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Assessment of anti-nutritional changes in elephant foot yam (*Amorphophallus paeoniifolius* Dennst Nicolson) cultivars

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Abstract

Elephant foot yam is basically premium crop in the South East Asian food system, which serves the major source of carbohydrate in Human's diets. It contains some antinutrient (oxalate) which when eaten pose adverse effect on the body system. The purpose of this study was to determine the antinutritional factors of elephant foot yamcultivar (BCA-1, BCA-2, BCA-4, BCA-5, BCA-6, NDA-4, NDA-5, NDA-9, IGAM-1, AC-28 and Gajendra) of India. The ranges of antinutrient contents were found to be: water soluble oxalate (WSO) 12.71-27.64 mg/100 g, total soluble oxalate (TSO) 19.68-33.83 mg/100g, calcium oxalate 7.01-15.28 mg/100g and total oxalate (TO) 22.85-37.57 mg/100g at different stages during growth and development. The entire investigated sample was found to be low oxalate content in all cultivars, which was safer from the viewpoint of accumulation of urinary oxalate leading to kidney stone. This information will provide breeders with the ability to develop desirable types having high yield and better anti-nutritional profile.

Keywords: *Amorphophallus paeoniifolius,* Cultivar, WSO, TSO, TO, Calcium Oxalate

Introduction

Elephant foot yam (*Amorphophallus paeoniifolius* Dennst- Nicholson) is a very popular tuber vegetable due to its high productivity, non-irritant and maximum monetary return within a short period of time (Dutta et al. 2003). Its native of tropical Asia belongs to the family Araceae under monocotyledons. Stem of this herbaceous species reduced into highly compressed corm the edible part of commercial importance. It is one of the major tuber crops produced in tropical and sub-tropical zones like India, Indonesia, Africa etc. and has great export potential since its commercial cultivation is not in many of the countries (Chandra 1984, Sugiyama and Santosa 2008, Mishra et al. 2001). Root and tubers are the second most staple food crops after cereals, which are grown throughout the world in hot and humid region (Latha et al. 2004). They have played major role in the history of human diet, since they could be collected from the wild and consumed by many of the worlds poorest and most foods insecure households (Harris 1996). It is difficult to ascertain whether the tubers can be relied upon as good sources of minerals because of the presence of anti-nutrition substances (oxalate), which render the minerals, in them unavailable to the consumers (Onwuka 2005). These corms are consumed by many people as a food and widely used in many ayurvedic preparations (Angayarkanni et al. 2007) because it contains different bioactive components like alkaloids, flavonoids, phenols, vitamins, minerals etc. (Bradbury and Holloway 1988, Chowdhury and Hussain 1979, Parkinson 1984, Sakai 1983, Dey and Ghosh 2010).Several antinutritional factors are present in root and tuber crops. Enzyme inhibitors, e.g.amylase and protease, occur in many tubers. The presence of these inhibitors could impair the digestion of starch and protein, thereby reducing the nutritional value of tubers and limiting their utilization as food (Prathibhaet al. 1995). Oxalate is a common constituent of plants and several species, including some crop plants, accumulate high levels of this dicarboxylic acid anion (Libert and Franceschi 1987). Oxalates in tubers may either be a cause or a contributor as to the acridity, which causes irritation, and swelling of mouth and throat (Holloway et al. 1989).Oxalate anion has the chemical formulae of $C_2O_4^{2-}$ or $(COO)_2^{2-}$ and their presence results it's in bitterness and astringent taste. Scratching of the mouth and throat is also experienced in yam (Sakai 1979,Onwuka 2005). Calcium oxalate (CaC_2O_4) is a major component of kidney stone. High intake of oxalate may reduce the calcium availability in the body and this may be an increased risk factor for

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women who require greater amount of calcium in their diets. Dietary oxalate has been known to complex with calcium, magnesium and iron leading to the formation of insoluble oxalate salt and resulting in oxalate stone (Onwuka 2005). Oxalates also interfere with the utilization of minerals making them unavailable or reduced in the body. The primary sources of dietary oxalate are plants and plant products. Many plant foods contain oxalate either in small or large quantity. The objective of this study is to determine the oxalate content in some selected elephant foot yam cultivars commonly consumed in India in daily diet which helps breeders to develop desirable type's cultivars having high yield and better nutritional profile.

Materials and Methods

Collection of samples: Eleven cultivars of elephant foot yam having smooth and glabrous pseudo-stems, collected from the State Agricultural Universities and Indian Council of Agricultural Research were evaluated at the research field of the All India Coordinated Research Project on Tuber Crops, Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal. The station was located at 23.5^{O}N latitude and 89^{O}E longitudes with an altitude of 9.75 m above mean sea level from 2011 to 2013. The soil was a slightly acidic (pH 6.5) with sandy loam. The climate of the region is tropical humid with rainfall of 0.00 to 264.00 mm, temperature maximum 37.59^{O}C and minimum 9.62^{O}C along with RH (%) 96.87 to 36.74 (Annual average) by AICRP on Agricultural Meteorology, BCKV, Kalyani, Nadia, West Bengal.

Physico-chemical analysis: The physic-chemical characteristics of elephant foot yam were recorded from 10 randomly selected plants from each replication throughout the year at monthly intervals during growth and development by mentioned methods *viz.,* oxalate by titrimetric methods of AOAC 1990 and Holloway et al. (1989).

Statistical procedure: All the laboratory data were used to Complete Randomized Design (CRD) as suggested (Raghuramula et al. 1983). The critical difference (CD) value at 5% level of probability was used for comparing the treatments and to find out the significant difference in between them. Each treatment was replicated for three times. The data analyzed with the help of statistical software from AGRES version 3.01 (Data Entry Module for AgRes Statistical Software <c> 1994 Pascal Intl Software Solution).

Results and Discussion

Year affected on water soluble oxalate, total soluble oxalate, calcium oxalate and total oxalate of the crop. The interaction between year and cultivar affected both crop growth and development and it showed that the all cultivars were collected from different place and was smooth pseudo-stem type.

Water-soluble oxalate: WSO content of corm also varied significantly among the different cultivars which presented in Table-1 and it was noticed that an in increasing trend during the growth and development stage. At the early stage of harvesting *i.e.,* at 100 days after planting (DAP), the cultivar BCA-4 content least amount (12.71 mg/100g) and NDA-4 content highest amount (27.64 mg/100g) of WSO. Whereas, significantly lowest and highest water-soluble oxalate content was obtained from BCA-4 (17.32 mg/100g) and NDA-9 (25.62 mg/100g) at 250 DAP, respectively.

Table 1: Changes in water-soluble oxalate content (mg/100g) in elephant foot yam corm during growth and development period

Cv.\DAP	100			130			160			190			220			250		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
BCA-1	27.39	23.64	25.51	29.48	27.33	28.41	32.15	31.05	31.60	35.23	37.74	36.49	27.80	29.93	28.86	24.10	25.64	24.87
BCA-2	19.49	20.95	20.22	22.89	25.23	24.06	28.26	28.10	28.18	33.62	31.87	32.74	26.41	26.39	26.40	21.04	23.97	22.51
BCA-4	15.26	10.15	12.71	17.33	16.54	16.93	23.21	27.82	25.51	28.43	28.64	28.54	21.85	24.28	23.06	18.85	15.80	17.32
BCA-5	20.31	18.05	19.18	24.33	22.02	23.18	29.64	27.44	28.54	35.39	37.46	36.42	32.41	27.27	29.84	23.15	24.28	23.72
BCA-6	20.87	27.08	23.97	25.64	29.77	27.70	31.85	32.85	32.35	38.77	35.26	37.01	31.97	30.37	31.17	22.72	25.85	24.28
NDA-4	28.39	26.90	27.64	29.24	31.90	30.57	33.49	35.23	34.36	39.15	41.28	40.22	33.28	29.82	31.55	24.10	26.90	25.50
NDA-5	19.05	22.72	20.89	21.41	24.82	23.12	28.49	28.94	28.72	35.54	32.15	33.85	29.85	25.21	27.53	21.49	21.23	21.36
NDA-9	25.39	29.33	27.36	28.67	31.28	29.98	32.21	35.05	33.63	36.92	39.85	38.39	31.15	28.59	29.87	25.03	26.21	25.62
IGAM-1	19.18	18.05	18.62	23.21	22.77	22.99	28.26	29.36	28.81	37.31	36.59	36.95	32.10	30.24	31.17	26.15	21.67	23.91
AC-28	19.62	21.69	20.65	23.92	28.15	26.04	31.05	33.23	32.14	39.69	41.46	40.58	32.97	30.84	31.91	25.80	22.15	23.97
Gajendra	16.92	18.05	17.49	22.53	24.10	23.32	27.97	29.92	28.95	35.08	37.49	36.28	28.64	24.73	26.68	19.28	21.28	20.28
Mean	21.08	21.51	21.29	24.42	25.81	25.12	29.69	30.82	30.25	35.92	36.35	36.13	29.86	27.97	28.91	22.88	23.18	23.03
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	3.045	1.511	**	2.923	1.450	**	3.182	1.579	**	3.144	1.560	**	2.848	1.413	**	2.795	1.387	**
Y	1.298	0.644	NS	1.246	0.618	*	1.357	0.673	NS	1.341	0.665	NS	1.214	0.602	**	1.192	0.591	NS
CY	4.306	2.136	NS	4.134	2.051	NS	4.501	2.233	NS	4.447	2.206	NS	4.028	1.998	NS	3.954	1.962	NS

BCA: Bidhan Chandra Amorphophallus; NDA: Narendra Dev Amorphophallus, IGA: Indira Gandhi Amorphophallus; C-Cv.- Cultivar, Y- Year, CD- Critical Difference at 5 %, SEd- Standard Error of Deviation, DAP- Days After Planting, R- Replication (3), NS- Non Significant, **- Highly Significant, *- Significant

Taking into consideration all the maturity stages, it was observed that there was significant variation in mean WSO content with the value ranging from 12.71 to 27.64 mg/100g. Such variation in water soluble oxalate content might be related to their genetic origin, geographical sources, and the level of soil fertility, where they are grown and the harvesting periods. However, these results were consistent with the results of a study by Chattopadhyay et al. 2009 and Misra and Sriram2001.

Total soluble oxalate: TSO content of corm was significantly influenced by cultivars during growth and development (Table-2). The cultivar BCA-4 content lowest amount (19.68 mg/100g) and NDA-9 content the highest amount (33.05 mg/100g) of TSO at 100 DAP. While, BCA-4 and NDA-9 contained lowest and highest amount (25.78 and 33.83 mg/100g, respectively) of TSO at 250 DAP. The mean value at six maturity stages was also varied significantly among the cultivars. Decrease in total soluble oxalate content of corms was found during growth and development. However, TSO compositions of elephant foot yam corms studied were similar to reported values of several cultivated elephant foot yam cultivar (Chattopadhyay et al. 2009).

Calcium oxalate: Calcium oxalate content of elephant foot yam corm ranged from 7.01-15.28 mg/100g during different stages (Table-3). The highest calcium oxalate content was found in cultivar BCA-4 (10.14 mg/100g) and the lowest content was in BCA-6 and NDA-4 (7.01 mg/100g each) at 100 DAP. While, the highest and lowest calcium oxalate values were observed in cv., NDA-5 and BCA-5 (15.28 & 7.63 mg/100g), respectively. Taking into consideration all the maturity stage it was observed that there was significant variation in mean calcium oxalate content and an in increasing trend in calcium oxalate was observed in all cultivar during development of corms. The average value of

Table 2: Changes in total-soluble oxalate content (mg/100g) in elephant foot yam corm during growth and development period

Cv.\DAP	100			130			160			190			220			250		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
BCA-1	32.51	28.36	30.44	34.74	31.59	33.17	37.56	36.85	37.21	41.31	44.59	42.95	33.59	36.46	35.03	29.80	31.38	30.59
BCA-2	25.59	26.69	26.14	29.18	31.72	30.45	35.21	36.21	35.71	42.26	43.90	43.08	33.92	37.23	35.58	27.41	33.33	30.37
BCA-4	21.46	17.90	19.68	25.62	25.67	25.64	32.39	37.13	34.76	39.21	39.23	39.22	31.13	33.33	32.23	26.92	24.64	25.78
BCA-5	25.15	26.33	25.74	29.82	31.28	30.55	36.33	37.05	36.69	42.15	47.49	44.82	38.21	34.76	36.48	28.85	29.08	28.96
BCA-6	25.95	31.64	28.79	31.74	35.80	33.77	39.13	39.56	39.35	46.10	42.54	44.32	38.82	36.89	37.86	28.05	31.64	29.85
NDA-4	33.85	31.08	32.46	36.31	36.97	36.64	41.44	40.77	41.10	48.05	48.67	48.36	39.49	36.67	38.08	29.74	32.90	31.32
NDA-5	25.95	28.64	27.29	29.65	32.41	31.03	37.95	41.26	39.60	46.63	45.54	46.09	40.80	37.56	39.18	31.33	32.40	31.86
NDA-9	30.46	35.64	33.05	35.56	38.23	36.90	42.56	44.97	43.77	47.95	51.23	49.59	40.92	39.46	40.19	33.28	34.38	33.83
IGAM-1	24.72	25.64	25.18	29.13	30.46	29.79	35.39	38.67	37.03	44.90	47.46	46.18	38.80	38.34	38.57	31.80	28.77	30.28
AC-28	26.72	28.51	27.62	31.87	36.15	34.01	39.85	41.74	40.80	48.85	50.67	49.76	39.92	37.92	38.92	31.92	28.51	30.22
Gajendra	21.44	23.64	22.54	28.13	31.59	29.86	34.64	37.74	36.19	42.80	45.59	44.19	35.69	30.83	33.26	26.05	27.90	26.97
Mean	26.71	27.64	27.18	31.07	32.90	31.98	37.49	39.27	38.38	44.56	46.08	45.32	37.39	36.32	36.85	29.56	30.45	30.00
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	2.293	1.138	**	2.102	1.043	**	2.298	1.140	**	1.821	0.904	**	1.645	0.816	**	1.822	0.904	**
Y	0.978	0.485	NS	0.896	0.445	**	0.979	0.486	**	0.776	0.385	**	.701	0.348	**	0.778	0.385	*
CY	3.243	1.609	*	2.973	1.475	NS	3.249	1.612	NS	2.576	1.278	*	2.326	1.154	**	2.576	1.278	**

BCA: Bidhan Chandra Amorphophallus; NDA: Narendra Dev Amorphophallus, IGA: Indira Gandhi Amorphophallus; C-Cv.- Cultivar, Y- Year, CD- Critical Difference at 5 %, SEd- Standard Error of Deviation, DAP- Days After Planting, R- Replication (3), NS- Non Significant, **- Highly Significant, *- Significant

Table 3: Changes in calcium oxalate content (mg/100g) in elephant foot yam corm during growth and development period

Cv.\DAP	100			130			160			190			220			250		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
BCA-1	7.46	6.86	7.16	7.65	6.19	6.92	7.87	8.43	8.15	8.84	9.96	9.40	8.43	9.50	8.96	8.28	8.36	8.32
BCA-2	8.88	8.35	8.62	9.15	9.44	9.29	10.11	11.79	10.95	12.57	17.49	15.03	10.93	15.77	13.35	9.27	13.61	11.44
BCA-4	9.02	11.26	10.14	12.06	13.28	12.67	13.35	13.54	13.45	15.68	15.40	15.54	13.50	13.17	13.33	11.75	12.87	12.31
BCA-5	7.05	12.05	9.55	7.98	13.47	10.72	9.73	13.99	11.86	9.85	14.59	12.22	8.43	10.89	9.66	8.28	6.97	7.63
BCA-6	7.39	6.64	7.01	8.89	8.77	8.83	10.59	9.77	10.18	10.67	10.59	10.63	9.96	9.49	9.72	7.76	8.43	8.09
NDA-4	7.94	6.08	7.01	10.29	7.39	8.84	11.56	8.06	9.81	12.94	10.74	11.84	9.03	9.98	9.50	8.21	8.73	8.47
NDA-5	10.03	8.61	9.32	11.98	11.04	11.51	13.75	17.92	15.84	16.14	19.47	17.80	15.93	17.96	16.94	14.32	16.24	15.28
NDA-9	7.39	9.17	8.28	10.03	10.11	10.07	15.07	14.43	14.75	16.04	16.56	16.30	14.21	15.81	15.01	12.01	11.90	11.95
IGAM-1	8.06	11.04	9.55	8.62	11.19	9.90	10.37	13.54	11.95	11.04	15.81	13.43	9.73	11.78	10.76	8.21	10.33	9.27
AC-28	10.33	9.92	10.13	11.57	11.64	11.60	12.79	12.38	12.59	13.32	13.39	13.35	10.11	10.30	10.20	8.91	9.25	9.08
Gajendra	6.56	8.13	7.35	8.14	10.89	9.51	9.70	11.38	10.54	11.23	11.78	11.51	10.26	8.87	9.57	9.85	9.62	9.73
Mean	8.19	8.92	8.56	9.67	10.31	9.99	11.35	12.29	11.82	12.57	14.16	13.37	10.96	12.14	11.55	9.71	10.57	10.14
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	1.039	0.548	**	1.476	0.733	**	1.293	0.641	**	1.301	0.645	**	1.216	0.604	**	1.253	0.622	**
Y	0.471	0.233	**	0.629	0.312	NS	0.551	0.273	**	0.555	0.275	**	0.519	0.257	**	0.534	0.265	**
CY	1.561	0.775	**	2.088	1.036	**	1.828	0.907	**	1.839	0.913	**	1.721	0.854	*	1.772	0.879	*

BCA: Bidhan Chandra Amorphophallus; NDA: Narendra Dev Amorphophallus, IGA: Indira Gandhi Amorphophallus; C-Cv.- Cultivar, Y- Year, CD- Critical Difference at 5 %, SEd- Standard Error of Deviation, DAP- Days After Planting, R- Replication (3), NS- Non Significant, **- Highly Significant, *- Significant

Table 4: Changes in total oxalate content (mg/100g) in elephant foot yam corm during growth and development period

Cv.\DAP	100			130			160			190			220			250		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
BCA-1	34.84	30.50	32.67	37.14	33.52	35.33	40.02	39.48	39.75	44.07	47.70	45.89	36.22	39.43	37.83	32.38	34.00	33.19
BCA-2	28.36	29.30	28.83	32.04	34.67	33.35	38.36	39.89	39.13	46.18	49.36	47.77	37.34	42.16	39.75	30.31	37.59	33.95
BCA-4	24.28	21.42	22.85	29.39	29.82	29.60	36.56	41.36	38.96	44.10	44.04	44.07	35.35	37.45	36.40	30.59	28.66	29.63
BCA-5	27.36	30.10	28.73	32.32	35.49	33.90	39.37	41.42	40.40	45.23	52.05	48.64	40.84	38.16	39.50	31.43	31.26	31.34
BCA-6	28.26	33.71	30.99	34.52	38.53	36.53	42.44	42.62	42.53	49.44	45.85	47.64	41.93	39.86	40.90	30.48	34.27	32.38
NDA-4	36.33	32.98	34.65	39.52	39.28	39.40	45.05	43.29	44.17	52.10	52.02	52.06	42.31	39.79	41.05	32.31	35.62	33.97
NDA-5	29.08	31.33	30.21	33.39	35.86	34.63	42.25	46.86	44.55	51.68	51.62	51.65	45.77	43.18	44.47	35.81	37.47	36.64
NDA-9	32.77	38.51	35.64	38.70	41.39	40.04	47.27	49.49	48.38	52.96	56.41	54.68	45.36	44.40	44.88	37.04	38.10	37.57
IGAM-1	27.24	29.09	28.16	31.82	33.96	32.89	38.63	42.90	40.76	48.35	52.40	50.38	41.84	42.02	41.93	34.36	32.00	33.18
AC-28	29.95	31.61	30.78	35.49	39.79	37.64	43.84	45.61	44.73	53.01	54.85	53.93	43.08	41.14	42.11	34.71	31.40	33.06
Gajendra	23.49	26.18	24.83	30.67	34.99	32.83	37.67	41.30	39.49	46.30	49.27	47.79	38.90	33.60	36.25	29.13	30.90	30.02
Mean	29.27	30.43	29.85	34.09	36.12	35.10	41.04	43.11	42.08	48.49	50.51	49.50	40.81	40.11	40.46	32.59	33.75	33.17
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	2.820	1.399	**	2.159	1.072	**	2.250	1.116	**	1.993	0.989	**	1.462	0.726	**	1.505	0.747	**
Y	1.202	0.596	NS	0.921	0.457	**	0.959	0.475	**	0.849	0.422	**	0.623	0.309	NS	0.642	0.318	**
CY	3.988	1.979	*	3.054	1.516	NS	3.181	1.578	NS	2.818	1.398	*	2.068	1.026	**	2.129	1.056	**

BCA: Bidhan Chandra Amorphophallus; NDA: Narendra Dev Amorphophallus, IGA: Indira Gandhi Amorphophallus; C-Cv.- Cultivar, Y- Year, CD- Critical Difference at 5 %, SEd- Standard Error of Deviation, DAP- Days After Planting, R- Replication (3), NS- Non Significant, **- Highly Significant, *- Significant

over cultivars was <50 mg, which is found in most of the cultivars, and does not pose problem to human digestion. This result agrees well with the study results reported by Fasset(1973).

Total oxalate: Total oxalate (TO) content of corm was significantly influenced by cultivars during growth and development (Table-4). The cultivars NDA-9 and NDA-5 contained highest amount (35.64 and 37.57 mg/100g, respectively) of TO at 100 and 150 DAP, respectively. While, the cultivars BCA-4 contained lowest content (22.85 and 29.63 mg/100g) of TO at 100 and 250 DAP, respectively. The mean value at six maturity stages was also varied significantly among the cultivars. Increase in total oxalate content of corms was found during growth and development. The range of variation observed in this study on this aspect among different collections are some what in accordance with findings of (Prakash et al. 1995, Gupta et al. 1989, Singh et al. 1999) and these variation in total oxalate content might be related to their genetic origin, geographical sources, the level of soil fertility, where they are grown and the harvesting periods.

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सारांश

वर्तमान अध्ययन का मुख्य उद्देश्य भारत में उपलबध सूरन में व्यानत अपोषकीय घटकों का विभिन्न प्रजाजियों (बी.सी.ए.–1, बी.सी.ए.–2, बी.सी.ए.–4, बी.सी.ए.–6, एन.डी.–4, एन.डी.–5, एन.डी.–9, आई. जी.ए.एम–1 एभी–28 व गजेन्द्र) का मूल्यांकन किया गया। परिणाम में आक्सालेट की मात्रा विभिन्न अवस्थाओं में सार्थकतापूर्ण अलग थी। ओषकीय घटकों में जल विलेय आक्जलेट (डब्ल्यू.एम.ओ.) 19.68–33.83 मिग्रा./100 ग्राम, कैल्सियम आक्जलेट 7.01–15.28 मिग्रा/100 ग्राम एवं कुल आक्सलेट (टी.ओ.) 22.85–37.57 मिग्रा./100 ग्राम विभिन्न वृद्धि एवं विकास की अवस्थाओं में पाया गया। प्रयोग की गयी सभी किस्मों के प्रतिदर्शी में आक्जलेट की मात्रा कम पायी गयी जिससे स्पष्ट होता है कि वृक्क में पथरी बनने व पेशाब में आक्जलेट कम होगी। इससे सब्जी प्रजनकों को वाछित प्रकार की प्रजाति अधिक उपज तथा उत्तम अपोषकीय घटक गुणों के विकसित करने में मदद मिलेगी।

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