vermicompost in combination to inorganic fertilizer resulted to an increase nitrogen use efficiency due to lower nitrogen losses caused by binding of mineral nitrogen with compost in the soil (Kasperczyk & Knickel, 2006).

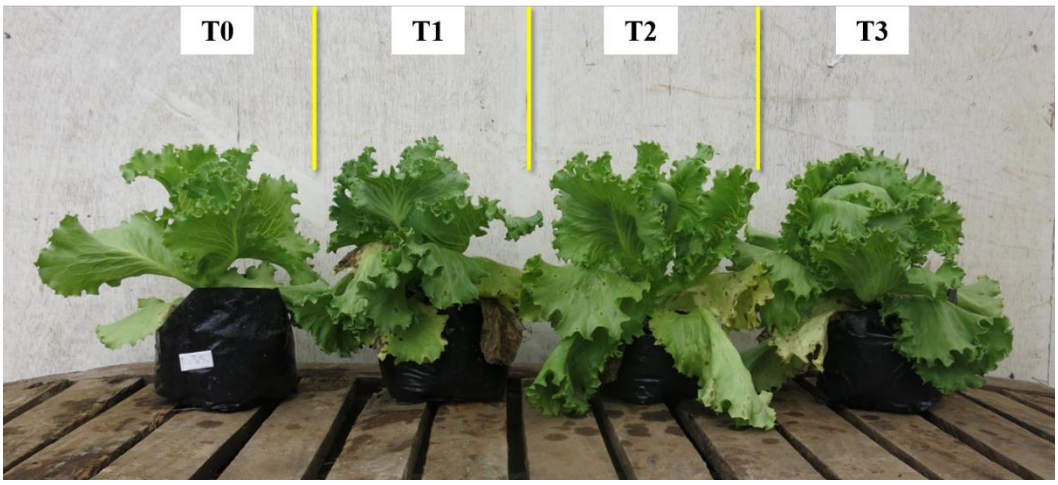

Figure 1. Successful head development of lettuce grown in sandy soil applied with highest rate of vermicast (T3 – 7.5 g/kg soil) while comparable inferior performance of lower vermicast rates (T1- 2.5 g/kg soil and T2- 5.0 g/kg soil) and control.

Effects of vermicast on soil parameters

The soil pH, OM and total N were numerically affected by different rates of vermicast applied (Table 4). These observations imply that generally, vermicast application in sandy soil could improve soil chemical properties. Among soil parameters gathered, only pH was statistically significant which indicate that application of vermicast regardless of varying rates surely improved sandy soil pH. This findings was supported by Albanell et al. (1988) that vermicomposts tended to have pH values near neutrality which may be due to the production of CO2 and organic acids produced during microbial metabolism.

Table 4. Means of soil pH, OM, total N of lettuce var. General grown in sandy soil with varying vermicast application

Treatment (g/kg soil)	pH	OM (%)	Total N (%)
T_0 - Control	5.40b	1.140	0.106
T_1 – 2.5	5.64a	1.290	0.107
T_2 – 5.0	5.78a	1.270	0.120
T_3 – 7.5	5.73a	1.220	0.119
CV%	1.36	8.33	9.71

Means in a column followed by a common letter and those without letters are not significantly different from each other based on 5% level of significance, using FPLSD.

CONCLUSION

The study was conducted at ACIAR-ICM nursery house, Department of Horticulture, College of Agriculture and Food Science, Visayas State University, Visca Baybay City, Leyte from July 18 to August 29, 2014 to evaluate the different rates of vemicast on the yield and N uptake of lettuce grown in sandy soil (1) and to determine the best rate of vermicast on the yield and N uptake of lettuce grown in sandy soil (2). The experiment was laid out in single factor Randomized Complete Block Design (RCBD) having 5 sample pots per treatment with 4 replications. T0 – Control, T1 – 2.5 g Vermicast/ kg soil (5 t/ha), T2 - 5 g Vermicast/ kg soil (10 t/ha) and T3 – 7.5 g Vermicast/ kg soil (15 t/ha). Lettuce grown in sandy soil incorporated with vermicast was more vigorous than control especially plants treated with the highest level of vermicast which is 7.5 g/kg soil while control plants have yellowish leaves. Treatments with lower rates of vermicast (5.0 and 2.5 g/kg soil) as well as the control were not successful in developing head of lettuce while highest rate of vermicast (7.5 g/kg soil) clearly produced head. Incorporating 7.5 g vermicast/kg soil obtained the heaviest fresh weight and total dry matter yield of 88.20 g/plant and 7.86 g/plant respectively. Moreover, application of vermicast regardless of varying rates evidently improved sandy soil pH. Therefore, incorporating vermicast in sandy soil obtained significantly higher dry matter yield and just numerically higher N uptake of lettuce than the control. Amending 7.5 g/kg vermicast to sandy soil is the best rate for producing lettuce head with heavier dry matter yield compared to sandy soil applied with 2.5, 5.0 g vermicast/kg soil and with no vermicast application.

Recommendation

A similar study may be conducted to confirm the result of the present study but additional treatments with higher rate of vermicast to obtain optimum rate in obtaining optimum lettuce yield.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Comparative Performances of Organic and Inorganic Sweet Corn Grown on Coastal Land

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Abstract

Coastal land serves as an alternative growing area for organic sweet corn production. Establishing an organic growing environment requires at least two years for short growing crop like sweet corn. This experiment aimed to evaluate the first year growth and yield performances of organic and conventional sweet corn production systems on coastal land. Experiment was conducted on entisol of coastal land from August to November 2019 at the City of Bengkulu and was arranged in a randomized complete block design with three replicates. Treatments were (1) organic production systems and (2) inorganic production systems. Sweet corn performances were observed in terms of plant weight, leaf number, leaf length, leaf greenness, shoot fresh weight, root fresh weight, root dry weight, level of sweetness, fresh weight of husked ear and fresh weight of unhusked ear. Results indicated that during the first year of organic production system for sweet corn, sweet corn grown in organic production system had similar plant weight, leaf number, leaf length, leaf greenness, shoot fresh weight, root fresh weight and root dry weight of sweet corn grown in inorganic production systems, except shoot dry weight. In addition, yield of organic sweet corn, as indicated by fresh weight of husked ear and fresh weight of unhusked ear, were 29 % and 23 %, respectively, lower than sweet corn grown in inorganic production system.

Keywords: *Organic Farming; Sweet Corn; Coastal Land.*

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INTRODUCTION

Organic vegetable productions, including sweet corn, in coastal areas of Indonesia, are becoming great interests of many parties due to declining arable land in highland production areas (Sugino, 2008) as well as increasing demands for organic vegetables (Golijan and Dimitrijevic, 2018). Increasing worldwide demands for organic vegetables were attributed to increasing awareness and concern of consumers on harmful effects of synthetic fertilizers, pesticides and machinery on the safety of food and human as well as the sustainability of soil and environment (Singh et al., 2017).

Extending organic sweet corn from high altitude to coastal areas require comprehensive understandings of how crop adapts to coastal environment. Stuart (2010) concluded that coastal ecosystem is strongly determined by specific location and land uses. According to Awal (2014) dynamic changes in coastal ecosystem is terms of salinity, tidal processes, water stresses, and water logging bring about agricultural practices in coastal areas are becoming unstable. Such variations might result locally variations in land fertility among coastal areas. Sandy and coarse textures, easily cultivated, low water holding capacity and high water permeability are among characteristic of Indonesia coastal lands (Ma'ruf, 2018).

Crop adaptation to new environment requires favourable growing environment, including temporal stability of soil nutrient of coastal lands. For example, the application of nitrogen fertilizer in the first year was only able to be detected in the second year, but not detected in the third year after application (Diaz et al., 2012).

Switching inorganic soil to organic soil is not an overnight process, since it involves many complex interactions between biological, chemical and physical aspects of soil ecosystems. Land conversion from conventional to organic land requires both temporal and spatial requirement and involves many aspects of rhizosphere elements. This process is not merely replacing synthetic inputs with organic inputs in the soil environments. According to Neeson (2010), establishing organic soil for growing environment goes through three critical stages, *i.e.* adjustment phases, comfort phases and maintenance phases. According to the Indonesian National Standard (2016), conversion of non-organic into organic soil for short growing season crops requires at least two consecutive years. However, conversion time might be different among regions and ecosystems.

Br*ü*ckler et al., (2018) concluded that crop yields on organic production systems vary among crop species and regions. First year performance of crop growth and yields are very important to provide information for improving cultural practices and management in the following years. Nevertheless, information of crop establishment for organic production systems in the coastal lands is considerably limited. This experiment aimed to determine the growth and yields performances sweet corn grown in organic and inorganic production systems during the first year of establishing organic growing environment on coastal areas.

MATERIAL and METHOD

The field experiment was conducted on entisol of coastal land from August to November 2019 at the City of Bengkulu (elevation of 5 m above sea level, 3°, 45', 26.40" South Latitude and 102°, 15', 41.78'' East Longitude). The experiment was arranged in a randomized complete block design with three replicates. Treatments were (1) organic production systems and (2) inorganic production systems. For each production system, a soil-bed of 1.5 m x 4.0 m was established, separated by 1.5 m within the block and each block was separated by 1.5 m away.

Both production systems were applied with vermicomposts at planting, 10 ton ha^{-1} for organic production systems and 5 ton ha^{-1} of vermicompost for inorganic production system. Additional 5 ton ha^{-1} of vermicompost was uniformly applied to the experimental plot of organic production system at three weeks after planting. This vermicompost contained 2.15 g kg^{-1} of total N, 0.24 g kg^{-1} of P, 0.55 g kg^{-1} of K, and 25.6 g kg^{-1} of organic C (Muktamar et al., 2017).

For inorganic production system, land was fertilized with 300 kg ha^{-1} of urea (applied at 2 and 4 weeks after planting with 150 kg ha^{-1} and 150 kg ha^{-1}, respectively), 100 kg ha^{-1} of SP36 and 100 kg ha^{-1} of KCl (applied at 2 weeks after planting).

For organic sweet corn production, crops were fertilized with tithonia-based liquid organic fertilizer (LOF) with a volume of 50, 100, 200, 300 and 350 ml for each plant, at 14, 21, 28, 35 and 42 days after planting, respectively.

LOF was produced by following the method suggested by Fahrurrozi et al. (2017). Lab analysis indicated that this LOF contained 0.37 % N, 0.18 % P, 0.87 % K, 0.72% organic-C, and 7.3 in pH. Seed of sweet corn (CAPS 5x6) was planted at 5 cm in depth, at the spacing of 0.25 m x 0.75 m to make 30 plants per plot. Sweet corns were watered every day since very few precipitations occurred during the experiment. Weed removals were conducted at 25 and 45 days after planting. Pest controls for organic sweet corn were conducted by using bio-pesticide Pestona® and bio-fungicide Glio®. Meanwhile, for inorganic sweet corn, pests were controlled by using Curacron® accordingly. Sweet corn performances were measured in terms of plant weight, leaf number, leaf length, leaf greenness, shoot fresh weight, root fresh weight, root dry weight, level of sweetness, fresh weight of husked ear and fresh weight of unhusked ear. Comparisons of observed variables between organic and inorganic production systems were determined by using t-Test Paired Two Sample for Means at $P < 0.05$.

RESULTS and DISCUSSION

Environmental Conditions

Soil of the experimental site was characterized with neutral pH (6.8), medium N-total (0.24%), low organic C (1.32%, very low available P (3.31 ppm), medium exchangeable K (0.37 me/100g), and low cation exchange capacity (14.28 me/100g). In addition, data from Meteorology, Climatology, and Geophysical Agency Bengkulu (ID WMO: 96255) indicated that the averages recorded monthly rainfall were 7.8 mm, 58 mm, 42.2 mm and 61.3 mm, for August, September, October and November 2020, respectively. Meanwhile, the averages monthly air temperatures were 26.1 ^{o}C, 26.19 ^{o}C, 26.12 ^{o}C and 26.92 ^{o}C, respectively. The averages monthly air relative humidity were 82.19 %, 83.33 %, 86.13 %, and 83.87 %, respectively. Although sweet corns were daily watered during the absence of precipitation, the quantity of water availability to support sweet corn growth was likely not effective since this coastal type was very permeable to water. Davis (2019) sweet corn will have successful pollination and kernels' growth if a continuous supply of moisture was guaranteed.

Growth of sweet corn

Results indicated that sweet corn grown in organic production system had similar plant weight, leaf number, leaf length, leaf greenness, shoot fresh weight, root fresh weight and root dry weight of sweet corn grown under inorganic production systems (Table 1). However, sweet corn grown in organic production had lower shoot dry weight compared to those of grown under conventional production systems.

Table 1. Effect of production system on growth of sweet corn

No	Observed variables	Production systems	
		Organic	Inorganic
1	Plant height (cm)	125.93 a	123.33 a
2	Leaf number (pieces)	11.20 a	10.67 a
3	Leaf length (cm)	68.40 a	72.60 a
4	Leaf greenness (SPAD values)	47.97 a	51.01 a
5	Root fresh weight (g)	14.60 a	15.07 a
6	Shoot fresh weight (g)	113.13 a	128.53 a
7	Root dry weight (g)	6.86 a	8.94 a
8	Shoot dry weight (g)	39.18 a	50.95 b

Note: Means in the same row followed with the same letter are not significantly different according to t-Test: Paired Two Sample for Means at P < 0.05

Relatively similar performances of sweet corn growth in organic production system to inorganic production systems, except for leaf width and shoot dry weight, implied that under new organic growing condition, growth of sweet corn was comparable to their counterparts grown with conventional systems. Similar growth performances might have attributed to the availability of similar nutrient sources in the soil since both production systems were fertilized with sufficient nutrients.

Research conducted by Hayati et al. (2012) in coastal area of Lampuuk Lokhnga, Aceh Besar, Indonesia, concluded that there was no different between organically fertilized and inorganically fertilized sweet corn in terms of plant height and leaf length of three commercial sweet corn varieties at 42 and 63 days after planting. In addition, Sari et al. (2017) also found that both plant height and leaf number of sweet corn fertilized with organic fertilizer grown in coastal area was similar to those of fertilized with synthetic fertilizer. Such comparable performances in terms of plant weight, leaf number, leaf length, leaf greenness, shoot fresh weight, root fresh weight and root dry weight must be properly maintained to ensure robust generative growth.

As sweet corn growing older, growth response changed as reflected by the higher shoot dry weight of sweet corn grown in inorganic production compared to organically grown sweet corn (Table 1). Shoot dry weight is one the acceptable measures to measure plant biomass as well as to estimate crop yield. Dry weight might have further responsible to higher yield of inorganic sweet corn compared to those of grown in organic system.

Sweet corn yields

Results indicated that fresh weight of husked ear and fresh weight of unhusked ear of sweet corn were lower than sweet corn grown under inorganic production system (Table 2). Fresh weight of husked ear and fresh weight of unhusked ear of sweet corn of organically grown sweet corn were, respectively, 29 % and 23 % lower than those of conventional production system.

Table 2. Effect of production system on yields of sweet corn

No	Observed variables	Production systems	
		Organic	Inorganic
1	Fresh weight of husked ear (g)	188.87 a	266.27 b
2	Fresh weight of unhusked ear (g)	141.07 a	182.73 b
3	Sweetness (^{o}Brix)	14.67 a	13.00 a

Note: Means in the same row followed with the same letter are not significantly different according to t-Test: Paired Two Sample for Means at P < 0.05

Lower yield of organically grown sweet corns compared to those grown with inorganic production systems, especially during the first year of growing season, generally reported. This period could be classified as the adjustment phases in the soil ecosystems in which sweet corn might not be able to optimally use the nutrients and other growing resources in the rhizosphere to support its growth. Murmu et al. (2013) found that sweet corn yields in the first year and the second year grown in organic production was 29 % and 30 %, respectively, lower than their counterparts grown in conventional production systems. Sofyan and Sara (2018) also concluded that yields of sweet corn grown in organic plots were significantly lower than those in inorganic plots. They suggested this was due to lower nutrient uptake of sweet corn grown under organic condition compared to sweet corn grown using inorganic fertilizer.

Lower biological yield of organic farming does not necessarily imply that organic production systems had lower economic returns. Research conducted by Sgroi et al. (2015);

Ankamah-Yeboah et al., (2016), for examples, concluded that consumers are will to pay by 20% more for organic products than non-organic products. This suggested that lower biological yield was compensated by higher selling prices which eventually benefit the farmers and at the same time the agricultural lands remain sustainable. Recently, Krause and Machek (2018) concluded that organic agricultural companies had higher profitability than conventional companies. This study was conducted based on a sample of Czech 291 organic and 4045 conventional farmers over the period 2009–2013.

Result from this experiment also revealed that the level of sweetness of sweet corn from both production systems was similar (Table 2), although organic sweet corn was 11.4 % sweeter than those of inorganic production system (14.67 ^{o}Brix vs. 13.00 ^{o}Brix). Nevertheless, this level was higher compared to sweetness level of commercial sweet corn available in the market, e.g. Bonanza F1 (12 ^{o}Brix) and Secada F1 (>12 ^{o}Brix).

CONCLUSION

During the first year of organic production system, organically grown sweet corn had similar plant weight, leaf number, leaf length, leaf greenness, shoot fresh weight, root fresh weight and root dry weight with conventional sweet corn production. However, sweet corn grown in organic production had lower shoot dry weight compared to those of grown under conventional production system. In addition, yield of organic sweet corn, as indicated by fresh weight of husked ear and fresh weight of unhusked ear, were 29 % and 23 %, respectively, lower than sweet corn grown in inorganic production system.

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Determination of Grain Yield and Some Quality Parameters of Popcorn (*Zea mays* L. *everta*) Genotypes

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Abstract

In this study, it was aimed to determine grain yield and quality parameters of some popcorn genotypes. Study was carried out in Şanlıurfa conditions during the second crop growing season of 2017. The experiment was designed complete randomized blocks design with three replicates. In the research 13 popcorn genotypes were used as a crop material. In the study, ear diameter ranged from 29.99 to 37.62 mm, ear length from 17.68 to 22.95 cm, kernel number of ears from 425.0 to 598.0 number ear^{-1} and kernel weight of ear from 56.2 to 120.9 g. And also, another characteristic such as thousand kernel weight values were between 149.06 and 241.81 g, hectoliter weight between 83.93 and 89.00 kg hL^{-1}. While the lowest grain yield was obtained from 123AYN04 genotype as 342.37 kg da^{-1}, the highest grain yield was obtained from 411KTR05 genotype with 967.91 kg da^{-1}. Popping volume values were between 18.06 and 26.5 cm^3 g^{-1}, unpopped kernel ratio 0.04% and 3.01%, protein content 9.3% and 11.40%. When the grain yield, popping volume, unpopped kernel number and protein content evaluated together it was determined that 411KTR05, 5YTR1305, ELACİN, AYCİN R-997 and KUM1347 popcorn genotypes was found better than others.

Keywords: popcorn, grain yield, popping volume, protein content, hectoliter

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INTRODUCTION

Popcorn (*Zea mays* L. *everta*) is a nutritious product consumed as a snack. Due to it contains the vitamins and minerals, popcorn is a preferred food item in terms of nutrition. It is also a good diet product with its satiety and stomach acid absorption feature.

Consumers want the popcorns they buy to have a high explosion volume, the popped product to be soft, tasty and less crust residue (Babic and Pajic, 1992). The types of popcorn to be grown in a region vary depending on the ecological conditions of the region, the adaptability of the variety and the wishes of the consumers (Hallauer, 1994).

In order to increase the yield and quality obtained in a unit area in popcorn, it is important to use quality seeds as well as to spread hybrid varieties in production. Because it is important that the product is homogeneous in terms of explosion quality in popcorn.

Previous studies on popcorn are summarized below. Dofing et al. (1990) stated that there are significant changes between varieties in terms of popping volume and unexploded grain rate.

It was stated that higher non-popped kernel ratio was observed in coarse grained varieties compared to small grained. It has been determined that the popping volume has a negative relationship with the non-explosive grain rate.

Ertaş et al. (2008) stated the explosion volume was found as 22.92 cm3 g^{-1} in Nermincin, 20.09 cm3 g^{-1} in Koçcin and 19.79 cm3 g^{-1} in Antcin-98. Vural and Dağdelen (2008) stated that the grain yield varied between 108.8 and 641.6 kg da^{-1}. İdikut et al. (2015) stated that grain yield was between 369 and 498 kg da^{-1}. Öz and Kapar (2011) found that the grain yield in popcorn varied between 353.5 and 539.9 kg da^{-1} and the explosion volume was between 38.2 and 46.5 cm^3 g^{-1}.

Jele et al., (2014) reported that the explosion volume was determined between 12.88 and 25.75 cm^3 g^{-1}. It was determined that there is a negative relationship between the popping volume and the grain size, and a positive relationship between the explosion volume and the number of popped kernels. Öztürk et al. (2016) stated that the detonation volumes varied between 8.3-29.3 cm^3 g^{-1} and the non-explosive grain rates varied between 1.8% and 35.4%.

Özsoy (2017) stated that the highest grain yield was obtained in Elacin variety with 447.6 kg per decare, but SH9201-Cin, Baharcin and Ateşcin varieties gave high yield. It was reported that the explosion volume in popcorn varieties varied between 28.23 and 35.75 cm^3 g^{-1}, and the largest explosion volume was obtained from the Ateşcin variety. non-explosive grain rate in the varieties was between 7.38% and 8.68%. Elacin and Ateşcin varieties were found to be prominent in terms of yield and quality characteristics.

Önem (2018) reported that thousand grain weight was between 128.8 and 181.1 g, yield per decare 240.6 and 808.6 kg da^{-1}, non-bursting grain rate 0.018 and 0.075%, explosion volume 15.550 and 21.780 cm^3 g^{-1}, protein content 8.43 and 16.65%.

The aim of this study was to determine grain yield and some quality parameters of popcorn genotypes.

MATERIAL and METHOD

This study was conducted in 2017 second crop conditions, Şanlıurfa, Turkey. The experimental field is located in Harran Plain where the climate varies from arid to semi-arid. Table 1. provides the climatic data obtained from Şanlıurfa City Meteorological Station. As can be seen from Table 1. that the weather is hot and dry in the months of June, July and August where maximum temperatures were all above 40 ^oC while the relative humidity was below 50%.

Table 1. Monthly some climatic data during 2017 popcorn growth period in Şanlıurfa[†].

Climatic parameters	**2017**							
	May	June	July	August	September	October	November	December
Av. Temp. (°C)	23.2	29.8	33.0	33.2	26.4	22.1	12.6	5.4
Max. Temp. (°C)	35.0	42.0	43.0	43.0	39.3	33.9	24.4	13.7
Min. Temp (°C)	10.7	18.9	20.9	21.2	14.7	12.3	3.0	-2.2
Av. Humidity (%)	38.3	28.0	25.4	30.6	32.1	35.9	42.9	70.1
Rainfall (kg m^{-2})	12.3	0.6	0.2	-	-	22.0	23.3	101.1

[†]Data collected from the Şanlıurfa Meteorological Station in 2017.

The research area is in Harran Soil Series which has a widespread area in the region. The soils of this series are alluvial base material, flat and deep profile soils. The soil of the research field was clay, slightly alkaline, high in lime and very low in salt contents. Organic matter was low. The research soil has A, B, C horizons and pH ranges between 7.3 and 7.8.

Organic matter content is low and cation exchange capacity is high. KDK is increasing towards the lower layers depending on the clay content (Dinç et al., 1988). Field capacity of the soil was 33.8% on dry basis, permanent wilting point was 22.6% and bulk density was 1.41 g cm^{-3}. Some physical and chemical properties of research soil were given in Table 2.

Table 2. Some chemical properties of research soil in 2017

Deep (cm)	Organic Matter (%)	Total Salt (%)	pH	Lime (%)	P_2O_5 (kg da^{-1})	K_2O (kg da^{-1})	Fe (ppm)	Zn (ppm)
0-20	1.37	0.098	7.5	22.3	2.8	93.4	1.23	0.67

Thirteen popcorn genotypes (*Zea mays* L. *everta*) were used as crop material. Land was ploughed and cultivated then prepared for planting with a single pass of a disk-harrow. The experiment was laid out in a randomize block design with four replications. Each plot area was 14 m^2 (5 m x 2.8 m) and consisted of four rows of 5 m in length. The plants were grown 70 cm apart between the rows with 18 cm spacing in each row. The seeds were sown in second part of June at a 50-60 mm depth. At sowing, 80 kg ha^{-1} of pure N, P and K, as a 15-15-15 composed fertilizer, was applied to each plot; this was followed by 160 kg ha^{-1} of pure N as urea when the plants reached 30-40 cm in height.

After sowing, parcels were irrigated by sprinkler irrigation method and germination of seeds was provided. After the emergence of plants, plots were irrigated equally by the furrow irrigation system. Ear and kernel characteristics were measured on randomly selected 25 plants in the center of each plot. After the nitrogen (N) content of the kernel samples was determined by the Kjeldahl method, the crude protein content was calculated with the formula Nx6.25. All the popcorn plants on the two rows in the middle of each plot were harvested for determination of grain yield. Two rows on the outside of each parcel are left as the edge effect.

An analysis-of-variance (ANOVA) was performed using Jump statistical package program to evaluate statistically differences between results. Means of the data obtained from research were compared using Duncan test at $P \leq 0.05$.

RESULTS and DISCUSSION

Ear Diameter (mm)

The difference between the popcorn genotypes was found to be statistically significant in terms of ear diameter ($P \leq 0.01$) at the variance analyses. As seen from table 3. that ear diameter values were ranged from 29.99 mm (AYCİN R-497) to 37.62 mm (411KTR05). General genotype average of ear diameter was found to be 33.27 mm. According to the results of other studies conducted on popcorn, different ear diameter values have been reported. According to these results, Özkaynak and Samancı (2003) found the diameter of the ear to be between 24.0 and 29.0 mm in lines, 26.0-30.0 mm in hybrids; Tekkanat and Soylu (2005) 33.0-44.0 mm; Özkan (2007) 29.7-33.9 mm; İdikut et al. (2012) 28.3-30.6 mm. Cihangir (2013) reported that it varied between 26.78-30.01 mm. The results obtained are consistent with the findings of other researchers.

Ear length (cm)

In performed variance analyses, differences between popcorn genotypes in term of ear length value was found significant (P≤0.01). Ear length values were varied from 17.68 cm to 22.95 cm (Table 3). The highest ear length value was obtained from AYCİN R-427 genotype whereas the lowest values were seen at ANTCİN-98 genotype. Genotype average was found as 20.72 cm. Similar to our findings, Özsoy (2017) reported the ear length between 17.1 cm and 19.0 cm, and Cihangir (2013) between 15.02 cm and 17.03 cm.

Kernel number of ear (number ear^{-1})

As seen from table 3 that differences between popcorn genotypes for kernel number of ear value was found statistically significant (P≤0.01). Kernel number of ear ranged from 425.0 to 598.0 number ear^{-1} (Table 3). It was seen from Figure 1 that the highest kernel number of ear value was obtained from AYCİN R-997 genotype whereas the lowest values were seen at 235EAD05 genotype. The general genotype average of grain numbers in the ear was found to be 507.68 number ear^{-1}. When we look at the other studies on popcorn, different results are seen. Doğrul (1999) stated that the number of grains in the ear was between 387 and 561 number ear^{-1}, and Cihangir (2013) stated that between 495.27 and 593.55 number ear^{-1}; Özsoy (2017), on the other hand, reported that it ranged between 678.8 and 574.3 number ear^{-1}.

Table 3. Ear diameter, ear length, kernel number of ear, kernel weight of ear and thousand kernel weight values of popcorn genotypes

Genotypes	Ear diameter** (mm)	Ear length** (cm)	Kernel number of ear ** (number ear^{-1})	Kernel weight of ear** (g ear^{-1})	Thousand kernel weight** (g)
123AYN04	30.21 cd	20.46 cd	430.60 d†	56.20 f	149.06 e
413MHT05	31.93 bcd	21.35 abc	486.80 cd	80.73 cd	195.40 bc
237A1K05	31.47 bcd	19.03 de	449.86 d	67.73 e	190.05 cd
4171ED05	33.00 b	20.77 cd	502.20 bcd	71.13 de	164.24 de
KUM1347	36.50 a	22.03 abc	556.33 abc	107.40 b	229.78 a
235EAD05	30.41 cd	18.51 e	425.00 d	65.66 ef	171.29 cde
411KTR05	37.62 a	21.50 abc	570.13 abc	120.93 a	241.81 a
5YTR1305	37.42 a	20.58 cd	580.00 ab	116.60 ab	223.41 ab
AYCİN R-997	32.54 bc	22.85 ab	598.00 a	90.06 c	162.96 de
AYCİN R- 427	29.99 d	22.95 a	480.20 cd	78.60 d	179.68 cd
ANTCİN- 98	33.00 b	17.68 e	503.80 bcd	74.13 de	164.64 de
ELACİN	37.12 a	20.53 cd	570.60 abc	114.60 ab	231.40 a
BAHARCİN	31.40 bcd	21.18 bc	446.33 d	77.73 d	185.12 cd
Average	33.27	20.72	507.68	86.26	176.83
LSD	2.48	1.75	90.84	9.96	28.22

†There is no statistical difference among values annotated with the same letter according to Duncan test at P≤0.05, ** : denotes P≤0.01.

Kernel weight of ear (g ear^{-1})

Differences among tested popcorn genotypes for kernel weight of ear value was significant (P≤0.01). It was seen from Table 3 and figure 2 that kernel weight of ear values ranged between 56.20 g ear^{-1} (123AYN04) and 120.93 g ear^{-1} (411KTR05). Genotype average was found as 86.26 g ear^{-1}. Similar results were obtained by some researchers. Özkan (2007) found that the weight of the grain in the ear was between 76.4 and 85.9 g ear^{-1}, Cihangir (2013) reported that it ranged between 59.45 and 68.83 g ear^{-1}.

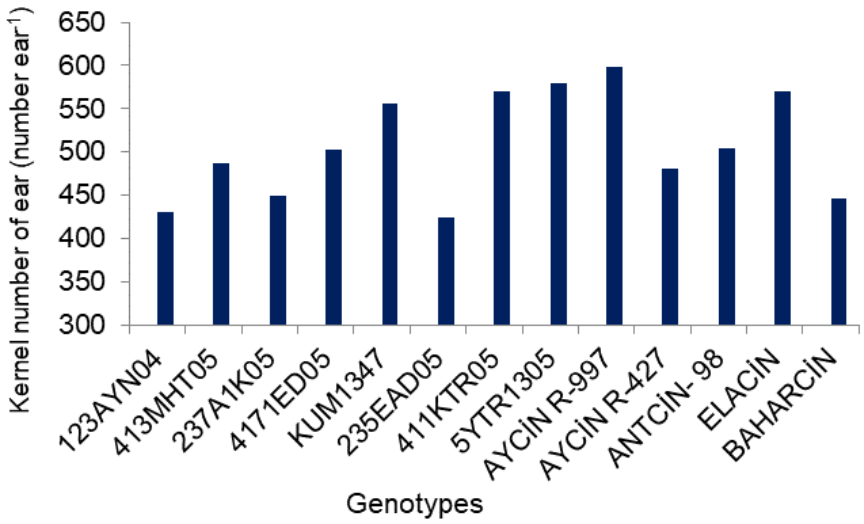

Figure 1. Kernel number of ear values of popcorn genotypes

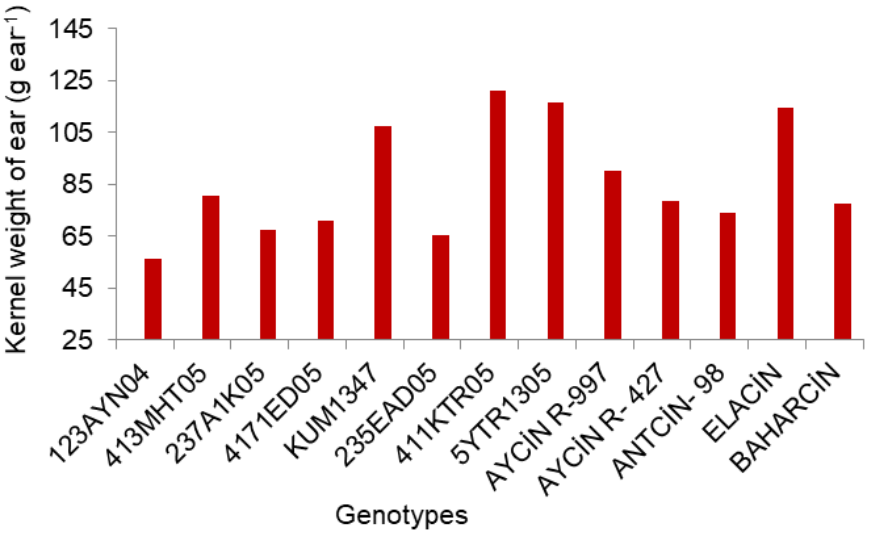

Figure 2. Kernel weight of ear values of popcorn genotypes

Thousand kernel weight (g)

According to variance analyses, differences between popcorn genotypes for thousand kernel weight value was found statistically significant (P≤0.01). Thousand kernel weight was the highest in 411KTR05 genotype as 241.81 g whereas the lowest thousand kernel weight value was seen at 123AYN04 genotype as 149.06 g (Figure 3). The average of genotype was found to be 176.83 g.

Different results have been obtained in other studies. Doğrul (1999) found the weight of thousand grain in popcorn between 104.2 and 208.3 g; Özkan (2007), between 127 g and 135 g; Vural and Dağdelen (2008), between 115.7 g and 130.0 g. Cihangir (2013) stated that thousand kernel weight was between 122.5 g and 138.7 g. Özsoy (2017) emphasized between 106.7 g and 124.5 g thousand kernel weight. Önem (2018) reported that it ranged from 128.8 g to 181.1 g. In addition, some researchers emphasized that environmental conditions and genotypes affect thousand grain weight (Pajic, 1990; Gökmen, 1997; Yılmaz, 1998 and Pajic and Babic, 1991).

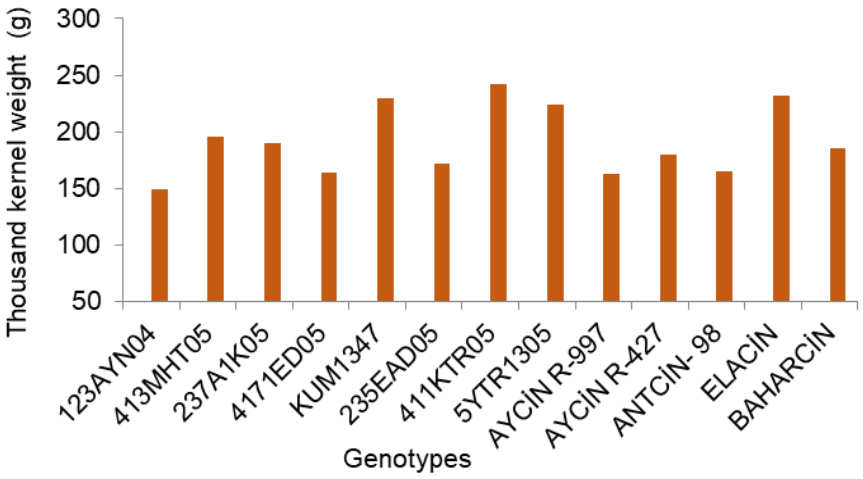

Figure 3. Thousand kernel weight of popcorn genotypes

Table 4. Hectoliter weight, grain yield, popping volume, unpopped kernel ratio and protein content values of popcorn genotypes

Genotypes	Hectoliter weight (kg hL^{-1})	Grain yield** (kg da^{-1})	Popping volume** (cm^3 g^{-1})	Unpopped kernel ratio** (%)	Protein content** (%)
123AYN04	85.80	342.37 h†	26.53 a	1.40 abc	11.20 ab
413MHT05	85.36	562.40 de	21.46 abc	1.74 abc	10.40 abc
237A1K05	86.06	383.99 gh	19.40 bc	1.65 abc	10.60 abc
4171ED05	83.93	493.23 ef	22.33 abc	0.63 bc	10.90 ab
KUM1347	84.76	765.49 c	19.00 bc	0.31 bc	11.40 a
235EAD05	87.53	359.64 gh	23.26 abc	1.98 ab	11.10 ab
411KTR05	86.30	967.91 a	23.93 abc	0.29 bc	9.30 d
5YTR1305	86.33	894.45 ab	21.80 abc	0.42 bc	9.80 cd
AYCİN R-997	89.00	774.46 c	24.86 ab	0.41 bc	10.70 abc
AYCİN R- 427	87.30	602.80 d	24.06 abc	0.54 bc	10.80 abc
ANTCİN- 98	88.43	593.98 de	18.06 c	3.01 a	11.00 ab
ELACİN	87.56	860.77 bc	23.20 abc	0.04 c	10.90 ab
BAHARCİN	86.13	454.78 fg	19.80 bc	0.58 bc	10.30 bcd
Average	86.49	619.71	22.13	1.00	10.64
LSD	5.97	106.21	6.59	1.85	1.06

†There is no statistical difference among values annotated with the same letter according to Duncan test at P≤0.05, ** : denotes P≤0.01.

Hectoliter weight (kg hL^{-1})

According to variance analysis there was no statistically significant difference (P≤0.01) between popcorn genotypes on hectoliter weight (Table 4). The highest hectoliter weight was obtained from AYCİN R-997 genotype (89.0 kg hL^{-1}), while the lowest value was found at 4171ED05 genotype (83.93 kg hL^{-1}). The average hectoliter weight of the cultivars was determined as 86.49 kg hL^{-1}.

When we look at the previous studies on popcorn, it has been reported that the hectoliter weight was between 84.4 and 84.8 kg hL^{-1} (Özkan, 2007), between 75.62 and 81.29 kg hL^{-1} (Cihangir, 2013), between 87.8 and 88.6 kg hL^{-1} (Yerdoğan, 2015), between 76.53 and 80.27 kg hL^{-1} (Özsoy, 2017).

Hectoliter weight in corn is affected by varieties, environmental and growing conditions like plant density, sowing date, fertilizer amount and type, irrigation amount and methods.

Grain yield (kg da^{-1})

Differences among tested popcorn genotypes for grain yield was significant at 0.01 level. Grain yield values and Duncan groups were given Table 4. Grain yield values ranged between 342.37 and 967.91 kg da^{-1} (Table 4). It was seen from Figure 4 that the highest grain yield value was obtained from 411KTR05 whereas the lowest values were seen at 123AYN04 genotype. Mean grain yield value was found as 619.71 kg da^{-1}.

In previous studies conducted with popcorn, Doğrul (1999) stated that grain yield ranged from 386 to 638 kg da^{-1}. Özkan (2007) emphasized that grain yield ranged from 340 to 453 kg da^{-1}, Cihangir (2013) stated that grain yield was between 421.27 and 526.54 kg da^{-1}. It was reported that grain yield was between 244 and 350.4 kg da^{-1} (Özsoy, 2017), 372.1 and 447.6 kg da^{-1} (Yerdoğan, 2015).

Grain yield in corn is affected by varieties, environmental conditions and growing conditions such as plant density, sowing date, fertilizer amount and type, irrigation amount and methods.

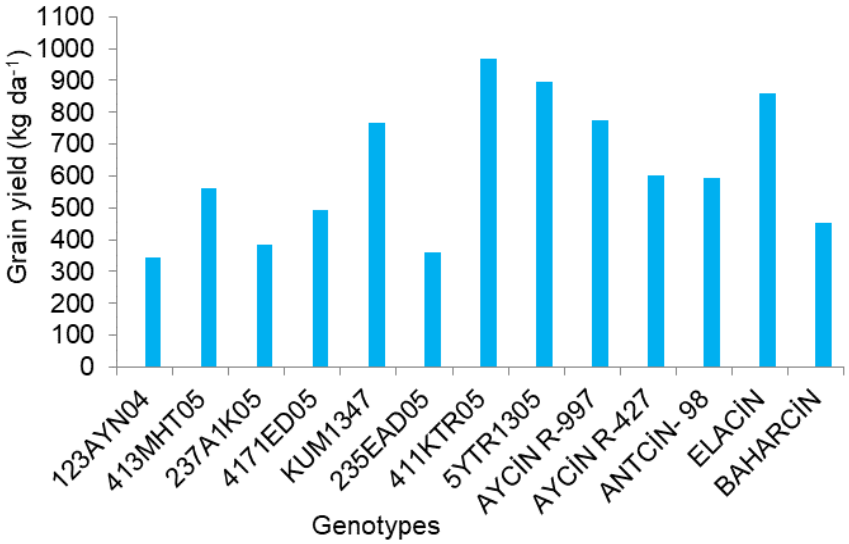

Figure 4. Grain yield values of some popcorn genotypes

Popping volume (cm^3 g^{-1})

According to variance analyses differences among tested popcorn genotypes was significant (P≤0.01) in terms of popping volume. It was seen clearly from Figure 5 that popping volume was the highest in 123AYN04 genotype as 26.53 cm^3 g^{-1} whereas the lowest popping volume value was seen at ANTCİN-98 genotype as 18.06 cm^3 g^{-1}. Average of genotypes was found as 22.13 cm^3 g^{-1}.

Cihangir (2013) emphasized lower popping values than our findings as 17.2 -19.7 cm^3 g^{-1}. Some researchers stated higher popping values than ours as 31.3-35.8 cm^3 g^{-1} (Güven, 2006), 34.6-34.1 cm^3 g^{-1} Yerdoğan (2015) and 32.41 -31.37 cm^3 g^{-1} Özsoy (2017).

Research results was in accord with some previous studies. Similar results were obtained by some researchers. Özkan (2007) stated that popping volume values were between 28.1 cm^3 g^{-1} and 28.7 cm^3 g^{-1}. Önem (2018) found the values of popping volume as 15.6 - 21.8 cm^3 g^{-1}.

Commercially popping volume is very important, because commercial buyers buy popcorn hybrids by weight and sell the popped corn by volume (Oktem and Oktem, 2020). Also, from a commercial stand point, popcorn genotypes with high expansion volumes will produce more popped corn than genotypes with low expansion volumes. The difference arising from the popping volume aspect may be due to the soft/hard starch ratio and distribution in the grain.

Since popcorn is used directly in human nutrition, the grain quality is required. It is especially desired to have a high proportion of popping volume and protein content. Popping volume depends on many factors such as 1000 kernel weight, moisture contents, test weight and genotype. Higher 1000 grain weight increase the popping volume (Oktem and Oktem, 2020). It is seen clearly from table 4 that genotypes have higher thousand weight values give more popping volume values. It is reported that popping volume is positively correlated with the 1000 kernel weight (Hallauer et al., 2010).

However, explosion percentage and burst volume decrease in extremely coarse grains. Dofing et al. (1990) stated that higher non-popped kernel ratio was observed in coarse grained varieties compared to small grained. It has been determined that the popping volume has a negative relationship with the non-explosive grain rate.

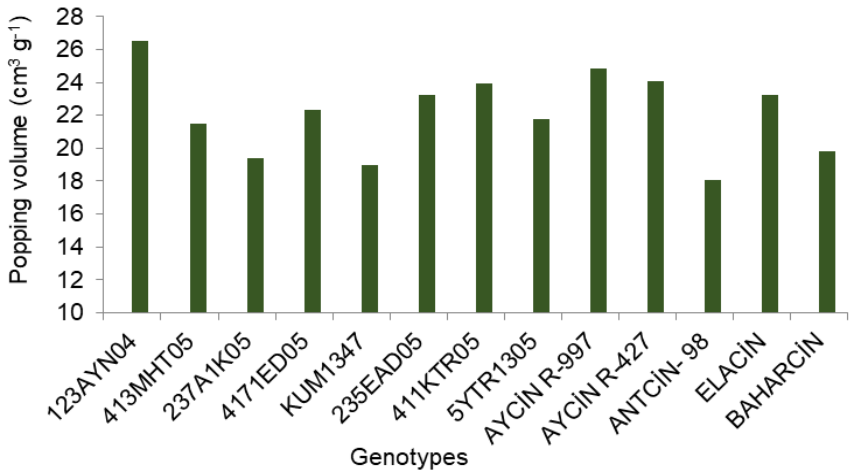

Figure 5. Popping volume values of popcorn genotypes

Jele et al. (2014) reported that there is a negative relationship between the popping volume and the grain size, and a positive relationship between the explosion volume and the number of popped kernels.

Unpopped kernel ratio (%)

According to the results of variance analysis, a statistically significant difference was found among popcorn genotypes in terms of unpopped kernel ratio compared at 1%. Unpopped kernel ratio ranged from % 0.04 to % 3.01.

The highest unpopped kernel ratio was obtained from ANTCİN-98 genotype, while the lowest value was found at ELACİN genotype (Table 4).

When looking at other studies on the ratio of unpopped kernel ratio in popcorn, it is seen that there are different results. Güven (2006) reported higher nonpopped kernel ratios ranging between 13.21% and 19.24%. Özsoy (2017) found that the rate of non-exploding grains varied between 7.38% and 8.68%. Cihangir (2013) stated the unpoped kernel ratio varying between 3.65% and 5.92%.

Our findings are supported by some researchers' findings. Önem (2018) reported that the rate of unpopped kernel ratio ranged from 0.018% to 0.075%, while Özkan (2007) stated that the rate of non-popped grains was between 2.77% and 3.48%. Some researchers stated that the unpopped kernel ratio, which is a parameter that significantly affects the quality of popcorn, differs in varieties (Sakin et al., 2005; Gökmen and Sakin, 2001).

Protein content (%)

A statistically significant difference was found among genotypes in terms of protein content compared to 1% (Table 4). The highest protein content was seen at KUM1347 (11.4%) while the lowest protein content value was obtained from 411KTR05 genotype (9.3%). The average protein content of genotypes was found to be 10.64%. Research results was in accord with Tekkanat and Soylu (2005) that stated protein content of popcorn kernel was between % 9.00 and % 11.34. Özkan (2007) stated the grain protein content between 8.03% and 8.89%, Cihangir (2013) between 12.3% and 16.3%, and Önem (2018) between 8.43% and 16.65%.

The grain protein content, which is one of the important quality parameters, varies according to the variety and environmental conditions. Considering the findings obtained in other studies on popcorn, it is seen that there are different results regarding the grain crude protein content.

CONCLUSION

At the light of research results, when the grain yield, popping volume, unpopped kernel ratio and protein content evaluated together it was determined that 411KTR05, 5YTR1305, ELACİN, AYCİN R-997 and KUM1347 popcorn genotypes was found better than others.

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Determination of Critical Potassium Concentration of Corn (*Zea Maize L.)* at Early Stage of Growth Using Flood and Drain Technique

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Abstract

Critical nutrient concentration is defined as the level that results in 90% of maximum yield or growth which can also be used as a basis in formulating recommendations. An experiment using hydroponically grown corn to determine the critical potassium concentration at its early stage of growth and to assess the suitability of the flood and drain technique. Five (5) treatments used in the experiment which consist of different levels of potassium using KCl arranged in a Completely Randomized Design. There was no significant difference observed in biomass and potassium content of the plant tissue. On the other hand, critical potassium concentration was observed in 2.1% which correlates to the plant biomass and has an r-value of 0.99. This finding suggests that the flood and drain technique is suitable in determining the critical potassium concentration of corn and also this could be useful to an experiment that also involves CNC determination.

Keywords: Critical K concentration, corn, flood and drain technique/ ebb and flow system

Research article
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INTRODUCTION

Corn (*Zea maize* L.) locally known "mais" is next to rice as the staple food for the most Filipinos, which is also considered as an important source of energy. About 20.8 % of the total population in the country eat corn, especially in the Visayas region (Boda, 1965). According to Successful Farming (1996), corn is the most highly valued of all cereal grains for it is multifarious uses of human food, as an important raw material and a vital ingredient for a variety of industries such as paper, beverages, corn starch, corn oil, plastics, high valued feeds, industrial chemicals, medical products, pharmaceuticals, ethanol and many more. Approximately 26% of the country's area are devoted to corn production or approximately 3,432,700 hectares of agricultural land (PCARR, 1975). However, it is important to increase food production to be able to meet the food demand of the continuing population of the country.

Plants require 17 essential elements for growth; carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), Sulphur (S), calcium (Ca), magnesium (Mg), boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Z). These essential elements are also called nutrients. The first group is the three macronutrients that plants can obtain from water, air or both (C, H, & O) the soil does not need to provide these nutrients, so they are sold as fertilizers. The other 14 essential elements are split into two groups- soil-derived macronutrients and soil-derived micronutrients. The split is based on the actual amount of nutrients required for adequate plant growth. One of the examples of soil-derived macronutrients is potassium (K), potassium (K) is needed by plants in a considerably large amount together with nitrogen (N), and phosphorus (P).

Potassium has many different roles in plants, in fact according to Min Wang et. al, (2013) potassium (K) is an essential nutrient that affects most of the biochemical and physiological processes that influence plant growth and metabolism. Potassium is also important for water and energy relationships and has been linked to improved cold hardiness. Since potassium is mobile in plants, deficiencies can be diagnosed by looking at the older plant tissue/leaves. Deficiencies appear along the outer margins of older leave as streak or spots of yellow (mild deficiencies) or brown (severe deficiencies).

Correct fertilization is necessary to maximize net returns from field crop production. Critical nutrient concentration or CNC is a term both common in soil and plant analysis. In plant analysis, it is defined as the level that results in 90% of the maximum yield or growth (Lal, 2017). Determining the CNC for every crop could also serves as a basis in formulating fertilizer recommendations.

Flood and drain technique by ebb and flow is a popular hydroponics, a method of growing plants in water rather than in soil. Drain system uses soilless media, the container that contains nutrient solutions will be pumped into the plants using an aerator for a specified time. In the case of corn, information on the critical potassium concentration of corn is available, hence this study is conducted. Hence, this particular research study was conducted to reassess the critical potassium (K) content of corn and to evaluate the suitability of the ebb and flow system in determining the critical concentration of potassium at the early stage of growth.

MATERIALS and METHODS

Preparation of Nutrient Solution

Eight (8L) modified Hoagland's solution as described by Taiz and Zeiger (2002) was prepared in the study. The modification was made in the composition of the solution (Table 1). Potassium application was varied for each treatment.

Table 1. Composition of a Modified Hoagland Nutrient Solution*

Salts	Stock solution (g 500 ml^{-1})	Volume of stock solution (ml L^{-1})
Macronutrient		
$Ca(NO_3)_2 \cdot 4H_2O$	118	4
$Na(NO_3)$	42.5	6
$MgSO_4 \cdot 7H_2O$	123	2
$NH_4H_2PO_4 \cdot H_2O$	66	1
Micronutrient	**(g 20 ml^{-1})**	
H_3BO_3	0.286	1
$MnCl_2 * 4H_2O$	0.181	
$ZnSO_4 * 5H_2O$	0.022	
$(NH_4)_2MoO_4 * 4H_2O$	0.080	
$CuSO_4 * 5H_2O$	0.002	
$FeCl_2 * 4H_2O$	0.89	10
Na_2EDTA	1.865	

* Source of K = KCl* H_2O

Nutrient Solution Management and Plant Set-up

Each container was transplanted with corn seedlings of almost the same size and vigor was grown hydroponically in a soilless medium employing the flood and drain (ebb and flow) system. Plant roots were flooded every after 2 hours daily with nutrient solution from the reservoir using a submersible pump. The solution was allowed to drain from the roots by gravity every after 15 minutes of submergence. The nutrient solution was kept aerated until harvest.

Experimental Design and Pot Layout

The experiment was conducted at the screen house of the National Abaca Research Center (NARC), Visca, Baybay City, Leyte. It was carried out in a Completely Randomized Design (CRD) with 5 nutrient solution containers containing different levels of N as treatments having 4 pots each as replicates. The different treatments were designated as follows:

T_0 = 0 mg K L^{-1} solution
T_1 = 30 mg K L^{-1} solution
T_2 = 60 mg K L^{-1} solution
T_3 = 90 mg K L^{-1} solution
T_4 = 120 mg K L^{-1} solution

Maintenance and Pest Control

The plants were kept pest free until harvest. If infested by pests and diseases, a suitable pesticide was applied not unless the damage reaches the critical threshold level.

Biomass Determination

Dry matter yield (g plant^{-1}) – This was determined by weighing the fresh plant parts composed of roots and shoots. Samples were oven-dried at 70 ^{o}C until constant weight is attained. The dry matter yield was calculated as follows:

Dry matter yield (g plant^{-1}) = Total dry weight of leaves + Total dry weight of pseudostem + Total dry weight of roots

Preparation and Analysis of Tissue Samples

Plant samples taken from the harvested leaves were used for nutrient analysis. These were washed with distilled water to remove any adhering soil particles. The samples were oven dried and ground in a tissue grinder ready for analysis.

A 0.2 g sample of both shoots and leaves was dry-ashed separately in a furnace at 500°C for 5 hours. The white ash in the crucible was added with 0.1N HCl solution and transferred into the volumetric flask up to 100 ml mark. The solution was filtered and the filtrate was analyzed. The total potassium in the extract was quantified using AAS (atomic absorption spectroscopy) in DOST-Philippine Nuclear Research Institute.

Critical Potassium Concentration Determination

Determination for the value of the critical K was determined using CurveExpert ver. 1.4. And by following the formula:

CNC= highest value of the computed Y – 10% of the highest value of the computed Y

Statistical Analysis

Statistical analysis of all data gathered obtained was done using the statistical tool available (STAR ver.2.0.1). Analysis of variance (ANOVA) will be used to test the significant effects among treatments and will be separated following the Duncan's Multiple Range Test at 5 % level of significance

RESULTS and DISCUSSION

General Observation

A week after the set-up, transplanted corn with different levels of potassium concentrations showed uniform growth. The majority of the treatments are showing interveinal chlorosis for 2 weeks after transplanting, but the plants recovered in the following weeks until harvest.

There were problems tackled during the conduct of the experiment such as uneven distribution of sunlight through the different treatments. The presence of leakage in each hose and hose malfunction makes the solution to run out in every container which was rehabilitated immediately.

Generally, corn grown hydroponically in treatment 4 (120 mg K L^{-1} solution) were taller (no presented data) but showing a thin stem which needed a stake to support the corn compared to other treatments.

Figure 1. Two-week-old corn seedlings hydroponically grown using ebb and flow system with varying levels of K (*levels were 0, 30, 60, 90, and 120 ppm*)

Growth Characteristics, Biomass Content and Potassium Uptake of Corn

The nutrients have a specific role in the various biochemical processes in the plant system specifically on the production of photosynthesis which is an essential component for dry matter production. The symptom of having a potassium deficiency could appear along the outer margins of older leave as streak or spots of yellow (mild deficiencies) or brown (severe deficiencies). In this particular study, both total K uptake and biomass were not significant. Transplanted corn showed uniform growth during the early stage of research (2 weeks). However, in the succeeding weeks, it was further observed that there was a change in variation to most of the growing plants. It was observed (no data presented) that corn grown hydroponically with 120 mg K L^{-1} solution (figure 2) were taller throughout the duration of the study. Amanullah et. al, (2016) demonstrated that increasing the rate of K (under a certain level) will improve growth and maize productivity of corn under certain conditions.

Figure 2. Comparative growth characteristics of corn flow system with varying levels of K (*levels were 0 T1 (30), T2 (60), T3 (90), and T4 (120 ppm*) upon harvest

Even though there was no significant difference in the different nutrient solutions used, it is worth mentioning that most corn with 120 mg K L^{-1} solution has higher K content and plant biomass.

Critical Potassium Concentration

According to Alsaeedi and Elprince (2000), CNC refers to the boundary between deficiency and adequacy zone, it could also refer to the nutrient concentration where plant growth first begins to decrease. In this particular study, the critical potassium concentration of corn at its early stage of growth is at 2.1 % K (figure 3) which correlates to biomass production and having an r value of 0.99. Cox and Barnes (2006) determined that the critical potassium concentration for corn grown in a goldsbro soil is 1.02%. The result may vary depending on the medium used in the experiment.

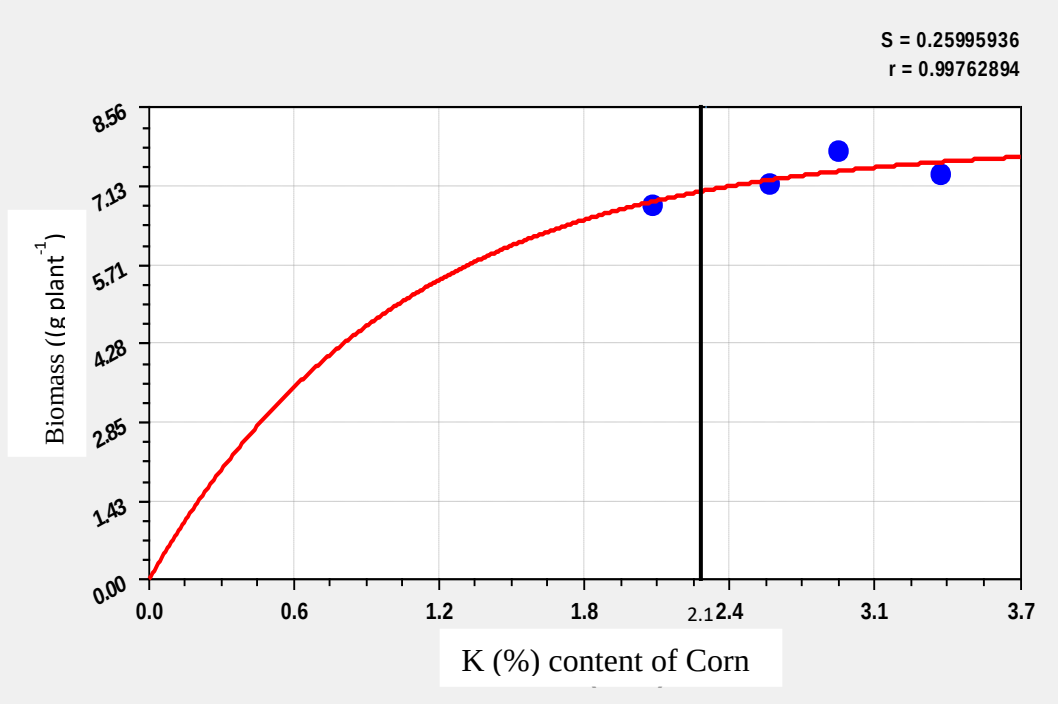

Figure 3. Critical potassium concentration of corn at early stage of growth (regression equation: $y=7.90E+00\ (1-e^{-(9.51E-01\ X)})$

CONCLUSION

Transplanted corn were grown hydroponically using flood and drain or ebb and flow system with the different treatments; T_0 = 0 mg K L^{-1} solution, T_1 = 30 mg K L^{-1} solution, T_2 = 60 mg K L^{-1} solution, T_3 = 90 mg K L^{-1} solution, & T_4 = 120 mg K L^{-1} solution. The plants were harvested after 4 weeks after transplanting.

There was no significant difference observed in both potassium content and biomass production of the corn. Treatment 4 (120 mg K L^{-1} solution) was observed be the tallest among the treatments.

Based on the results of the study, critical potassium level was determined at 2.1% for corn at its early stage of growth, and Ebb and Flow or the flood and drain system suits perfectly in determining the critical concentration of potassium of corn at its early stage of growth.

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Food-borne Pathogens in Seafood

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Abstract

Nowadays food poisoning is a major social and scientific issue. Food poisoning is caused by those foods which looks normal when we see it, smells normal and even tastes normal when we eat it. Only special scientists can analyze food quality by checking its all-sensory parameters. Food poisoning caused by foodborne pathogens. These pathogens can be bacteria, viruses, fungi and algae. Pathogens mostly attack on those foods which stored in humid environment, high temperature and which have more water content. According to these conditions' seafood is more susceptible food for contamination. Seafood can be contaminated by pathogens at any stage from harvesting to fork. Sometime fish can become poisonous even in water by some bacteria's or by some algal toxins. Most common pathogens which involve in seafood poisoning are *Vibrio, Salmonella, Listeria, Shigella, Staphylococcus, Clostridium* and *Escherichia coli*. Poisoning diseases which can occur are scombroid poisoning, amnestic shellfish poisoning and diarrheic poisoning, etc. Some viruses also involved in seafood born infections. These infections can be avoided by using proper cleanliness and care in handling fish. In this review the most common food-borne pathogens in fish and fish products are discussed.

Keywords: Seafood poisoning, food-borne pathogens, contamination, infection, bacteria, virus

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INTRODUCTION

What is Pathogen?

Biological agents (viruses, bacteria, parasites) that can cause foodborne infections are called foodborne pathogens. When two or more than two cases of same disease occur due to eating of same food is called foodborne disease epidemic (CDC, 2012). Pathogens were divided into groups on the basis of illness brutality in 1986. In 2000 International Commission on Microbiological Specification for Foods revised this division of pathogens, which is given in below table. Some indicator organisms can be used to reveal the occurrence of those foodborne pathogens which are difficult to detect. 'Indicator organisms' are linked with organisms of intestinal origin.

Another term used for the detection of environmentally similar foodborne pathogens is 'index organism' that was proposed by Ingram in 1977 as a marker. Microbial indicators are mostly used for checking the food quality and safety. Ideal food safety indicator should: a) be easily and quickly detectable, b) be easily differentiated from other members of the food flora, c) whose numbers perfectly relate with concerned pathogen, d) keeping growth rate and requirements similar to those of the pathogen. Common indicator organisms are coliforms *E. coli*, Enterobacteriaceae and Fecal *Streptococci.*

Table 1. Some pathogens and effects of hazards

Effects of hazards	Pathogens
. Moderate, direct, limited spread, death rarely occurs Moderate, direct, potentially extensive spread, death or serious sequelae can occur. Considered severe, direct Categorization of common foodborne pathogens (ICMSF, 1986)	*B. cereus, C. jejuni, Cl. perfringens, S. aureus,Y. enterocolitica, Tuenia saginata, Toxoplasma gondii,* Pathogenic *E. coli, S. enteritidis* and other *Salmonellae* other than *S. typhi and S. paratyphi, Shigellae other than Sh. dysenteriae, L. monocytogenes, Cl. botulinum types* A, B, E and F, hepatitis A virus, *Sh. dysenteriae, S. typhi* and *S. paratyphi* A, B, and C, 7: spiralis
Proposed updated categorization (ICMSF, 2000) Food poisoning organisms causing moderate, not life threatening, no sequelae, normally short duration, self-limiting Serious hazard, incapacitating but not life-threatening, sequelae rare, moderate duration Severe hazard for general population, life- threatening, chronic sequelae, long duration Severe hazard for restricted populations, life-threatening, chnic sequelae, long duration	*B. cereus* (including emetic toxin), *Cl. perfringens* type A, Norwak-like viruses, *E. coli* (EPEC, ETEC), *S. aureus, V. cholerae* non-01 and non-0139, *V. parahaemolyticus* *C. jejuni, C. coli, S. enteritidis, S. typhimurium, shigellae, hepatitis* A, L. *monocytogenes, Cryptosporidium parvum, pathogenic Y. enterocolitica, Cyclospora cayetanens*is Brucellosis, botulism, *EHEC (HUS), S. typhi, S. paratyphi, tuberculosis, Sh. dysenteriae, aflatoxins, V. cholerae* O1 and O139 *C. jejuni* O: l9 (GBS), *C. Perfringens type* C, hepatitis A, *Cryptosporidium parvum, V. vulnificus, L. monocytogenes,* EPEC (infant mortality), infant botulism, *Ent. sakazakii*

Food poisoning is caused by those foods which looks normal, gives normal smell and even normal in taste. In this condition consumer could not estimate that this food has pathogens and when they ingest it to exceeding limit of infectious dose, they become ill. As a result, it is difficult to know which food was the exact reason of food poisoning. Many organisms can cause food poisoning, their incubation and disease time periods significantly change from one organism to another organism.

Table 2. Microorganisms and incubation periods

Microorganism	Incubation period	Duration of illness
Aeromonas species	Unknown	1- 7 days
C. jejuni	3-5 days	2- 10 days
Escherichia coli types		
ETEC	16-72 hours	3-5 days
EPEC	16-48 hours	5- 15 days
EIEC	16-48 hours	2-7 days
EHEC	72-120 hours	2- 12 days
Hepatitis A	30-60 days	2-4 weeks
Listeria monocytogenes	3-70 days	Variable
Norwalk-like virus	24-48 hours	1-2 days
Rotavirus	24-72 hours	4-6 days
Salmonellae	16-72 hours	2-7 days
Shigellae	16-72 hours	2-7 days
Yersinia enterocolitica	3-7 days	1-3 weeks

Food poisoning is divided into two types on the basis of their causing factors and their method of causing disease. Infections contain those microorganisms which growing in the human intestinal tract, while Intoxications contain those microorganisms which can produce toxins in the food or also when passing through the intestinal tract. These groups are very useful to identify the paths of food poisoning. Aquatic environment naturally contains pathogens or these can produce due to polluted water. This water pollution produced by excreted fertilizers, human sewage, and due to animal farms. Aquaculture products become contaminated from bacteria, viruses, parasites and biotoxins (Huss et al., 2003). Most common aquatic pathogens are *Escherichia coli, Salmonella, Shigella, Yersinia, Brucella* and *Edwardsilla*.

Why Fish is Important in Poisoning?

Seafood is a best nutritional food containing proteins, unsaturated fatty acids, vitamin D, iodine and selenium. Ingestion of fish is very important for health, during pregnancy and early growth stages (Emmett et al., 2013) and it is also useful for cardiac patients (Zarrazquin et al., 2014). Usage of Seafood has increased in U.S regularly from 1980 to 2006. Seafood is very health but it is also a main carrier for spreading of many bacterial diseases. Food poisoning diseases in humans caused by different pathogenic bacteria and these are normally transferred from fin fish, shell fish and other sea food products (Okuda et al., 1997).

Pathogens which are main causing agents of infection in fish are *Vibrio cholerae, Vibrio parahaemolyticus, Salmonella sp., Staphylococcus aureus, Listeria monocytogenes, Yersinia enterocilitica, Campylobacter jejuni* and *Escherichia coli* (Venugopal et al., 1999). Seafood which is getting from coastal areas is the main source of pathogenic microorganisms due to joined population (Kumar et al., 2005).

Antimicrobials which are officially used for seafood protection in aquaculture farming are therapeutics and prophylactics. As usage of antimicrobials increasing, their extra residues accumulated in water and become dangerous for aquatic species (Marshall and Levy, 2011). When unapproved antimicrobials such as chloramphenicol, nitrofuran, etc. are used it becomes dangerous for human health. Extra use of antibiotics for elimination of bacteria can improve antibiotic resistance in aquatic pathogens (Cabello, 2006). Antimicrobials such as b-lactams, streptomycin's, and aminoglycosides can add in aquaculture through water solution or through feed and these can be a major cause of contamination in aquaculture.

Scientists reported that genes of antimicrobial resistance can transfer horizontally from microorganisms to human through food chain (Heuer et al., 2009). This transfer can be of two types: one is direct transmission and other is indirect transmission. If this transfer done by ingestion of zoonotic bacteria which itself carries antimicrobial gene then it is called direct transmission (Heinitz et al., 2000). If aquatic pathogens transfer antimicrobial resistance gene to human pathogen then it is transferred to humans is called indirect transmission (Heuer et al., 2009). Zoonotic infections are of two types: a) when it caused by direct contact with aquatic animals is called topically acquired infection; b) when it caused by eating of undercooked food.

BACTERIAL INFECTIONS

When humans come in direct contact with bacterias like *V. vulnificus, M. marinum, S. iniae, E. tarda, Aeromonas hydrophila* (Lehane & Rawlin, 2000) and *Erysipelothrix rhusiopathiae* (Brooke and Riley, 1999; Harada et al., 2011) from fish, shellfish or crustaceans, through damage of vertebera (Janda & Abbott, 1993). These infections are mostly occurred in immunodeficient patients. Those persons who have routinely skin contact with fish, live in humid climate and at temperature which is favorable for bacterial growth, are also more susceptible for infection. Principal species of Vibrio (*Vibrio vulnificus, V. parahaemolyticus, V. damsela* and *V. cholerae* are incriminate in human infections. (Dryden et al., 1989). This infection can be lethal when it is caused by *V. vulnificus* (Austin, 2010).

Edwardsiella tarda

A systemic disease 'fish gangrene' caused by *Edwardsiella tarda*, catfish disease known as 'emphysematous putrefactive' and 'red disease of eels' caused by *Edwardsiella septicaemia*.

Streptococcus iniae

A zoonotic pathogen *Streptococcus iniae* in fresh & marine water produce infection in aquatic species mostly in the tilapia and hybrid striped bass (Agnew and Barnes, 2007). It is a Gram-positive bacterium, which produced severe infection in humans.

Mycobacterium marinum

It is an acid-fast rod-shaped bacterium that produces lethal and severe infection in many fish species in fresh and marine waters all over the world (Evans et al., 2009; Nichols et al., 2004).

Mycobacterium marinum usually causes loss of scales, loss of appetite, discoloration, apathy, exophthalmus, slimeless skin, ulcers and produces tumors in many parts of body, even leads to death (Gauthier & Rhodes, 2009). *M. marinum* has ideal growth temperature of 30°C. *M. marinum* causes granulomatous swelling of the skin, swelling of dermal tissues, tendon sheaths of fingers and hands, Offensive septic arthritis and osteomyelitis in less immune hosts (Jernigan and Farr, 2000; Lahey, 2003).

Grouping on the Basis of Etiologic Agents

Pathogenic microorganisms are the main factors for water contamination. This contaminated water will produce infectious food. These pathogenic infections have different causes and prevalence's. On the basis of their prevalence, etiologic agents categorized pathogens into two groups of major and minor concern. Microbial agents of major concern in seafood include: norovirus, *Vibrio*, and *Salmonella*. Minor agents of concern include hepatitis A virus (HAV), *Shigella, Listeria monocytogenes, Clostridium botulinum, Staphylococcus aureus* and *E. coli* (Hadler, 1991).

SIGNIFICANT GROUP of PATHOGENS

Norovirus

It is known as "RNA calicivirus" highly transmissible infection causing in humans. Norovirus has two Geno groups GI and GII, which can cause infection in human (Woods et al., 2016; Bazzardi et al., 2014). This infection known as the principal reason of digestive problems without bacteria due to eating of undercooked shellfish and oysters (Woods et al., 2016). The main sources of norovirus were Mussels and clams (Bazzardi et al., 2014; Terio et al., 2010) prawns, crabs, and finfish (Anbazhagi and Kamatchiammal, 2010) spider, gooseneck and barnacles (Sala et al., 2008). Symptoms of this infection are vomiting, nausea, abdominal cramps, headache and fever (Iwamoto et al., 2010).

Vibrio

Vibrio is the main cause of human food poisoning. It spreads in the main portion of fresh and marine waters so it is mostly secluded from seafood specifically from shellfish. *Vibrio* species are rod-shaped, Gram-negative bacterium. It is facultative anaerobic, halophilic, curved and non-spore forming. It is motile with the help of flagella. Their habitat is in seashore areas, water deposits, and nearly all animals and plants of seaside containing this pathogen (Scha€rer et al., 2011; Thompson et al., 2005).

Vibrio has 65 species, from which only 3 species *V. parahaemolyticus, V. cholera* and *V. vulnificus* are mostly responsible for food borne infections (Sudha et al., 2012; Gopal et al., 2005). Other Vibrio spp. which can cause disease in humans infrequently are *V. mimicus, V. fluvialis, V. damsella, V. hollisae, V. alginolyticus, V. furnissi, V. metschnikovii* and *V. cincinnatiensis.*

Vibrio vulnificus

Vibrio vulnificus is seafood borne pathogen. *V. vulnificus* has been divided into three subtypes on the basis of their biochemical properties are following:

- Biotype 1 in crustaceans and humans (Tison et al., 1982)
- Biotype 2 in eels (Tsai et al., 1990)
- Biotype 3 in tilapia (Bisharat et al., 1999). It causes wound infection in humans during dealing with fish, also causes liver illnesses and hemochromatosis which leads to death (Rajapandian et al., 2009).

Vibrio vulnificus is a zoonotic offensive pathogen (Austin, 2010). When an injured person comes into contact with contaminated seawater, fish or shellfish caused primary wound infections even in low number of pathogens (Dalsgaard et al., 1996; Oliver, 2005) followed by fasciitis necroticans (Dijkstra et al., 2009; Kuo et al., 2007) and even leads to death (Ralph & Currie, 2007).

Vibrio parahaemolyticus

In many Asian countries *V. parahaemolyticus* usually known as cause of seafood-borne infection (Deepanjali et al., 2005). It is a halophilic gram negative, motile, oxidase positive, straight or curved rod- shaped, facultative anaerobic bacteria that occur naturally in marine water. These are native microflora of aqueous environment and mostly cause severe illnesses in penacid shrimp, shellfish and fish (Nelapati et al., 2012). Gastroenteritis, wound infections, and septicaemia are three major diseases caused by *V. parahaemolyticus* (Nair et al., 2007).

Vibrio cholera

V. cholerae and its relative *V. mimicus*, both bacteria's can occur in both marine and pond water. They can grow in laboratory without using sodium chloride so these are known as unusual *Vibrio* species (Nishibuchi and DePaola, 2005; Parveen and Tamplin, 2013). *V. cholerae* produce Cholera, a severe chronic diarrhea. Centre for Disease Control and Prevention has classified Cholera as category B bioterrorism (WHO, 2008).

Salmonella

Seafood is a main source of *Salmonella* contamination (D'Aoust et al., 2001). This pathogen excretes in fresh water reservoirs and in seashore reservoirs through fecal contamination. Salmonellae are facultative anaerobic and Gram-negative bacteria. This bacterium is small, rod-shaped, catalase positive, oxidase negative, and can move with flagella. It causes diarrhea and inflammatory reaction. This infection starts symptoms after 12 to 72 h of ingestion of contaminated food. *Salmonella* infections are mostly caused by eating poorly cooked seafood like finfish, shrimps and crustaceans (NACMCF, 2008).

MINOR GROUP of PATHOGENS

Hepatitis A Virus

It is non-enveloped virus belongs to the Hepatovirus genus and the Picornaviridae family. Natural habitat of Hepatitis A virus are humans and other Vertebrates (ICTV, 2012). Symptoms of this disease can appear in 2 to 3 weeks (WHO, 2016) and it can also reach 45 days (Richards, 2013). Children have no symptoms; most patients have mild symptoms but these can be severe in old or less immune persons. Symptoms of this disease are loss of appetite, fever, abdominal pain, jaundice and diarrhea (Ghasemian et al., 2016). HAV is a critical disease with low death rate. Main reasons of this disease are usage of fecal polluted water, ingestion of contaminated seafood, and improper cleanliness (Richards, 2013).

Listeria Monocytogenes

It is a non-spore forming, Gram-positive bacteria with rod shaped. It is facultative food borne pathogen microorganism of humans and animals (Dhama et al., 2013). It can survive at refrigerated temperature, at low pH and in high salty environment (Gandhi and Chikindas, 2007). It is a lactic acid producing bacteria. *Listeria monocytogenes* are universal bacteria of all soil, water, animal and plant environments because it can adjust in broad range of temperature and PH (Jay et al., 2005). A foodborne disease also involving seafood caused by *Listeria* spp. is called Listeriosis. This disease can be transmitted to humans by eating packed seafood products (Miya et al., 2010). Symptoms of this disease are chilling, nausea, fever, gastroenteritis etc. followed by septicemia, meningitis, encephalitis, abortion and even death (Barbuddhe et al., 2008). Pregnant women, immunodeficient and elderly people have more chances of listeriosis (Parihar et al., 2008; Das et al., 2013).

Shigella Spp.

It is rod-shaped, Gram-negative, immobile, oxidase-negative and non-lactose fermenting bacteria. *Shigella* species are categorized into four types due to its serology antigen. Group. A involve *Sh. dysenteriae*, Group. *B involve Sh. flexneri*, Group. *C involve Sh. boydii*, and Group. D involve *Sh. sonneii* (O'Connel et al., 1995; Lampel, 2005). Symptoms of shigellosis are fever, abdominal pain, tenesmus, and bloody diarrhea. This bacterium attack on intestinal cells, can exist in stomach acid, due to its multi-virulence aspects (Wang et al., 2011).

Clostridium botulinum

It is spore forming, anaerobic, Gram-positive bacillus bacteria. *C. botulinum* produces neurotoxin which can contaminate food. Human botulism has four transmission types involving fish, wound, child, adult and immunodeficient persons (CDC, 2014b). Symptoms of this disease are dizziness, fatigue, double vision, difficulty in swallowing and speaking, and weak muscles (Aberoumand, 2010). This infection can cause by eating canned products of seafood. Spores and toxins of *Clostridium botulinum* are mostly occurred in flounder, cod, white fish, rock fish and in smoked fish. (Iwamoto et al., 2010).

Staphylococcus aureus

It is catalase positive, Gram +Ve and chemotrophic bacterium. *S. aureus* enterotoxins are causing foodborne infection but it is not done by raw seafood (NACMCF, 2008). Worldwide most prevalent causes of gastroenteritis caused by eating staphylococcal contaminated food (Jablonski and Bohach, 2001).

Escherichia coli

All over the world *Escherichia coli* serogroup 0157 is one of the most important evolving foodborne pathogens (WHO, 1997). *E. coli* can produce many enterotoxins so it can mostly become the reason of food infections (Sharma et al., 2005). *E. coli* 0157:H7 infection can cause severe bloody diarrhea (Haemorrhagic Colitis, HC), chronic complications such as Haemolytic Uraemic Syndrome (Kumar et al., 2001).

SEAFOOD POISONING ASSOCIATED WITH BIOTOXINS

Seafood considered as 'healthy food, but it can also cause food poisoning produced by toxins. These toxins are originating from toxic algae and also from bacteria, for example: Puffer fish poisoning and scombroid poisoning.

Scombroid Poisoning

This poisoning caused by ingestion of contaminated seafood, especially of the Scombridae species. Scientists thought that histamine is main causing factor of this poisoning (Ucak and Gokoglu, 2020; Ucak et al., 2019; Ucak et al., 2018; Yerlikaya et al., 2014). This histamine produced from histidine which is naturally present in fish. Bacterial enzymes histidine decarboxylase converted histidine to histamine biogenic amine. Bacteria's which are commonly involved in this process are *Proteus, Enterobacter, Serratia, Citrobacter, Clostridium, Vibrio, Acinetobacter, Pseudomonas,* and *Photo bacterium* (Lopez-Sabater et al., 1996; Tsai et al., 2004).

Fish species which can mostly cause scombroid poisoning are Tuna, mackerel, bonito, sardines, anchovies, herring and pilchards (Scoging, 1998; Bartholomew et al., 1987). Symptoms of this disease are rashes on neck, face and upper chest, diarrhea, sweating, nausea, headache, abdominal pain, dizziness, metallic taste and burning in mouth (Scoging, 1998; Attaran and Probst, 2002).

Toxic Diseases Caused by Marine Algae

40 species of marine algae, out of more than 5000 species produce effective toxins. These toxins are produced in the form of cysts that can rest inactive for years. As algae found proper growing conditions, algae cell will multiply rapidly (Daranas et al., 2001). This toxin may then enter in the aquatic organisms which can be eaten by fish or sometime directly enter in fish. In this way Shellfish can become enough poisonous to cause disease in person within 1 day.

Amnesic shellfish (ASP) Poisoning

ASP produces neurotoxins that are water-soluble. Major toxic compound is domoic acid which gradually stored in gastrointestinal mucosa (Hess et al., 2001; Daranas et al., 2001). Toxin is produced by dinoflagellates and by diatoms an effective promoter for increasing calcium permeability and glutamate receptors, which eventually ends with cell death. Domoic acid found in many types of fish, like mackerel, jack smelt, albacore, anchovies, sardines, sanddabs and in krill (Lefebvre et al., 2002). This disease can cause neurological problems (confusion, memory loss, disorientation, seizure, and coma) and gastrointestinal diseases (vomiting, diarrhea, abdominal pain) (Todd, 1993). Neurological symptoms occur within 2 days, while gastroenteritis symptoms occur within 1 day.

Azaspiracid Poisoning

This poisoning is caused by *Protoperidinium*. This genus is universal hence azaspiracids can exist in shellfish of allover northern Europe. This poisoning was confirmed first in Netherlands in 1995. Symptoms of this disease are nausea, vomiting, severe diarrhea and stomach cramps, with disease interval up to 5 days (James et al., 2002).

Diarrheic shellfish (DSP) Poisoning

DSP toxins are of four types.

- Okadaic acid
- Dinophysis toxins
- Pectenotoxins
- Yessotoxins

Two types of toxins like okadaic and sometime dinophysis toxins are strong protein phosphatase inhibitors, hence they promote the accumulation of phosphate in many intracellular proteins and promote tumor formation. Dinoflagellates produce pectenotoxins and yessotoxin (Burgess and Shaw, 2001). Symptoms of this disease are gastrointestinal disorders, including nausea, diarrhea, and abdominal cramps with chills, headache and fever. This disease can occur within half hour to a few hours after eating contaminated seafood (Daranas et al., 2001).

Paralytic shellfish Poisoning

Paralytic shellfish poisoning (PSP) is lethal. Incubation period of disease differs from 15 min to few hours less than 10 hours. Symptoms include tingling or numbness around the lips, which spreads to the face and neck, a prickling sensation in the fingertips, headache, fever, nausea, vomiting and diarrhea. In the worst cases Death can occur due to breath obstruction (Anonymous, 2002). Toxins of this disease occur in mussels, clams, oysters, scallops, abalone, gastropods, crustacea, crabs and lobster (Oikawa et al., 2002). Toxins of this disease secreted from dinoflagellates.

Ciguatera Poisoning

Ciguatoxins are produced by algae found on tropical coral reefs (Yasumoto, 2001) and are mostly occur in toxic coral reef fish, including moray eels, groupers, snappers, barracuda, parrot fish and mullet. In this disease patients have sensory problems, that touching cold water gives pain as an electric shock (Ting and Brown, 2001). Symptoms of this poisoning are diarrhea, vomiting, muscle pain and itching, Prickling of the lips, tongue and throat, Headache Severe pain in arms, legs, impaired vision. Neurological disorders can last for many years but this disease is not lethal (Yasumoto, 2001).

CONCLUSION

Seafood is a main carrier of many bacterial disease's transmission in humans. This contamination can occur by bacteria, viruses and many other algal toxins. Seafood pathogens naturally live in both marine and fresh water environments. These pathogens can contaminate seafood at any stage of harvesting and processing. Seafood demand increasing worldwide but due to contamination of fish and seafood products, fish exporters facing loss. To overcome this problem proper handling and care should apply during fish processing from harvesting to table.

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Evaluation of pH Changes in Trout Farms: A Case Study of Niğde Region, Turkey

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Abstract

In this study, it was aimed to periodically examine the pH changes in the water resources used for some trout farms in the Niğde region. For this purpose, the pH values of pool entrances and pool exits were determined in the trout farms. In this context, four (A, B, C, D) trout farms were defined and water samples were taken periodically (Spring, Summer, Autumn and Winter period). The pH values in the water samples were interpreted within the scope of the "Water Pollution Control Regulation" standards. According to the results, the average pH values were determined as 7.25, 7.26, 7.19 and 7.18, in the A, B, C and D trout farms, respectively. In general, the pH values of the pool's entrances were lower than the pH values of the pool's exits. According to the ''Water Pollution Control Regulation'' and the classes of inland water resources, it has been seen that the water resources are suitable for fish farming in terms of pH value in the examined stations.

Keywords: Trout farms, pH value, Water quality, Niğde region, Turkey

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INTRODUCTION

The aquaculture sector is a growing and developing sector all over the world. According to the data reports of FAO, Turkey is the 3rd fastest growing country in aquaculture in the world (Coşkun et al., 2011). World aquaculture production is 170 million tons in total, 80 million tons of which is obtained through aquaculture (TUIK, 2018). In Turkey, aquaculture, which started especially in the 1970s, is around 630 thousand tons in total, 354 thousand tons of which is hunting and 276 thousand tons of aquaculture.

With a production of approximately 110 thousand tons, trout ranks first among the species that are farmed in Turkey. The reason of this is the ease of production of trout compared to other fish, the better marketing network, the availability of fresh water resources with suitable characteristics for aquaculture in Turkey, the number of facilities and the amount of production (Emre and Kürüm, 1998).

The increase in the need for animal protein with the increasing population in recent years causes a continuous increase in production capacity and pollution of water resources due to intensive production (Verep et al., 2017). In addition, the fact that natural stocks are affected by global warming and environmental pollution has led to an increased interest in aquaculture (Anonymous, 1993; Çelikkale et al., 1994). Seafood is a valuable food source because its protein content is uniform and of high quality and contains omega-3 fatty acids. Its contribution to nutrition, consumption of natural resources and meeting animal protein needs make aquaculture important. However, with the increasing interest in aquaculture, the deterioration of water quality has become inevitable. Various factors, especially feed residues and metabolic wastes, cause pollution of freshwater resources used in trout farming. All these cause fish farming to have some undesirable effects on the aquatic environment and the environment. For this reason, studies on the effects of aquaculture on fresh water resources have been increasing recently.

Tsutsumi et al. (1991) stated that 85% of phosphorus, 80-88% of carbon and 52-95% of nitrogen entering the aquaculture system as feed are given to the environment as metabolic wastes (feces, respiration, secretions) and feed waste. Kucukyilmaz et al. (2016) reported that in Şanlıurfa Balıklıgöl region, which generally has I. class water quality, is in II. class in terms of total phosphorus and nitrite, III. class in terms of nitrate. Bulut et al. (2012) evaluated the water quality of the Akpınar Stream (Denizli), where trout is produced, in the study where the parameters measured at station I did not pose a risk for Salmonids according to the EC directive, but in the II. They stated that the biochemical oxygen demand (BOD) and nitrite values in the station were high enough to affect fish health from time to time. In a study conducted in five different trout farms established on Karasu Stream (Bozüyük-Bilecik), water samples were taken monthly for a year and as a result, it was determined that the quality of the effluent differs from farm to farm and season to season.

In addition, it has been determined that the dissolved oxygen, pH, suspended solids, ammonium nitrogen, nitrite nitrogen and nitrate nitrogen levels in the effluent of the enterprises are within the prescribed standard and mandatory values (Palatsü et al., 2004). Yurtman (2006) periodically examined the pollution load created by different trout farms operating on Yene Stream (Kırklareli). They determined that the resulting pollution factors were primarily caused by the fish feeds used. They observed that the unconsumed feed left and the wastes resulting from the metabolic activities of the fish do not accumulate due to the high flow rate and do not create any visible periodic pollution.

Selong and Helfrich (1998) examined the effluent quality of five different trout farms in order to determine the environmental effects of trout farms. In line with the data they obtained, they reported that the effluent of the enterprises caused an increase in the total ammonia nitrogen, free ammonia and nitrite nitrogen in the receiving environment, but this load was below the limits that would endanger the life of aquatic organisms. They also stated that the settling pools in some enterprises significantly reduced the load of the effluent.

In this study, the pH values of the water resources of some trout production areas in the Niğde region were monitored and the results were periodically determined whether they were appropriate in terms of pH value according to the Water Pollution Control Regulation.

MATERIALS and METHODS

In the study, pH analyzes were carried out in the pool entrance and pool exit in seasonal periods (spring, summer, autumn, winter) in order to determine the water quality of the wastewater of some trout farms in the Niğde region. The location of the trout farms, which are the subject of the research, are shown on the map given in Figure 1.

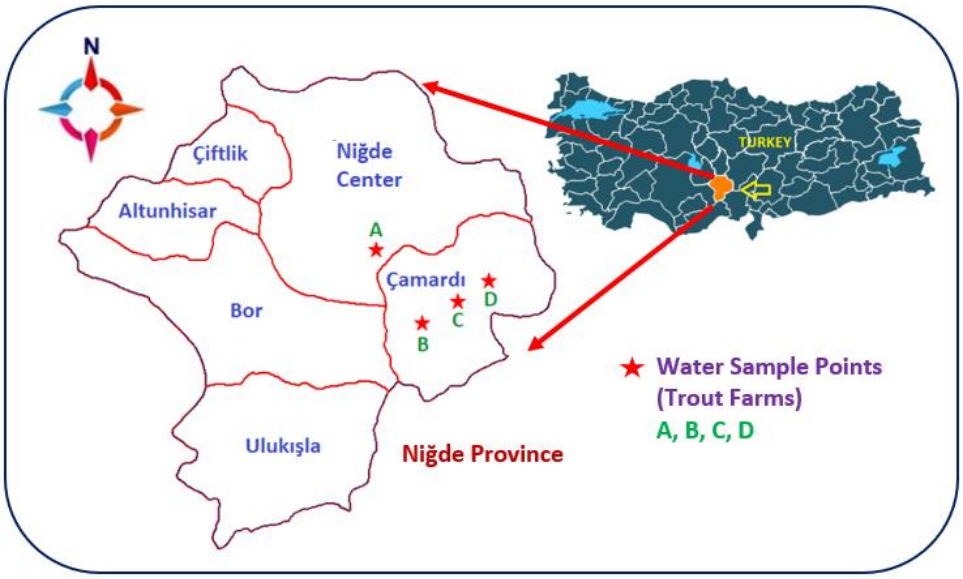

Figure 1. The location of research area

Water samples were taken from four farms during four seasons, from pool inlet water and pool outlet water at each trout farm. Water samples were collected and stored at +4^{o}C in a refrigerator. The pH values of the water samples were determined in the laboratory with digital display pH meters. The application regarding pH measurements made in the laboratory is given in Picture 1. The pH values of the research were evaluated according to the Water Pollution Control Regulation (Anonymous, 2004). Water samples were taken from the pool inlet and outlet waters during four periods from the determined areas. The periods during which water samples were taken are listed in Table 1.

Picture 1. pH measurements in the laboratory

Table 1. Pool locations and periods of water samples

Periods	Months	Sample Locations
Spring	April	Entrance
Spring	April	Exit
Summer	July	Entrance
Summer	July	Exit
Autumn	October	Entrance
Autumn	October	Exit
Winter	January	Entrance
Winter	January	Exit

RESEARCH FINDINGS

The pH changes in the pool inlet and the pool outlet of the "A" station trout farm is presented in the in Figure 2.

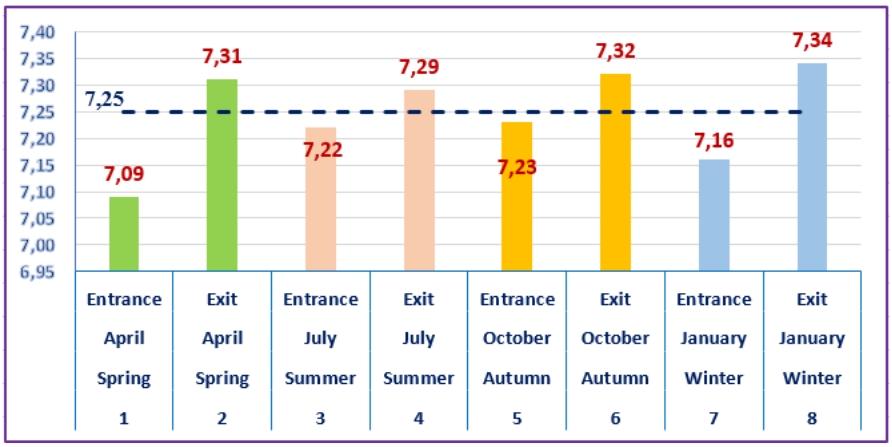

Figure 2. pH Changes of "A" Station During the Seasons

While the pH value of the entrance of the A station pool was 7.09 in April season, the pH value at the pool exit was determined as 7.31. In the same station the pH value of the pool entrance was 7.22 and the pH value of the pool exit was measured as 7.29 in July. In October, the pH of the pool entrance was 7.23, while it was determined as 7.32 in the pool exit. The pH value in January was determined as 7.16 in the entrance of the pool and 7.34 in the exit of the pool. The average pH value of A station was determined as 7.25. The pH changes in the pool inlet and the pool outlet of the "B" station trout farm is presented in the in Figure 3.

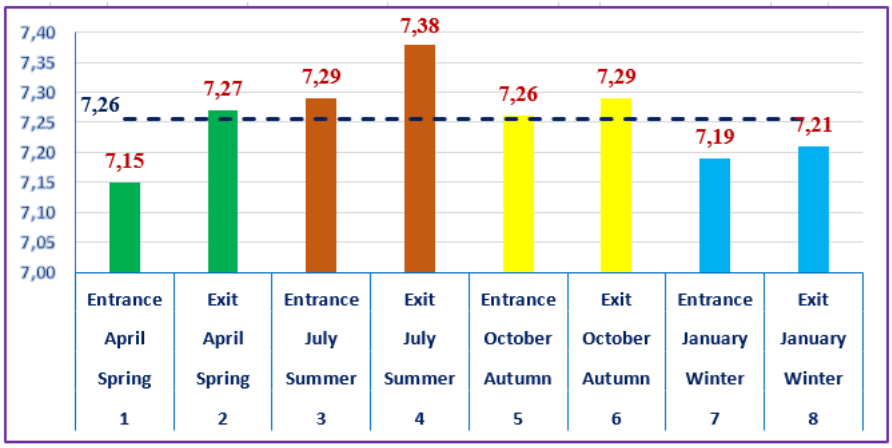

Figure 3. pH Changes of "B" Station During the Seasons

The pH value of the pool entrance of B station was determined as 7.15 in April, while the pH value of the pool exit was 7.27. In July, the pH value was determined as 7.29 in the entrance of the pool and 7.38 in the exit of the pool. In October, the pH value of the pool entrance was 7.26 and the pH value of the pool exit was 7.29. In January, while the pH value of the pool entrance was 7.19, the pH value of the pool exit increased to 7.21. The average pH value of B station was determined as 7.26. The pH changes in the pool inlet and the pool outlet of the "C" station trout farm is presented in the in Figure 4.

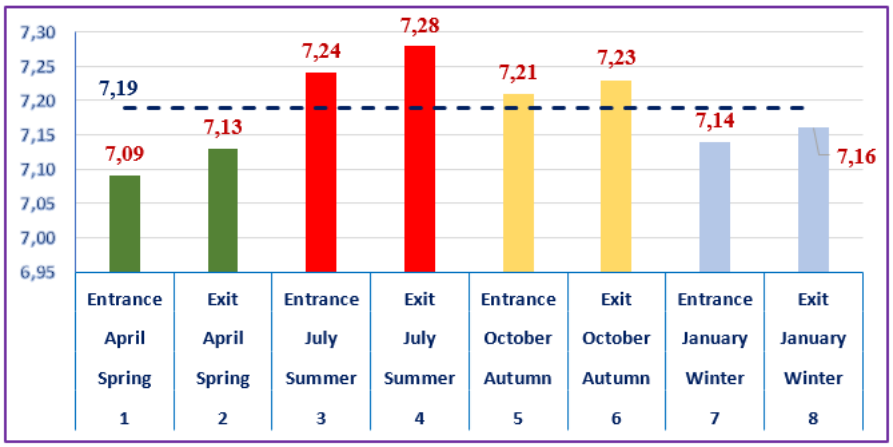

Figure 4. pH Changes of "C" Station During the Seasons

Significant changes were detected among the pH values in the water samples taken from the C station pool entrance and pool exits in April, July, October and January. While the pH value of the pool entrance was 7.09 in April, the pH value of the pool exit was 7.13. The pH value of the entrance of the C station was 7.24 in July season and the pH value at the pool exit was determined as 7.28. In the same station the pH value of the pool entrance was 7.21 and the pH value of the pool exit was measured as 7.23 in October. In January, the pH of the pool entrance was 7.14, while it was determined as 7.16 in the pool exit. The pH changes in the pool inlet and the pool outlet of the "D" station trout farm is presented in the in Figure 5.

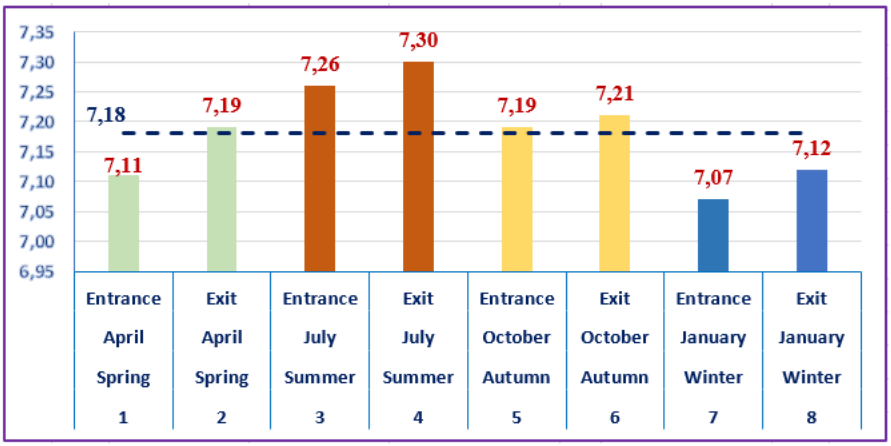

Figure 5. pH Changes of "D" Station During the Seasons

It was observed that there is a significant change between periods. pH values in April, July, October and January were measured as 7.11, 7.26, 7.19, and 7.07, respectively, in the pool entrances of D station. The pH values of the pool exit were determined as 7.19, 7.30, 7.21 and 7.12, respectively. The average pH value of the D station, measured during all periods, was determined as 7.18.

CONCLUSION

pH changes in some trout farms in Niğde region were determined during four seasons. Water samples were collected from the pool enterance and pool exit. In general, average pH values in water samples were determined as 7.25, 7.26, 7.19 and 7.18 in A, B, C and D farms, respectively. In terms of trout farming, pH characteristic close to neutral. Continuous monitoring of water quality in trout farms is extremely important for fish farming. Negative changes in water quality will adversely affect fish farming. In this context, studies to evaluate water resources in trout facilities in terms of water quality will also make positive contributions to fish production.

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