IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399. Volume 3, Issue 6 (May. - Jun. 2013), PP 20-31
www.Iosrjournals.Org

Effect of Temperature on the Uptake of Na^+, K^+, Ca^{2+} and Mg^{2+} By the Various Anatomical Parts of the Vegetable Amaranth Gangeticus

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Abstract: *In Bangladesh, Amaranth Gangeticus L. is widely cultivated common vegetable plant especially in winter season. This study examined the effect of temperature on the distribution of major nutrient elements (Na, K, Ca & Mg) in the different anatomical parts (roots, stems and leaves) of this vegetable. The investigation was performed in the laboratory in batch system in different tubs at different salinity at four different temperatures which are considered from the average temperature change during summer and winter season in the three upazila named Sonagazi, Savar and Bashail in Bangladesh. The average temperature change was determined in air as well as different depth of soil in a sunny agriculture land of these three upazila. It was found that the average temperature change for sunny lands follows the trend Bashail > Savar > Sonagazi during summer season and reverse trend in winter season. A pot experiment was conducted to assess the effect of temperature on the uptake of mineral nutrients like* Na^+, K^+, Ca^{2+} *and* Mg^{2+} *by the vegetable Amaranth Gangeticus L. At four different temperatures* 8^oc, 25^oc, 30^oc *and* 40^oc. *A salinity treatment was also applied in normal growth condition without temperature controlled. It was noted that the vegetable Amaranth Gangeticus L. Very sensitive towards salinity and temperature. At 25* ^oc, *the minerals uptake (Na, K, Ca & Mg) by Amaranth Gangeticus are higher than the rest three applied temperatures. The highest uptake levels of Na, K, Mg and Ca were obtained in the soil of Sonagazi upazila with respective values (mg/g dry weight) 33.285, 44.936, 27.207 and 45.071 at 25* ^oc. *The levels of all the elements were highly varied in the different anatomical parts of the selected plant. Moreover, this study also finds that the soil of Sonagazi upazila is more useful to cultivate Amaranth Gangeticus than other two upazila's soil and it follows the trend Sonagazi > Savar > Bashail.*
Keywords: *Temperature, Salinity, Nutrient, Vegetable, Analysis And Digestion.*

I. Introduction

Vegetables are good source of vitamins, mineral elements, fiber and other nutrients the body requires. During evolution and cause of life, plants have developed several biochemical mechanisms that have resulted in adaptation to and tolerance of new or chemical imbalanced environments [1]. Vegetables and crops are often influenced significantly by a few weather factors for their growth and development [2]. For instance, crops that mature during autumn contain higher vitamin a than those that mature in poorer light of winter [3]. During the rainy season, when temperature is normal it is the distribution of rain fall that becomes important. In the dry season temperature and water-use requirements of individual plant becomes paramount [4]. Seasonal changes in concentration of nutrients result mainly from movement of nutrients into component during growth and the reverse process when senescence approached although individual nutrients differ in their mobilities. These changes are most evident in photosynthetic tissues such as leaves. Translocation affects N, P and K in particular whilst the less mobile elements such as ca tend to be retained and even increased in apparent concentration as the leaf becomes older though changes of this nature vary from species to species [5]. Certain elements are considered as especially desirable for successful crop growth. If they are lacking or improperly balanced, normal development does not occur. Of the eleven essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, boron, copper and zinc) obtained from the soil by plants, six are used in relatively large quantities and consequently are receiving major attention [6]. They are magnesium, phosphorus, potassium, calcium, nitrogen and sulphur. Because they are used by plants in relatively large amounts they are sometimes designated for convenience as the primary elements [6]. Plant growth may be retarded because these elements are actually lacking in the soil, because they become available too slowly, or because they are not adequately balanced by other nutrients. Sometimes all three of these limitations are operative particularly with respect to nitrogen [6]. On the other hand, salinity is a factor which directly affects the plant growth through its

Interaction with metabolic rates and pathways within the plants. It affects plant growth at all stages of the development. It is noted that the sensitivity to salinity varies from one growing stage to another. Adverse effects of salt stress on germination, seedling growth as well as some physiological activities of a number of cultivated plant species have been extensively investigated [7-9]. The influence of salinity and mineral nutrient added to the nutrient solution, on productivity, photosynthesis and growth has been studied in different plants [10-14]. Saghir *et al*. [15] reported that salinity increases Na^+ and Cl^- and decreases K^+, Ca^{2+} and Mg^{2+} in leaves of cotton. Chavan *et al*. [16] found that NaCl and Na_2SO_4 caused accumulation of Na, P, Fe and Mn in root, stem, leaf and gynophores whereas K uptake was hampered by both salts and Ca uptake were retarded mainly by Na_2SO_4. Nevertheless, nutrient supply is not uniform down the soil profile and crop plants differ in their ability to obtain nutrients from different soil profiles [17]. Several investigations indicated that salinity affects metabolic processes and induces irreversible physiological disorders [18]. Salinity is creating problem for growing vegetables in many area of Bangladesh. However, heavy rain fall usually happens in Bangladesh from June–October. Average temperature of about 40°c is observed in the months of March-May, while cold weather December-February with temperature as low as 4°c depending on district position. *Amaranth gangeticus* L. Is a very common vegetable plant in all areas of Bangaldesh. It is cultivated widely specially in winter season. Now a day, it has been cultivated throughout the all season. But winter seasonal *amaranth gangeticus* l. Vegetable is more tasteful than that of other seasonal. Tunde et al. [3] also reported that there is some seasonal variation in the availability of many vegetables. Since, vegetable like *amaranth gangeticus* L. Is very essential component of human diet, the need for their availability throughout the year become necessary. This has led to the cultivation of this vegetable in optimum temperature condition for better taste and production. Moreover, this vegetable can grow in varied types of soil such as sandy loam to clay and also tolerate moderate acidic and saline soils. *Amaranth gangeticus* L. Is a quick growing leafy vegetable. Bashail, Savar, Sonagazi are the three upazila (sub-district) in Bangladesh. The average temperature change of the agriculture land of these three upazila is very different during both in summer and winter season. The salinity of soil of these lands is also different. In this study, the average temperatures of these three areas are determined during summer season and winter season. Moreover, because *amaranth gangeticus* L. Can grow in varied type of soil and tolerate moderate temperature, our present research interest has also tried to investigate the cause why winter seasonal *amaranth gangeticus* L. Is more tasteful than summer season of it. Data on the effect of seasonal variation on the nutrient contents of the selected vegetable from the above three areas is limited. In view of this, the present study was tried to determine the uptake value of mineral nutrients (Na^+, K^+, $Ca^{2+}$and Mg^{2+}) by plant, *amaranth gangeticus* with or without temperature controlled of soil as well as atmosphere and investigate the effect of temperature on the mineral nutrients uptake at different anatomical parts (leaves, stems, roots) of the above selected plant. This mineral nutrients uptake observation was performed in the laboratory by considering filed data of average temperature. This investigation also finds which agriculture soil land of the selected three upazila is best.

II. Materials and Methods

2.1 Determination *of soil temperature:*

By using the thermometer we measured the soil temperature in 1.5cm depth, 15cm depth and 30cm depth. Digging soil we inserted the thermometer and kept 30 min for each reading to collect steady temperature. We took temperature in the morning (8.30am), noon (2.30pm) and evening (6.40pm) from the sunny agriculture land of each Upazila (sub-district) named Bashail, Savar, Sonagazi during both summer season and winter season. We also took temperature from shaded area where sunlight can be entered never.

2.2 Soil *Sample Collection and Analysis:*

The soils are collected from the three selected upazila's sunny agriculture land in the same day within the time period between summer season end and winter season beginning. The soils were stored into 45 (15x3) tubs of 3 batches labeled for three upazila. Some soils were stored separately for soil analysis. The soil ph determination was at a ratio of 1:1 with distilled water. Exchangeable cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were extracted with 1M NH_4-acetate at ph 7. The Na^+, K^+, Ca^{2+} and Mg^{2+} were determined with with AAS [19] Fasina et al., 2005; Badora and Filipek, 1998; Wilcke et al., 1998). The soil samples were prepared for trace metal analysis by refluxing 1.0 g of air dried sample with 10 cm^3 of HNO_3 for 45 min. Heating was continued with 10 cm^3 of aqua-regia and finally with 10 cm^3 HNO_3. The filtrates were diluted to the marks of 50 cm^3 volumetric flasks and the determinations were carried using AAS [20] (Uba and Uzairu, 2008).

2.3 Plant *material, culture conditions and vegetable sample collection:*

This experiment was conducted at Wazed Miah Science Research Center, Jahangirnagar University, Savar, Dhaka, Bangladesh from April to June, 2012. Amaranth Gangeticus seeds were collected from local market. Then, the fresh seeds were germinated in the 45 (15x3) heat transferable tubs which are filled with soil collected from the selected three upazilas. The tubs were kept under normal conditions, 24±4^{o}c for several days. After 6 weeks, lovely teenage plants were found in each tub. Plants were irrigated with distilled water solution at each watering using an irrigation system. When the plants grew up to 10 cm in height then we started experiment upon them. An artificial saline water was prepared by dissolving approximate amount of nacl, kcl, $MgSo_4$ and $CaSO_4$ (P^H = 6.48 at 28.6^{o}c). In each tub only 5 plants were kept and others were discarded. The saline water was applied with soils of 12 tubs of each batch keeping intake of other three tubs of the batch. We divided the plants of each batch (labeled by the name of upazila) in four groups - 1st group contain plants under normal growth conditions without saline water treatment and temperature controlled (room temperature); 2nd, 3rd, 4th and 5th group contain plants that were treated with prepared saline water with temperature maintained of soil as well as atmosphere around 8^{o}c, 25^{o}c, 30^{o}c and 40^{o}c respectively. Therefore, 12 tubs of each batch were subjected to salinity treatment twice (at 10:00 AM & 3:00 PM) every day until water drained from the bottom of the tub. The remaining plants of other three tubs of each batch were treated with normal distilled water. Each treatment was applied to three replicates located randomly in order to avoid positional effects. Three plants per treatment were collected for analysis at two weeks after salinity and temperature treatment. We collected root, stems and leaves from each vegetable plant. Before collecting sample all the plant parts were washed out with normal water and finally with deionized water and then, transferred to the laboratory where they were spread on polyethylene sheets until dried. After air-drying, roots were again rinsed with deionized water, re-dried and homogenized, the plant sample were sieved using 200 mm mesh. The sieved sample dried again in an oven at 65°C for 48 h and then weighed [21].

2.4 Plant *sample treatment:*

To determine the mineral concentrations of Na^+, K^+, Ca^{2+}, Mg^{2+} the oven dried samples of vegetables were first ground into a fine powder using a vibratory mill and passed through a 1 mm mesh. Then the samples were digested by taking 600 mg of each oven dried powder sample into a separate 100 cm^3 quick fitted round bottom flasks (Pyrex, Germany), 30 cm^3 of 69.5% (w/w) HNO_3 were added to each of the flasks and heated until about 10 cm^3 of each of the solution remained. Then the flaks were followed with the addition of 2 cm^3 of 60% $HClO_4$ acid, 10 cm^3 of 69.5% (w/w) HNO_3 and 1 cm^3 of 98% (w/w) H_2SO_4. The mixtures were further heated in a fume cupboard until the appearance of white fumes. The resulting solutions after cooling were filtered into separate 100cm^3 volumetric flasks and then diluted to the mark with de-ionized water [22]. Sodium, potassium, magnesium and calcium were analyzed in the samples using a flame atomic absorption spectrophotometer (AA-7000, Shimadzu Corporation, Japan). All the standard solutions (1000ppm) with certificates were purchased from Kanto Chemical Co., Japan. The background correction was done by the D_2 lamp method. Analyses were made in triplicate. The detection limits of all the elements were determined before sample solutions were analysed [23]. The detection limits were Na (0.001 ppm), K (0.005 ppm), Mg (0.001 ppm) and Ca (0.02 ppm) (all for aqueous solutions). The optimum analytical range was 0.5 to 5 absorbance units with coefficient of variation of 0.05-0.40%. Determination were made on dry weight basis for all samples. The measuring conditions of Na, K, Ca and Mg metal ions are as follows:

Na: Burner height: 7 mm; wave length: 589.0 nm; burner angle: 0 deg; slit width: 0.2 nm; acetylene fuel gas flow: 1.8 l/min; lighting mode: hcl; type of oxidant: air.

A five points calibration curve is also made with 0, 0.1ppm, 0.2ppm, 0.3ppm, 0.4ppm standard solutions prepared from certified 1000ppm standard solution.

K: Burner height : 7 mm; Wave length: 766.5 nm; Burner angle: 0 deg; Slit width: 0.5 nm; Acetylene fuel gas flow: 2.0 l/min; Lighting mode: HCl; Type of oxidant: air.

A Five points calibration curve is also made with 0, 0.1ppm, 0.2ppm, 0.4ppm, 0.8ppm standard solutions prepared from certified 1000ppm standard solution. Moreover, same volume of 0.1 to 0.2% cesium chloride is added to the standard and unknown sample to prevent the ionization of potassium.

Ca: Burner height: 17 mm; Wave length: 422.7 nm; Burner angle: 0 deg; Slit width: 0.5 nm; Fuel gas flow: 6.5 l/min; Lighting mode: BGC-D_2; Type of oxidant: N_2O.

A five points calibration curve is made with 0, 0.1ppm, 0.2ppm, 0.4ppm, 0.6ppm standard solutions prepared from certified 1000ppm standard solution. Negative interference, due to coexist substances in the Air-C_2H_2 flame, is removed by using the N_2O-C_2H_2 flame. However, it is ionized and 0.1 to 0.2% potassium chloride is added to the standard and unknown sample with same extent.

Mg: Burner height: 7 mm; Wave length: 285.2 nm; Burner angle: 0 deg; Slit width: 0.5 nm; Fuel gas flow: 1.8 l/min; Lighting mode: BGC-D_2 ; Type of oxidant: air. A five points calibration curve is also made with 0, 0.1ppm, 0.2ppm, 0.4ppm, 0.8ppm standard solutions prepared from certified 1000ppm standard solution. Moreover, a negative interference is found if P, Al, Ti and Si are put in the form of an oxyacid, and coexist in the same or more quantity than Mg. For this, the interference is retrained by the addition of 0.1% strontium chloride to the standard and unknown sample.

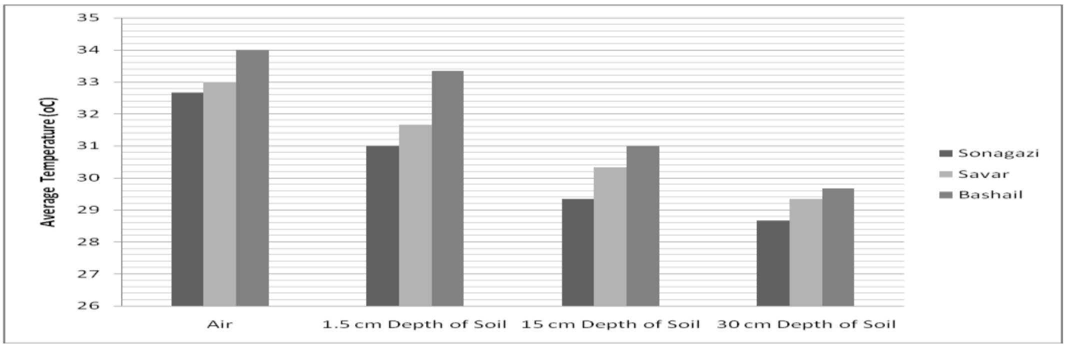

figure 1: average temperature change of the selected three upzila's soil during summer season.

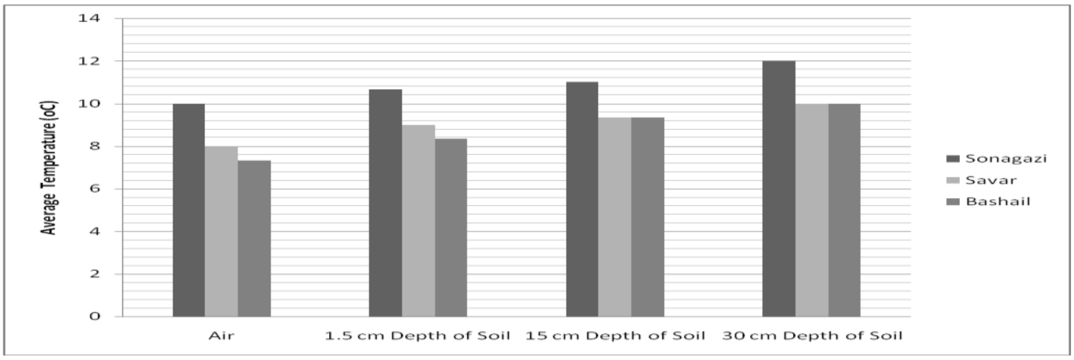

Figure 2: Average temperature change of the selected three upzila's soil during Winter Season.

III. Results And Discussion

At present time due to climate change temperature is rising all over the world. Bangladesh is also facing such problem. Moreover due to Storm, Cyclone and Flood saline water is entering cultivable land. So it is hampering the production of various Vegetables. Moreover vegetables are more sensitive towards saline water. Temperature has an effect upon uptake of macro nutrient from saline water. There have been several excellent treatments of soil temperature effects on root growth and related processes [24-28]. Hence, we measure the soil temperatures of the three agriculture lands of the three selected upazila (Sonagazi, Savar, Bashail) of Bangladesh during summer season and winter season in various depth of soil and compare the values in Figure 1&2. It was found the average temperature change trend is Bashail > Savar > Sonagazi during summer season and it follows reverse trend during winter season. So, from Figure 1& 2, we took 8^{o}c, 25^{o}c, 30^{o}c and 40^{o}c as our treated temperatures for soil in the tub as well as atmosphere in the laboratory for doing experimental works. Table 1 presents the ph and the available and exchangeable forms of the macro elements (Na^+, K^+, Mg^{2+} and Ca^{2+}) in the soils of the selected three upazila. The availability of elements to plants is influenced by various soil factors among which according to literature data is soil reaction which is observed to occur at ph below 4.2 [29]. The ph range observed in the soils is almost neutral. The cations concentration (Na^+, K^+, Mg^{2+} and Ca^{2+}) are higher in Sonagazi upazila than the other two upazila. So, the soil of Sonagazi contains higher value of major nutrients for plants compare to other two upazilas.

Table 2 shows the major elements uptake by different parts of plant, *Amaranth Gangeticus* in the selected three upazila's soil without temperature controlled (in normal condition) and saline water treatment. The average uptake values of major elements by the three anatomical parts of *Amaranth Gangeticus* are higher in the soil of Sonagazi (Na = 31.635 mg/g, K = 43.244 mg/g, Mg = 25.537 mg/g and Ca = 43.349 mg/g) than those of other two upazila's soil. Although stems has the highest value for Ca for all upazila's soil, the leaves generally have the highest levels of Na and Mg is consistently the least value in the stems of *Amaranth Gangeticus* whereas K shows consistently the high value in roots for all three upazila's soil.

Table-1: pH and available cation concentration in the selected upazila's soils

Name of Upazila	Sample ID	pH	Na^+(mg/g)	K^+(mg/g)	Mg^{2+}(mg/g)	Ca^{2+}(mg/g)

Sonagazi	SN-1	7.31	0.025	0.064	0.048	0.036
	SN-2	7.28	0.024	0.069	0.046	0.039
	SN-3	7.29	0.025	0.073	0.047	0.037
	SN-Mean Value	**7.29**	**0.025**	**0.068**	**0.047**	**0.037**
	SD	0.02	0.000	0.005	0.001	0.002
	RSD	0.21	1.704	6.615	2.296	4.487
Savar	SV-1	6.71	0.024	0.059	0.035	0.025
	SV-2	6.65	0.024	0.060	0.032	0.029
	SV-3	6.69	0.023	0.059	0.037	0.028
	SV-Mean Value	**6.68**	**0.024**	**0.059**	**0.035**	**0.028**
	SD	0.03	0.001	0.001	0.003	0.001
	RSD	0.46	2.157	1.415	7.700	0.696
Bashail	BS-1	6.69	0.022	0.042	0.038	0.028
	BS-2	6.55	0.023	0.042	0.039	0.027
	BS-3	6.61	0.021	0.040	0.038	0.029
	BS-Mean Value	**6.62**	**0.022**	**0.041**	**0.038**	**0.028**
	SD	0.07	0.001	0.001	0.001	0.001
	RSD	1.06	3.053	2.589	2.192	3.398

SD= Standard deviation, RSD= Relative standard deviation

Table 3, Table 4 and Table 5 show the major elements (Na, K, Mg & Ca) concentration uptake by different parts of plant, *Amaranth Gangeticus* in the selected three upazila's soil respectively after temperature controlled saline water treatment. In roots, the trend of element concentration is K>Ca>Na>Mg for all applied temperatures. In stems, the trend is K>Ca>Na>Mg at 40°C & 30°C, K>Ca>Mg>Na at 8°C and Ca>K>Na>Mg at 25°C. But, for leaves no such correlation can be made among the temperatures, only Na has the higher concentration than other nutrients (K, Ca & Mg) for the temperatures 40°C, 30°C and 25°C but it has the least value at 8°C. These results are comparable to Ado-Ekiti samples for *Lycopersicon esculentum & Hibiscus esculentus* [30]. Moreover, table-3, 4 & 5 also illustrate that the highest uptake of mineral nutrients (Na, k, Mg & Ca) happens at 25°C in all different anatomical parts (roots, stems & leaves) but, beyond or less this temperature (25°C), the uptake value becomes lower. On comparative basis, the concentration of K in different parts of the selected plant follows the trend stems > roots > leaves for all upazila's soil for all temperatures. Similarly, the trend is leaves > stems > roots for Na & Mg and roots > stems > leaves for Ca. However, Figure-3 shows that there is tremendous effect of temperature on the major mineral nutrients (Na, K, Mg & Ca) uptake by plants. We find that the average major mineral nutrients uptake by the plant (*Amaranth Gangeticus)* is increased from 8°C to 25°C temperature but, after that, it is gradually decreased from 30°C to 40°C temperature for all upazila's soil. It has the highest value at 25°C and least value at 8°C for all upazila's soil. The highest values of Na, K, Mg & Ca are 33.285 mg/g, 44.936 mg/g, 27.207 mg/g, 45.071 mg/g respectively in Sonagazi upazila's soil at 25°C but the values are decreased from Savar to Bashail upazila's soil at same temperature. The least values of Na, K, Mg & Ca are 5.846 mg/g, 21.073 mg/g, 6.320 mg/g and 13.922 mg/g respectively in Bashail upazila's soil at 8°C. So, too high or too low temperature of soil causes lower mineral nutrients uptake by plant. This is happened because soil temperature influences plant nutrient uptake through effects on soil water, rates of chemical reactions, and nutrient transport [31]. Since most chemical reactions and nutrient transport occur in water, how soil water is affected by soil temperature directly impacts nutrient uptake. It has been estimated that only 1 % of the nutrients reaching the surface of plant root systems is due to direct interception, while the remainder is transported to the roots by mass flow (transpiration and hydrodynamic dispersion) and diffusion [32], although interception may be much more important for immobile nutrients such as P [33]. The most obvious effect of soil temperature on soil water is increased rates and depth of evaporation with increasing soil temperature, especially in situations where the supply of water may be limited. The high temperature of soil causes dryness of soil which not only does prevent mass flow and diffusion of nutrients, but it may also lead to increased mechanical impedance to root growth [34], thereby limiting nutrient interception. Hence, in this study, we have lower value of mineral nutrients uptake by plant at 40°C for all upazila's soil.

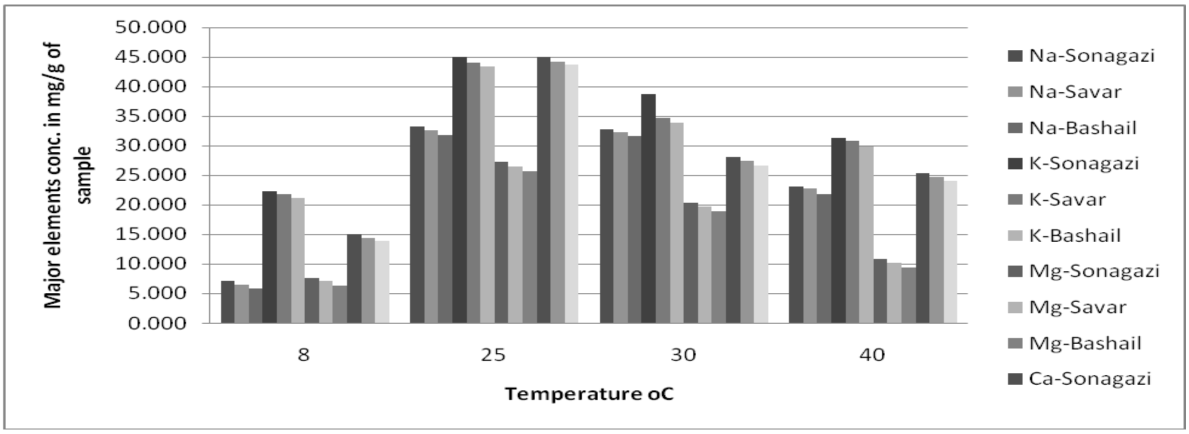

Figure 3: comparative study of major nutrients uptake by the plant, by *a. gangeticus* in selected three upazila's soil with varying temperature [na- sonagazi means concentration of na in sonagazi upazila's soil and similar meaning for others just varying metal name and soil location]

Again, Soil temperature has a significant effect on the viscosity of water. The viscosity of water is inversely related to its temperature in a nearly linear fashion (r^2=0.94) over the range of temperatures experienced in soil in ecosystems around the world (0 to ~70 °C), from 1.15 x 10^{-3} to 0.41 x 10^{-3} N s m^{-2} [35]. The increased viscosity at low temperatures is known to decrease rates of water uptake by roots and transport within the plant [36-38], and therefore reduces the rate of nutrient transport to the plants via roots in mass flow. Similarly, the transport of nutrient ions from areas of high to low concentration by the process of diffusion is directly influenced by soil temperature. Therefore, this study also has lower value of mineral nutrients uptake by the selected plant at 8°C for all upazila's soil. Moreover, all chemical reactions that occur in soil, including mineral weathering [39], biologically mediated nitrogen transformations [40], and most reactions involving nutrient ions in soil solution [41], are strongly influenced by temperature. Concentrations of Ca^{2+}, Mg^{2+}, Na^+, and K^+ are decreased with increasing soil temperature, however, indicating that it cannot be assumed that all ions respond equally in all anatomical parts of plant. Temperature can alter specific rates of ion uptake in different anatomical parts of plant, root respiration, cell membrane permeability and rates of transport in the xylem. However, the mechanism for increased nutrient uptake in different anatomical parts of the selected plant with rising soil temperature is not well understood and this study cannot make generalizations about the multiple, interacting processes.

Table-2: Major elements (Na, K, Mg & Ca) concentration without temperature control (in normal condition)

Zone	Plant Part	Sample ID	Element			
			Na (mg/g)	K (mg/g)	Mg (mg/g)	Ca (mg/g)
Savar Upazila	Roots	SVW-1	22.188	41.026	21.860	69.777
		SVW-2	22.222	41.031	21.871	69.761
		SVW-3	22.258	41.006	21.878	69.817
		Mean Value	22.223	41.021	21.869	69.785
		SD	0.035	0.014	0.009	0.029
		RSD	0.158	0.033	0.041	0.041
	Stems	SVW-4	28.113	54.515	14.832	34.480
		SVW-5	28.025	54.592	14.778	34.462
		SVW-6	27.908	54.581	14.824	34.345
		Mean Value	28.016	54.563	14.811	34.429
		SD	0.103	0.042	0.029	0.073
		RSD	0.367	0.077	0.198	0.213
	Leaves	SVW-7	42.675	29.814	37.704	23.967
		SVW-8	42.725	29.799	37.717	23.962
		SVW-9	42.805	29.796	37.750	23.943
		Mean Value	42.736	29.803	37.724	23.957
		SD	0.067	0.009	0.024	0.013
		RSD	0.158	0.032	0.064	0.054
	Average uptake value by plant, *A.*		**30.992**	**41.799**	**24.801**	**42.724**

	Gangeticus					
Sonagazi Upazila	Roots	SNW-1	22.944	43.672	22.538	70.335
		SNW-2	22.835	43.678	22.506	70.647
		SNW-3	22.927	43.680	22.507	70.650
		Mean Value	22.902	43.677	22.517	70.544
		SD	0.059	0.004	0.019	0.181
		RSD	0.255	0.009	0.083	0.256
	Stems	SNW-4	28.778	55.870	15.666	34.963
		SNW-5	28.760	55.509	15.653	34.944
		SNW-6	28.759	54.989	15.609	34.927
		Mean Value	28.766	55.456	15.643	34.945
		SD	0.010	0.443	0.030	0.018
		RSD	0.036	0.799	0.190	0.052
	Leaves	SNW-7	43.180	30.611	38.462	24.592
		SNW-8	43.268	30.583	38.463	24.506
		SNW-9	43.262	30.601	38.434	24.581
		Mean Value	43.237	30.598	38.453	24.506
		SD	0.049	0.014	0.016	0.047
		RSD	0.114	0.046	0.042	0.192
	Average uptake value by plant, *A. Gangeticus*		**31.635**	**43.244**	**25.537**	**43.349**
Bashail Upazila	Roots	BSW-1	21.352	42.244	21.076	69.393
		BSW-2	21.371	42.242	21.064	69.384
		BSW-3	21.384	42.248	21.074	69.385
		Mean Value	21.369	42.245	21.071	69.387
		SD	0.016	0.003	0.007	0.005
		RSD	0.075	0.007	0.031	0.007
	Stems	BSW-4	27.192	53.680	13.361	33.944
		BSW-5	27.275	53.678	13.371	33.961
		BSW-6	27.360	53.680	13.363	33.949
		Mean Value	27.276	53.679	13.365	33.951
		SD	0.084	0.001	0.005	0.009
		RSD	0.308	0.002	0.039	0.026
	Leaves	BSW-7	41.842	28.980	36.908	23.259
		BSW-8	42.166	28.845	36.898	23.276
		BSW-9	41.981	28.852	36.925	23.248
		Mean Value	41.996	28.892	36.909	23.261
		SD	0.163	0.076	0.015	0.014
		RSD	0.387	0.264	0.041	0.060
	Average uptake value by plant, *A. Gangeticus*		**30.214**	**41.605**	**23.782**	**42.200**

Table-3: Major elements (Na, K, Mg & Ca) concentration after temperature treatment on Sonagazi Upazila soil

Zone	Temperature (^oC)	Plant Part	Sample ID	Element			
				Na (mg/g)	K (mg/g)	Mg (mg/g)	Ca (mg/g)
	40	Roots	A1-1	20.432	28.607	7.352	27.074
			A1-2	20.170	28.601	7.430	27.006
			A1-3	19.668	28.606	7.427	27.081
			Mean Value	20.090	28.605	7.403	27.054
			SD	0.388	0.003	0.044	0.041
		Stems	A4-1	22.795	40.347	8.509	25.610
			A4-2	22.292	40.444	8.504	25.634
			A4-3	22.302	40.426	8.509	25.614

Sonagazi Upazila			Mean Value	22.463	40.406	8.507	25.619
			SD	0.288	0.052	0.003	0.013
		Leaves	A7-1	26.574	24.722	16.302	23.285
			A7-2	26.581	24.669	16.298	23.315
			A7-3	26.551	24.676	16.301	23.317
			Mean Value	26.568	24.689	16.300	23.305
			SD	0.016	0.029	0.002	0.018
		Average uptake value by *A. Gangeticus*		**23.040**	**31.233**	**10.737**	**25.326**
	30	Roots	A8-1	23.610	38.172	15.161	32.482
			A8-2	23.592	38.715	15.148	32.480
			A8-3	23.593	38.702	15.160	32.465
			Mean Value	23.598	38.712	15.156	32.476
			SD	0.010	0.009	0.007	0.009
		Stems	A9-1	28.169	45.944	21.822	27.713
			A9-2	28.172	45.901	21.737	27.822
			A9-3	26.838	45.992	21.759	27.814
			Mean Value	27.726	45.946	21.772	27.783
			SD	0.769	0.046	0.044	0.060
		Leaves	A10-1	47.129	31.601	24.132	24.132
			A10-2	47.111	31.611	24.126	24.116
			A10-3	47.169	31.701	24.142	24.130
			Mean Value	47.136	31.638	24.133	24.126
			SD	0.029	0.055	0.008	0.009
		Average uptake value by *A. Gangeticus*		**32.820**	**38.765**	**20.354**	**28.128**
	25	Roots	A2-1	24.592	45.339	17.194	72.314
			A2-2	24.600	45.469	17.259	72.296
			A2-3	24.669	45.499	17.169	72.318
			Mean Value	24.620	45.435	17.207	72.309
			SD	0.042	0.085	0.046	0.012
		Stems	A5-1	30.443	57.169	24.259	36.552
			A5-2	30.444	57.176	24.205	36.647
			A5-3	30.451	57.177	24.335	36.633
			Mean Value	30.446	57.174	24.266	36.611
			SD	0.004	0.005	0.065	0.051
		Leaves	A6-1	44.843	32.172	40.165	26.314
			A6-2	44.680	32.170	40.147	26.278
			A6-3	44.847	32.259	40.131	26.285
			Mean Value	44.790	32.200	40.148	26.292
			SD	0.095	0.051	0.017	0.019
		Average uptake value by *A. Gangeticus*		**33.285**	**44.936**	**27.207**	**45.071**
	8	Roots	A3-1	4.428	21.900	4.006	18.295
			A3-2	4.432	21.669	3.983	18.278
			A3-3	4.502	21.670	3.992	18.504
			Mean Value	**4.454**	21.746	3.994	18.359
			SD	0.042	0.133	0.011	0.126
		Stems	A11-1	5.555	25.853	8.422	13.669
			A11-2	53563	26.002	8.384	13.650
			A11-3	5.554	25.965	8.390	13.647
			Mean Value	5.557	25.940	8.398	13.655
			SD	0.004	0.077	0.021	0.012
		Leaves	A12-1	11.087	19.169	10.258	13.074
			A12-2	11.118	19.177	10.172	12.962
			A12-3	11.110	19.150	10.240	12.961

			Mean Value	11.105	19.165	10.223	12.999
			SD	0.016	0.014	0.046	0.065
		Average uptake value by *A. Gangeticus*		**7.039**	**22.284**	**7.538**	**15.004**

Table-4: Major elements (Na, K, Mg & Ca) concentration after temperature treatment on Savar Upazila soil

Zone	Temperature (°C)	Plant Part	Sample ID	Element			
				Na (mg/g)	K (mg/g)	Mg (mg/g)	Ca (mg/g)
Savar Upazila	40	Roots	A1-1	19.762	28.107	6.765	26.570
			A1-2	19.918	27.825	6.765	26.574
			A1-3	19.668	28.098	6.752	26.609
			Mean Value	19.783	28.010	6.761	26.584
			SD	0.126	0.160	0.008	0.021
		Stems	A4-1	22.295	39.935	7.923	24.899
			A4-2	22.292	40.015	7.982	24.872
			A4-3	22.302	39.925	7.942	24.825
			Mean Value	22.296	39.958	7.949	24.865
			SD	0.005	0.049	0.030	0.037
		Leaves	A7-1	26.077	24.285	15.802	22.829
			A7-2	26.017	24.185	15.788	22.802
			A7-3	25.929	24.353	15.808	22.820
			Mean Value	26.007	24.274	15.800	22.817
			SD	0.075	0.085	0.010	0.014
		Average uptake value by *A. Gangeticus*		**22.695**	**30.748**	**10.170**	**24.755**
	30	Roots	A8-1	22.903	34.718	14.426	31.982
			A8-2	22.838	34.715	14.318	31.935
			A8-3	22.685	34.702	14.410	31.930
			Mean Value	22.809	34.712	14.385	31.949
			SD	0.112	0.009	0.058	0.028
		Stems	A9-1	27.530	41.948	21.155	27.047
			A9-2	27.692	41.792	21.070	27.037
			A9-3	27.537	41.943	21.092	26.989
			Mean Value	27.586	41.894	21.106	27.024
			SD	0.091	0.089	0.044	0.031
		Leaves	A10-1	46.378	27.605	23.465	23.465
			A10-2	46.318	27.613	23.407	23.444
			A10-3	46.385	27.618	23.442	23.454
			Mean Value	46.361	27.612	23.438	23.454
			SD	0.037	0.007	0.029	0.011
		Average uptake value by *A. Gangeticus*		**32.252**	**34.739**	**19.643**	**27.476**
	25	Roots	A2-1	23.852	44.353	16.348	71.622
			A2-2	23.905	44.378	16.360	71.592
			A2-3	23.875	44.505	16.443	71.558
			Mean Value	23.877	44.412	16.384	71.591
			SD	0.027	0.081	0.052	0.032
		Stems	A5-1	29.680	56.233	23.505	35.887
			A5-2	29.692	56.335	23.528	35.884
			A5-3	29.608	56.275	23.372	35.881
			Mean Value	29.660	56.281	23.468	35.884
			SD	0.045	0.051	0.085	0.003
		Leaves	A6-1	44.342	31.458	39.357	25.535
			A6-2	44.392	31.468	39.362	25.137
			A6-3	44.327	31.480	39.370	24.102

			Mean Value	44.353	31.469	39.363	24.924
			SD	0.034	0.011	0.007	0.740
		Average uptake value by *A. Gangeticus*		**32.630**	**44.054**	**26.405**	**44.133**
	8	Roots	A3-1	3.920	21.405	3.339	17.735
			A3-2	3.952	20.990	3.355	17.818
			A3-3	3.947	20.980	3.370	17.813
			Mean Value	3.940	21.125	3.355	17.789
			SD	0.017	0.242	0.016	0.047
		Stems	A11-1	5.039	25.353	7.923	13.039
			A11-2	5.062	25.192	7.982	13.020
			A11-3	5.048	25.872	7.942	13.050
			Mean Value	5.050	25.472	7.949	13.036
			SD	0.011	0.355	0.030	0.015
		Leaves	A12-1	10.587	18.683	9.796	12.407
			A12-2	10.618	18.600	9.769	12.382
			A12-3	10.597	19.250	9.814	12.435
			Mean Value	10.601	18.844	9.793	12.408
			SD	0.016	0.354	0.022	0.027
		Average uptake value by *A. Gangeticus*		**6.530**	**21.814**	**7.032**	**14.411**

Table-5: Major elements (Na, K, Mg & Ca) concentration after temperature treatment on Bashail Upazila soil

Zone	Temperature (^{o}C)	Plant Part	Sample ID	Element			
				Na (mg/g)	K (mg/g)	Mg (mg/g)	Ca (mg/g)
Bashail Upazila	40	Roots	A1-1	18.835	27.169	6.099	25.907
			A1-2	19.003	27.148	6.092	25.898
			A1-3	18.991	27.167	6.075	25.944
			Mean Value	**18.943**	**27.161**	**6.088**	**25.916**
			SD	0.094	0.011	0.012	0.024
		Stems	A4-1	21.259	38.999	6.923	24.092
			A4-2	21.335	38.925	6.926	24.038
			A4-3	21.334	39.002	6.907	24.142
			Mean Value	**21.309**	**38.975**	**6.919**	**24.091**
			SD	0.044	0.043	0.010	0.052
		Leaves	A7-1	25.167	23.353	15.136	21.843
			A7-2	25.204	23.353	15.129	21.978
			A7-3	25.176	23.334	15.115	21.987
			Mean Value	**25.182**	**23.347**	**15.126**	**21.936**
			SD	0.019	0.011	0.011	0.081
		Average uptake value by *A. Gangeticus*		**21.811**	**29.828**	**9.378**	**23.981**
	30	Roots	A8-1	22.240	33.882	13.676	31.110
			A8-2	22.135	33.871	13.643	31.097
			A8-3	22.142	33.870	13.652	31.046
			Mean Value	**22.172**	33.874	13.657	31.084
			SD	0.059	0.007	0.017	0.034
		Stems	A9-1	26.723	41.129	20.223	26.191
			A9-2	26.850	41.126	20.240	26.259
			A9-3	26.848	41.115	20.277	26.248
			Mean Value	**26.807**	41.123	20.247	26.233
			SD	0.073	0.007	0.027	0.037
		Leaves	A10-1	45.648	26.819	22.796	22.647
			A10-2	45.643	26.814	22.802	22.648
			A10-3	45.631	26.817	22.793	22.676
			Mean Value	**45.640**	26.816	22.797	22.657
			SD	0.008	0.003	0.004	0.016
		Average uptake value by *A. Gangeticus*		**31.540**	**33.938**	**18.900**	**26.658**

	25	Roots	A2-1	23.019	43.848	15.509	70.925
			A2-2	23.038	43.911	15.527	70.909
			A2-3	23.050	43.841	15.538	70.898
			Mean Value	**23.036**	43.866	15.525	70.911
			SD	0.016	0.038	0.014	0.014
		Stems	A5-1	28.858	55.676	22.759	35.181
			A5-2	28.942	55.647	22.748	35.211
			A5-3	28.860	55.650	22.749	35.218
			Mean Value	**28.887**	55.658	22.752	35.203
			SD	0.048	0.016	0.006	0.019
		Leaves	A6-1	43.509	30.515	38.537	24.843
			A6-2	43.666	30.515	38.590	24.853
			A6-3	43.648	30.514	38.575	24.814
			Mean Value	**43.607**	30.514	38.567	24.836
			SD	0.086	0.001	0.027	0.020
		Average uptake value by *A. Gangeticus*		**31.843**	**43.346**	**25.614**	**43.650**
	8	Roots	A3-1	3.499	20.659	2.669	17.602
			A3-2	3.480	20.667	2.671	17.601
			A3-3	3.461	20.650	2.669	17.592
			Mean Value	**3.480**	20.659	2.670	17.598
			SD	0.019	0.008	0.001	0.006
		Stems	A11-1	4.373	24.523	7.343	12.259
			A11-2	4.390	24.538	7.343	12.248
			A11-3	4.375	24.525	7.352	12.249
			Mean Value	**4.379**	24.528	7.346	12.252
			SD	0.009	0.008	0.005	0.006
		Leaves	A12-1	9.678	18.009	8.890	11.872
			A12-2	9.680	18.011	8.980	11.941
			A12-3	9.678	18.074	8.965	11.931
			Mean Value	**9.678**	18.031	8.945	11.914
			SD	0.001	0.037	0.048	0.037
		Average uptake value by *A. Gangeticus*		**5.846**	**21.073**	**6.320**	**13.922**

IV. Conclusion

None-the-less, these findings suggest that soil temperature effects on nutrient availability are greatest when soil temperature is low and changes on short timescales such as in temperate systems in spring and fall. Increased nutrient availability on short timescales as soils warm may provide the selective pressure for the ability to rapidly increase rates of nutrient uptake. There is great variation of major nutrients (Na, K, Ca & Mg) uptake in different anatomical parts of vegetable plant, *Amaranth Gangeticus* with varying soil temperature. The soil of Sonagazi is best for cultivating vegetable *Amaranth Gangeticus* among the three upazila's soil studied in Bangladesh. And, we also can conclude that salinity and rising temperature is a threat for growing vegetables like Amaranth Gangeticus. Excessive uptake of the macro nutrient than normal can cause even death of the vegetables. This salinity also hampered their normal water content in body. We also noted during our research that due to excessive salinity some tissue of the amaranth was damaged. So much awareness is required for salinity and rising temperature in Bangladesh.

Acknowledgement

We are extremely grateful to Express our deepest sense of gratitude and sincere thanks to our respectful teachers Professor Shariff Enamul Kabir, Professor Kazi Ali Azam and Professor Tapan Kumar Saha, Depertment of Chemistry, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh for their prudent suggestions and constant encouragement at all stages of my research work and revision of this manuscript.

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