PLANT NUTRIENT CONTENT OF OKRA AS AFFECTED BY DIFFERENT LEVELS OF SOIL APPLIED NUTRIENTS

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ABSTRACT: *Three promising okra varieties (Bemisal, Sabz Pari and Reshum) were evaluated for consecutive two years against seven NPK levels (0-0-0, 25-25-25, 50-25-25, 75-37-37, 100-50-50, 125-62-62 and 150-75-75 kg ha^{-1}) and equally seven Zn-B rates (0-0, 10-1.5, 10-2.0, 15-1.5, 15-2.0, 20-1.5 and 20-2.0 kg ha^{-1}). The experiment was laid out in a three replicated Randomized Complete Block Design (Factorial), and treatment effects were determined on plant nutrient content. The increasing NPK level of 150-75-75 NPK kg ha^{-1} positively and significantly (P<0.05) influenced the plant nutrient contents with 2.2744% leaf N, 0.1391% leaf P and 0.506% leaf K. Decrease in soil applied N caused a significant decrease in plant nutrient contents. The Zn-B @ 20-1.5 kg ha^{-1} proved to be an optimum level in addition to NPK fertilizers with 0.2412% leaf Zn. The results showed significant impact (P<0.05) of NPK and Zn-B levels on plant nutrient contents. Sabz Pari okra variety contained higher plant P content with 1.5053% leaf N, 0.0921% leaf P, 0.4613% leaf K and 0.2235% leaf Zn content.*

Keywords: Okra, nitrogen, phosphorus, potash, zinc, boron, plant nutrient content

INTRODUCTION

Okra as vegetable is choice of every rich and poor alike and it is cultivated almost round the year. Generally okra is cultivated as kharif crop, but due to varied climates in different parts of the country, it is available in the market almost all months of the year. However, the quality produce is achieved in summer season. The okra yield achieved in this region is far less than the varietal potential due to soil deficiency in most of the macro and micronutrients. Because of soil deficiency in macro and micronutrients, not only the yields are lower than the potentials, but the plant could not grow vigorously to resistant insect pests and diseases attack. The situation clearly suggests the soil application of micronutrients along with usual supply of macronutrients [1].

Among the factors that associated with successful cultivation of okra, the appropriate fertilizer application is of the vital importance. Among macronutrients, N, P and K are essential plant requirement for their growth and vigor. Nitrogen is considered as an essential element of bio-molecules such as amino acids, proteins, nucleic acids, phytohormones and a number of enzymes and coenzymes [2]; that stimulates growth, expansion of the crop canopy and interception of solar radiation [3]. P functions both as a part of several key plant structure compounds and as a catalysis in the conversion of various biochemical reactions in plants. P stimulates root development, increase stem strength, improve flower formation and seed production, more uniform and earlier crop maturity, improvements in crop quality, and increased resistance to plant diseases. Similarly, K is one of sixteen essential nutrient elements required for plant growth and reproduction. Nitrogen being an essential element and important determinant in growth and development of crop plants also improves the plant N content and stimulates the plant to accumulate other nutrients. It plays an important role in chlorophyll, protein, nucleic acid, and hormone and vitamin synthesis and also helps in cell division, cell elongation. Several workers have reported linear increase in green pod yield of okra and leaf N content with the application of N from 56 to 150 kg ha^{-1} [4,5]. Phosphorus helps in nutrients uptake by promoting root growth and thereby ensuring a good pod yield through the increase in total dry matter [6] and P deficiency results in poor root development, poor pod setting and subsequently reduces yield [7,8,9].

The fertility requirements for okra in regard to N, P, and K rates and ratios have not been extensively studied. For achieving a yield of 11.5 tons of pods, leaves and stems of okra contain 21, 62 and 46 kg of N, P_2O_5 and K_2O, respectively [10,11,12]. Selvi [13] reported that 40:50:30 kg ha^{-1} NPK alongwith micronutrients showed optimistic results for crop production and plant nutrient contents.

Apart from the essentiality of various macronutrients, the soils also have become deficient of some essentially required elements such as zinc and boron and application of these micronutrients enhance the crop production greatly on soils with micronutrients deficiency [14]. El-Fouly [15] observed that Zn concentration affects micronutrient contents of the plant organs; the leaf number, leaf area and plant Zn content are increased by addition of Zn. Similarly, boron is nonmetal micronutrient element tourmaline, a complex borosilicate is the main boron-containing mineral found in most soils. Release of boron from this mineral is quite slow [16]. Boron availability decreases with increasing soil pH, thus it is often inadequately available in calcareous soils. Boron uptake by plants correlates extractable soil boron [17]. The okra crop growth and yield parameters followed an increasing trend with increased levels of N, P, K when applied alongwith micronutrients particularly zinc and boron to certain quantities [18,19]. There was a reduced shoot/root growth and plant dry weight with boron deficiencies. In view of the facts stated above, it was imperative to examine the effect of macro and micro nutrient combination to various proportions on the plant nutrient concentrations in okra under field conditions.

MATERIALS AND METHODS

The experiments were conducted for consecutive two years (2009-10 and 2010-11) to investigate the impact of macro

and micronutrients on the plant nutrient content of okra under agro-ecological conditions of Tandojam, Pakistan, located at 25°25' 60'N 68°31' 60E and 19.5 m above the sea level. Three promising okra varieties (Bemisal, Sabz Pari and Reshum) were evaluated for consecutive two years against seven NPK levels (0-0-0, 25-25-25, 50-25-25, 75-37-37, 100-50-50, 125-62-62 and 150-75-75 kg ha^{-1}) and equally seven Zn-B rates (0-0, 10-1.5, 10-2.0, 15-1.5, 15-2.0, 20-1.5 and 20-2.0 kg ha^{-1}). The experiment was laid out in a three replicated Randomized Complete Block Design (Factorial), and treatment effects were determined on plant nutrient content. Land was prepared properly at required depth for better root penetration and for equal distribution of irrigation and fertilizer. Pure seed of different okra verities was used. The seed was sown on ridges at distance of 60 cm between rows and 30 cm plants. The soil was kept with enough moisture to facilitate better germination. The crop was irrigated at an interval of 5-6 days in summer. Four hoeing at 3, 6, 9 and 12 weeks interval was preferred to keep weed under control. The tender young pods were harvested every alternate day. This caused to promote fruit development and yield. The sowing was done with single coulter hand driven drill in the month of February 2009 and 2010 in rows (60 cm spacing). After thinning at 2nd irrigation, 30 cm plant to plant distance was maintained. In each growing season eight irrigations were applied i.e. first after 21 days of sowing and subsequent irrigations when felt necessary. The crop was kept free of weeds by giving one hoeing with spade before the 1st irrigation. All the cultural practices including plant protection measure were adopted uniformly in all the plots to maintain the experimental area. At maturity of the crop, the leaf samples were collected from each sub-plot and subjected to determine plant nutrient content for the following elements:

Nitrogen (%): By Kjedahl method as described in soil chemical analysis method no. 8-4, P. 183. Samples were analyzed at soil science Laboratory, Department of Soil Science, S.A.U Tandojam.

Phosphorus (%): By acid wet digestion method, ($HClO_4$ / HNO_3) method using by spectrophotometer. Samples were analyzed at soil science Laboratory, Department of Soil Science, S.A.U Tandojam.

Potassium: By acid wet digestion method ($HClO_4$ / HNO_3) method using EEL Flame photometer. Samples were analyzed at soil science Laboratory, Department of Soil Science, S.A.U Tandojam.

Zn (mg kg^{-1}): By AB-DTPA method, using automatic absorption spectro photometerically. Samples were analyzed at soil science Laboratory, Department of Soil Science, S.A.U Tandojam.

Data collection and Statistical analysis: The data were collected on the basis of randomly taken five plants in each sub-plot and averaged and statistical analyses were performed by using the Statix (ver 8.1) statisrtical computer software package.

RESULTS AND DISCUSSION

Leaf N content

The leaf N content in okra varieties examined in this research was significantly ($P<0.05$) affected by NPK levels, varieties and years. Table 1 showed that the leaf N content of okra variety Sabz pari was higher (1.5053%) as compared to Bemisal (1.4823%) and Reshum (1.457%). This indicated that variety Sabz pari is more efficient to take nitrogen from the soil as compared to rest of the tested varieties. The increasing NPK levels over control, significantly improved the leaf N content in okra. On average, the leaf N content of okra was highest (2.6771%) in plants fertilized with highest NPK level of 150-75-75 kg ha^{-1}, while the leaf N content was simultaneously decreased to 2.2744, 2.1095, 1.3014, 1.1112 and 0.7214% with reducing rate of NPK fertilizers to 125-62-62, 100-50-50, 75-37-37, 50-25-25 and 25-25-25 kg ha^{-1}, respectively. The lowest leaf N content (0.1916%) was determined in control, where crop was grown without NPK application. The effect of years on the leaf N content of okra plants was examined and it was noted that during 2010, the leaf N content was significantly higher (1.49%) as compared to the year 2009 (1.47%). The interactive effect of varieties and NPK levels on leaf N content showed that highest leaf N content (2.7137%) was determined in the interaction of variety Sabz pari, 150-75-75 kg ha^{-1} NPK and minimum (0.1094%) in interaction of variety Reshum and 0 kg ha^{-1} NPK (control). In case of variety and years interaction, Sabz pari in 2010 resulted in highest leaf N content (1.51%) on average and lowest (1.4594%) in variety Bemisal in 2009.

The results suggested that okra variety Sabz pari showed greater leaf N content than rest of the tested varieties, and statistically differences in leaf N content among varieties was linearly significant ($P<0.05$). Among NPK levels, 150-75-75 kg ha^{-1} showed most positive impact on leaf N content, which suggested that plants take N according to the N availability in the soil or according to the N quantity applied by the grower. The higher leaf N content in okra during 2010 than those in 2009 may be associated with multiple factors which may include residual effects of N applied in the previous crop. These results are fully supported by Amjad [20] who reported that the the plant N improved simultaneously with increasing quantities of soil applied nitrogenous fertilizers and Sabz pari contained higher leaf N content as compared rest of the varieties. Yadav [21] found that okra cv. Varsha Uphar resulted in exceptionally higher yield and and improved plant N content under higher N application. Gowda [10] evaluated okra cultivars Arka Anamika, Varsha and Vishal and reported that Varsha had the maximum N uptake, accumulation in leaves and fruits at the higher N rates.

Table 1. Interactive effect of nutrients, varieties and years on leaf N content (%) of okra

Years	NPK levels	Varieties			Average
		Bemisal	Sabz Pari	Reshum	
2009	F1=0-0-0	0.19	0.19	0.19	**0.19 g**
	F2= 25-25-25	0.71	0.72	0.71	**0.71 f**
	F3= 50-25-25	1.11	1.12	1.12	**1.12 e**
	F4= 75-37-37	1.29	1.31	1.32	**1.30 d**
	F5= 100-50-50	2.08	2.12	2.09	**2.10 c**
	F6= 125-62-62	2.25	2.28	2.23	**2.25 b**
	F7= 150-75-75	2.57	2.63	2.57	**2.59 a**
	Average	1.46 b	1.48 a	1.46 b	-
2010	F1=0-0-0	0.19	0.19	0.19	**0.19 g**
	F2= 25-25-25	0.72	0.73	0.71	**0.72 f**
	F3= 50-25-25	1.12	1.14	1.11	**1.12 e**
	F4= 75-37-37	1.30	1.32	1.29	**1.30 d**
	F5= 100-50-50	2.11	2.14	2.08	**2.11 c**
	F6= 125-62-62	2.27	2.31	2.25	**2.27 b**
	F7= 150-75-75	2.67	2.71	2.65	-
	Average	1.48 b	1.51 a	1.47 b	**1.49 A**
Mean	F1=0-0-0	0.19	0.19	0.11	**0.16 g**
	F2= 25-25-25	0.72	0.73	0.71	**0.72 f**
	F3= 50-25-25	1.12	1.14	1.11	**1.12 e**
	F4= 75-37-37	1.30	1.32	1.29	**1.30 d**
	F5= 100-50-50	2.11	2.14	2.08	**2.11 c**
	F6= 125-62-62	2.27	2.31	2.25	**2.27 b**
	F7= 150-75-75	2.67	2.71	2.65	**2.68 a**
	Overall Average	1.48 b	1.51 a	1.46 c	-

Statistical analysis

Factors	F-Value	P-Value	LSD at 0.05
Varieties(A)	132.80	0.0000	**0.0138**
NPK levels (B)	186561	0.0000	**0.0158**
Years (C)	133.46	0.0000	**0.0131**
AxB	12.22	0.0000	**0.0201**
AxC	10.71	0.0000	**0.0153**
BxC	49.75	0.0000	**0.0182**

Leaf P content (%)

Table 2 indicated that the leaf P content in okra was significantly (P<0.05) influenced by NPK levels, varieties as well as by the years of study. Leaf P content in okra variety Sabz pari was higher (0.0921%) as compared to Bemisal (0.0907%) and Reshum (0.0898%). Sabz pari okra variety proved to be relatively more efficient to take phosphorus from the soil as compared to other varieties examined in this study. There was a significant increase in leaf P content of okra with increasing NPK levels over control. On average, the leaf P content of okra was highest (0.1615%) in plants receiving highest NPK level of 150-75-75 kg ha^{-1}, while the leaf P content was concurrently reduced to 0.1391, 0.1209, 0.0816, 0.0517 and 0.0501% with decreasing NPK levels to 125-62-62, 100-50-50, 75-37-37, 50-25-25 and 25-25-25 kg ha^{-1}, respectively. The lowest leaf P content (0.0291%) was obtained in control, where the okra crop did not receive NPK fertilizers. In case of years, the leaf P content of okra plants showed significant (P<0.05) variation during the two years of study. During 2010, the leaf P content was significantly higher (0.0914%) as compared to the year 2009 (0.0903%). The interactive effect of varieties and NPK levels on leaf P content indicated that highest leaf P content (0.164%) was determined in the interaction of variety Sabz pari, 150-75-75 kg ha^{-1} NPK and minimum (0.029%) equally in the interaction of varieties Bemisal, Reshum and 0 kg ha^{-1} NPK (control). In case of variety and years interaction, highest leaf P content (0.093%) was noted in variety Sabz pari during 2010 and lowest (0.089%) in variety Reshum in the year 2009. It was observed that plant P content was relatively better in variety Sabz pari than rest of the tested varieties, and regardless the years, statistically differences in leaf P content between varieties Bemisal and Reshum were non-significant (P>0.05). Among NPK levels, 150-75-75 kg ha^{-1} resulted most positive impact on leaf P content, which indicated that with increasing soil applied P, the plants take more P from the soil. The higher leaf P content in okra during 2010 than 2009 may be the residual effect of nutrient application during the previous season. Similar results have also been reported by Sundaram [22] who reported improvement in the plant P content with increasing soil applied P rate. Jana [23] found that okra varieties differed significant in plant P concentrations and leaf P increased

simultaneously with increasing the rate of P fertilizer. Bandyopadhyay [24] reported that higher P application resulted in an increased plant P concentration.

Table 2. Interactive effect of nutrients, varieties and years on leaf P content (%) of okra

Years	NPK levels	Varieties			Average
		Bemisal	Sabz Pari	Reshum	
2009	F1=0-0-0	0.029	0.029	0.030	**0.0295 f**
	F2= 25-25-25	0.049	0.050	0.049	**0.0498 e**
	F3= 50-25-25	0.051	0.052	0.050	**0.0513 e**
	F4= 75-37-37	0.083	0.084	0.082	**0.0831 d**
	F5= 100-50-50	0.120	0.122	0.119	**0.1202 c**
	F6= 125-62-62	0.138	0.140	0.137	**0.1382 b**
	F7= 150-75-75	0.160	0.163	0.158	**0.1604 a**
	Average	**0.090 b**	**0.092 a**	**0.089 b**	-
2010	F1=0-0-0	0.029	0.030	0.029	**0.0293 f**
	F2= 25-25-25	0.051	0.051	0.050	**0.0504 e**
	F3= 50-25-25	0.052	0.053	0.051	**0.0521 e**
	F4= 75-37-37	0.084	0.085	0.083	**0.0840 d**
	F5= 100-50-50	0.121	0.123	0.120	**0.1216 c**
	F6= 125-62-62	0.140	0.142	0.139	**0.1400 b**
	F7= 150-75-75	0.162	0.165	0.160	**0.1620 a**
	Average	**0.091 b**	**0.093 a**	**0.090 b**	-
Mean	F1=0-0-0	0.029	0.030	0.029	**0.0291 f**
	F2= 25-25-25	0.050	0.051	0.050	**0.0501 e**
	F3= 50-25-25	0.052	0.053	0.051	**0.0517 e**
	F4= 75-37-37	0.083	0.085	0.083	**0.0836 d**
	F5= 100-50-50	0.120	0.122	0.119	**0.1209 c**
	F6= 125-62-62	0.139	0.141	0.138	**0.1391 b**
	F7= 150-75-75	0.161	0.164	0.159	**0.1615 a**
	Overall Average	**0.0907 b**	**0.0921 a**	**0.0898 b**	-

Statistical analysis

Factors	F-Value	P-Value	LSD at 0.05
Varieties(A)	9482.40	0.0000	0.0038
NPK levels (B)	808431.1	0.0000	0.0050
Years(C)	7431.43	0.0000	0.0026
AxB	590.40	0.0000	0.0086
AxC	7.20	0.0014	0.0046
BxC	378.43	0.0000	0.0070

Leaf K content (%)

Leaf K content was significantly (P<0.05) affected by NPK levels, varieties as well as by the years. On average, the leaf K content was higher in variety Sabz pari (0.4613%) as compared to Bemisal (0.4542%) and Reshum (0.0.4507%) and the results values are presented in Table 3. Sabz pari okra showed better leaf K content as compared to rest of the tested varieties. Increasing NPK levels resulted in a marked increase in the leaf K content of okra. On average, the leaf K content was highest (0.532%) in plants receiving highest NPK level of 150-75-75 kg ha^{-1}, while the leaf K content was gradually decreased i.e. 0.506, 0.496, 0.478, 0.435 and 0.423% with reduced soil applied NPK levels of 125-62-62, 100-50-50, 75-37-37, 50-25-25 and 25-25-25 kg ha^{-1}, respectively. The lowest leaf K content (0.0.318%) was determined in control plants, where no NPK were applied. The effect of years on this trait indicated that, the leaf K content of okra during 2009 was higher (0.4573%) as compared to the year 2010 (0.4535%). The interactive effect of varieties × NPK levels on leaf K content showed that highest leaf K content (0.5386%) was determined in the interaction of variety Sabz pari, 150-75-75 kg ha^{-1} NPK and minimum (0.3150%) in the interaction of varieties Bemisal and 0 kg ha^{-1} NPK (control). In case of variety and years interaction, highest leaf K content (0.4629%) was noted in variety Sabz pari during 2009 and lowest (0.4482%) in variety Reshum in the year 2010. Okra variety Sabz pari maintained its superiority and plant K content was also higher in this variety than other tested varieties, and on average statistically differences in leaf K content between varieties Bemisal and Reshum were non-significant (P>0.05). Among NPK levels, 150-75-75 kg ha^{-1} remained effective to improve leaf K content, and this might be associated with soil application of P in higher quantities along with N and P. The present findings are in concurrence withthose of Udeogalanys [25] who found that soil applied K

application in higher quantities resulted in an increased leaf K content. The K increased application of K fertilizers not only produced quality yield but the leaf nutrients were also improved. Langaroodi [26] obtained highest yield pod yield and increased leaf K content when higher K levels were applied. The leaf K concentration was mainly associated with the rate of application of K fertilizer.

Table 3. Interactive effect of nutrients, varieties and years on leaf K content (%) of okra

Years	NPK levels	Varieties			Average
		Bemisal	Sabz Pari	Reshum	
2009	F1=0-0-0	0.3144	0.3196	0.3254	**0.3198 g**
	F2= 25-25-25	0.4236	0.4206	0.4196	**0.4246 f**
	F3= 50-25-25	0.4354	0.4424	0.4314	**0.4364 e**
	F4= 75-37-37	0.4793	0.4866	0.4743	**0.4800 d**
	F5= 100-50-50	0.4974	0.5054	0.4924	**0.4984 c**
	F6= 125-62-62	0.5070	0.5150	0.5020	**0.5080 b**
	F7= 150-75-75	0.5327	0.5407	0.5277	**0.5337 a**
	Average	**0.4557 b**	**0.4629 a**	**0.4533 b**	-
2010	F1=0-0-0	0.3156	0.3206	0.3124	**0.3162 g**
	F2= 25-25-25	0.4203	0.4271	0.4163	**0.4212 f**
	F3= 50-25-25	0.4320	0.4390	0.4280	**0.4330 e**
	F4= 75-37-37	0.4756	0.4829	0.4706	**0.4763 d**
	F5= 100-50-50	0.4934	0.5014	0.4884	**0.4944 c**
	F6= 125-62-62	0.5030	0.5110	0.4980	**0.5040 b**
	F7= 150-75-75	0.5286	0.5366	0.5236	**0.5296 a**
	Average	**0.4526 a**	**0.4598 a**	**0.4482 b**	-
Mean	F1=0-0-0	0.3150	0.3201	0.3189	**0.3180 g**
	F2= 25-25-25	0.4219	0.4289	0.4179	**0.423 f**
	F3= 50-25-25	0.4337	0.4407	0.4297	**0.435 e**
	F4= 75-37-37	0.4774	0.4847	0.4724	**0.478 d**
	F5= 100-50-50	0.4954	0.5034	0.4904	**0.496 c**
	F6= 125-62-62	0.5050	0.5130	0.5000	**0.506 b**
	F7= 150-75-75	0.5306	0.5386	0.5256	**0.532 a**
	Overall Average	**0.4542 b**	**0.4613 a**	**0.4507 b**	-

Statistical analysis

Factors	F-Value	P-Value	LSD at 0.05
Varieties(A)	84.20	0.0000	0.0016
NPK levels (B)	6333.58	0.0000	0.0025
Years(C)	30.20	0.0000	0.0014
AxB	2.06	0.0308	0.0044
AxC	0.96	0.3894	-
BxC	0.03	0.9999	-

Leaf zinc content (%)

Leaf Zn content was significantly ($P<0.05$) influenced by Zn-B levels, varieties as well as by the years and the results values are presented in Table 4. On average, the leaf Zn content was higher in variety Sabz pari (0.2235%) as compared to varieties Bemisal (0.2201%) and Reshum (0.2178%). Sabz pari maintained its superiority for leaf Zn content over Bemisal and Reshum. Increasing Zn-B levels resulted in a marked increase in the leaf Zn content of okra. On average, the leaf Zn content was highest (0.2426%) in plants receiving highest Zn-B level of 20-2.00 kg ha^{-1}, while the leaf Zn content was simultaneously decreased to 0.2412, 0.2268, 0.2256, 0.2145 and 0.2136% with decreasing soil applied Zn-B of 20-1.5, 15-2.0, 15-1.5, 10-2.0 and 10-1.5 kg ha^{-1}, respectively. The lowest leaf Zn content (0.1789%) was determined in Zn-B control plants. The effect of years on leaf Zn content indicated that, the leaf Zn content of okra during 2010 was higher (0.2273%) as compared to the year 2009 (0.2173%).

The interactive effect of varieties and Zn-B levels on leaf Zn content showed that highest leaf Zn content (0.2461%) was determined in the interaction of variety Sabz pari, 20-2.0 kg Zn-B ha^{-1} and minimum (0.1786%) in the interaction of variety Reshum and 0 kg ha^{-1} Zn-B (control). In case of variety × years interaction, highest leaf Zn content (0.2268%) was noted in variety Sabz pari during 2010 and lowest (0.2148%) in variety Reshum in the year 2009. Application of Zn-B proved to be significantly beneficial for leaf Zn content

in okra, and on average statistically differences in leaf Zn content between Zn-B levels of 20-2.0 and 20-1.5 kg ha^{-1}, and between varieties Sabz pari and Bemisal were non-significant (P>0.05). This indicates that variety Sabz pari maintained its quality and its leaves contained markedly greater contents of Zn apart from the level of Zn-B or year of study. The boron treatment not only increased the crop yield but also increased B content of leaves. Selvi [27] reported higher net returns and plant/fruit Zn-B contents with application of Zn-B in combination at higher rates.

Table 4. Interactive effect of nutrients, varieties and years on leaf Zn content (%) of okra

Years	NPK levels	Varieties			Average
		Bemisal	Sabz Pari	Reshum	
2009	ZB1= 0-0	0.1766	0.1790	0.1740	**0.1763 d**
	ZB2=10-1.5	0.2101	0.2131	0.2081	**0.2105 c**
	ZB3=10-2.0	0.2110	0.2140	0.2090	**0.2113 c**
	ZB4=15-1.5	0.2219	0.2251	0.2199	**0.2223 b**
	ZB5=15-2.0	0.2231	0.2263	0.2211	**0.2235 b**
	ZB6= 20-1.5	0.2371	0.2453	0.2350	**0.2378 a**
	ZB7= 20-2.0	0.2384	0.2426	0.2363	**0.2391 a**
	Average	**0.2168 b**	**0.2202 a**	**0.2148 b**	**-**
2010	ZB1= 0-0	0.1811	0.1841	0.1791	**0.1815 d**
	ZB2=10-1.5	0.2161	0.2200	0.2141	**0.2168 c**
	ZB3=10-2.0	0.2170	0.2210	0.2150	**0.2177 c**
	ZB4=15-1.5	0.2289	0.2319	0.2259	**0.2289 b**
	ZB5=15-2.0	0.2301	0.2331	0.2271	**0.2301 b**
	ZB6= 20-1.5	0.2444	0.2480	0.2416	**0.2447 a**
	ZB7= 20-2.0	0.2457	0.2496	0.2431	**0.2461 a**
	Average	**0.2233 a**	**0.2268 a**	**0.2209 b**	**-**
Mean	ZB1= 0-0	0.1786	0.1816	0.1766	**0.1789 d**
	ZB2=10-1.5	0.2136	0.2166	0.2111	**0.2136 c**
	ZB3=10-2.0	0.2140	0.2175	0.2120	**0.2145 c**
	ZB4=15-1.5	0.2254	0.2285	0.2229	**0.2256 b**
	ZB5=15-2.0	0.2266	0.2297	0.2241	**0.2268 b**
	ZB6= 20-1.5	0.2408	0.2446	0.2383	**0.2412 a**
	ZB7= 20-2.0	0.2421	0.2461	0.2397	**0.2426 a**
	Overall Average	**0.2201 a**	**0.2235 a**	**0.2178 b**	**-**

Statistical analysis

Factors	F-Value	P-Value	LSD 0.05
Varieties(A)	5.7857	0.0000	0.00457
ZB levels (B)	8.1313	0.0000	0.00373
Years(C)	11.5898	0.0000	0.00698
AxB	2.4907	0.0021	0.00646
AxC	46.0829	0.0000	0.00210
BxC	9.2880	0.0000	0.00988

CONCLUSIONS

It was concluded that application of N-P-K fertilizers at the rate of 150-75-75 kg ha^{-1} resulted in maximum plant nutrient content and found that the plant N, P, K and Zn were dose depedent for respective nutrients. Sabz Pari okra variety showed higher nutrient accumulation as compared to Bemisal and Reshum.

LITERATURE CITED

[1] Maqsood, M. A., Rahmatullah, S. Kanwal, T. Aziz and M. Ashraf. "Evaluation of Zn distribution among grain and straw of twelve indigenous wheat, *Triticum aestivum* L. genotypes". *Pak. J. Bot.,* **41**(1): 225-231 (2009).

[2] Don Eckert. "Efficient Fertilizer Use of Nitrogen". *Book,* pp. 1-19 (2010).

[3] Milford, G. F. J., M. J. Armstrong, P. J. Jarvis, B. J. Houghton, D. M. B. Travers, J. Jones and R. A. Leigh. "Effects of potassium fertilizer on the yield, quality and potassium offtake of sugar beet crops grown on soils of different potassium status". *J. Agril. Sci.,* **135**: 1-10 (2000).

[4] Singh, I. P. "Effect of various doses of nitrogen on seed yield and quality of okra (*Abelmoschus esculentus* (L) Moench)". *Annals of Agril. Res.,* **16**(2): 227-229 (1995).

[5] Shivasankeb, A., P. R. Reddy and B. G. Singh. "Nitrogen nutrition in groundnut. 2. Effect of phosphorus on N_2 fixation and dry matter pertitioning". *Legume Res.,* **7**: 105 (1982).

[6] Rao, S. K. "Effect of Rhizobium inoculation and P fertilization on yield of groundnut". *Andra Agric. J.,* **29**:78-80 (1995).

[7] Jam, R. C., D. P. Nema, R. Khandwe and R. Thakur. "Effect of phosphorus and potassium on yield and nutrients uptake and oil cotitents of groundnut". *Indian J. Agril. Sci.,* **60**: 559-566 (1990).

[8] Mohanta, H. C. "Effect of phosphorus and genotypes on the yield and contributing characters in okra (*Abelmoschus esculentus* L. Moench)". *M.S. Thesis, Dept. Hort, IPSA, Salna, Gazipur, India* (1998).

[9] Sadat, M. S. I. "Studies on the effects of different levels of nitrogen, phosphorous and potassium on the growth yield and seed production of okra (*Abelmoschus esculentus* L.)". *M S. Thesis, Dept. of Horticulture, Bangladesh Agril. Univ., Mymensingh, Bangladesh,* (2000).

[10] Gowda, M. C. B., K. S. Krishnappa, M. C. Gowda and T. B. Puttaraju. "Effect of NPK levels on seed production, dry matter, nutrient accumulation and uptake of nutrients in okra". *South Ind. Hort.,* **50**(4/6): 543-549 (2002).

[11] Aslam, J., M. Ibrahim and M. Ishaq. "Okra seed production and nitrate accumulation in okra and as influenced by fertilizer application". Pak. J. Botany, **35** (4): 637-640 (2003).

[12] Uwah D. F., F. A. Nwagwu and G. A. Iwo. "Response of okra (*Abelmoschus esculentus* (L.) Moench.) to different rates of nitrogen and lime on an acid soil". *Int. J. Agric. Sci.,* **2**(2): 14-20 (2010).

[13] Selvi, D. and R. Perumal. "Effect of integrated nutrient management on yield and economics of okra in an inceptisol". *Vegetable Sci.,* **27**(2): 207-208 (2000).

[14] Mortvedt, J. J., F. R. Cox, L. M. Shuman and R. M. Welch. "In: Micronutrients". *Agric., 2nd Edition. (Eds.): Soil Sci. Soc. Am.: Madison, WI, USA,* (1991).

[15] El-Fouly, M. M., O. A. Nofal and Z. M. Mobarak. "Effects of Soil Treatment with Iron, Manganese and Zinc on Growth and Micronutrient Uptake of Sunflower Plant Grown in High pH Soils". *J. Agron. & Crop Sci.,* **186**(4): 245-251 (2001).

[16] Singh, D. K., A. K. Pandey, U. B. Pandey and S. R. Bhonde. "Effect of farmyard manure combined with foliar application of NPK mixture and micronutrients on growth, yield and quality of onion". *Newsletter-National Hort. Res. and Dev. Foundation,* **21-22**(1): 1-7 (2002).

[17] Gunes, A. and M. Alpaslan. "Boron uptake and toxicity in cotton genotypes in relation to boron and phosphorus supply". *J. Pl. Nutr*., **23**(4): 541-550 (2000).

[18] Ambare T. P., V. S gonge, S. S Rewatkar, A. Mohariya and T. S. Shelke. "Influenced of nitrogen levels and varieties on yield and quality of okra". *Crop Res. (Hisar),* **30**(1): 80-82 (2005).

[19] Ogbaji , M. I. "Response of okra to Nitrogen and potassium fertilizers in a southern guinea savallah Agro-ecological location". *J. Sus. Agric. & Environ.,* **4**(1): 17-22 (2002).

[20] Amjad, M., M. A. Anjum and A. Ali. "Impact of phosphorus and planting geometry on growth, yield and quality of green pods in okra". *Int. J. of Agric. and Biol.,* **3**(4): 341-344 (2001).

[21] Yadav, S. K., B. S. Dhankhar, D. P. Deswal, R. P. S. Tomer. "Effect of sowing date and plant geometry on seed production and quality of okra, *Abelmoschus esculentus* L. (Moench) cv. Varsha Uphar". *Seed Res.,* **29**(2) (2001).

[22] Sundaram, V. and V. Kanthaswamy. "Response of okra to foliar feeding of water soluble fertilizers". *Vegetable Sci.,* **32**(1): 92-93 (2005).

[23] Jana, J. C., S. Guha, R. Chatterjee. "Effect of planting geometry and nitrogen levels on crop growth, fruit yield and quality in okra grown during early winter in terai zone of West Bengal". *J. Hortl. Sci.,* **5**(1): 30-33 (2010).

[24] Bandyopadhyay, S., T. Chakraborty and P. Poddar. "Effect of polythene and organic mulching under different levels of manuring practices of growth and seed yield of okra *Abelmoschus esculentus* (L.) Moench". *Environ. & Ecology,* **19**(2): 261-264 (2001).

[25] Udeogalanya, A. C. C. "Response of okra, *Hibiscus esculentus* to plant density and pattern of plant arrangement in Nigeria". *Ind. J. of Agril. Sci.,* **61**(10): 726-730 (1991).

[26] Langaroodi, H. M., and N. Kazerani. Study on the yield of okra cultivars. *Seed and Plant,* **15**(1): 68-69 (1999).

[27] Selvi, D., S. Thiageshwari, P. Santhy and B. Rajkannan. "Effect of integrated nutrient management of yield and economics in okra in a inception". *J. Maharashtra Agril. Univ.,* **29**(2): 122-124 (2004).