ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 11, pp.61646-61650, November, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

STATUS OF IODINE IN SOIL AND VEGETABLE CROPS GROWN IN DIFFERENT AGRO CLIMATIC ZONES OF ASSAM

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ARTICLE INFO

Article History:
Received 14th August, 2017
Received in revised form
25th September, 2017
Accepted 27th October, 2017
Published online 30th November, 2017

Key words:
Total and available iodine,
Soil,
Agro climatic zone,
Assam,
Agro forestry,
Rabi and Kharif crops.

ABSTRACT

Iodine is one of the most important essential trace elements not only for plant but for human being and animal also. Plant derive iodine from soil but animal kingdom uptake it through food crops. North eastern region of India especially Assam is identified as iodine deficient state. It has been divided in six agro-climatic zones on basis of rainfall, temperature, humidity and soil. Three sites from each zone were selected for the study. The present investigation was carried out to evaluate total and available iodine content in soil and to explore the accumulation of iodine in edible part of *Kharif* and *Rabi* crops under agroforestry in different zones. Highest iodine content in soil was recorded in upper Brahmaputra valley (3.24 mg kg^{-1}) followed by lower Brahmaputra valley (2.84 mg kg^{-1}). Among the *Kharif* crops, highest iodine content was found in lady's finger (7.09 mg kg^{-1}) while in *Rabi* crops it was recorded in cabbage (11.10 mg kg^{-1}). Iodine content was found comparatively more in *Rabi* crops than *Kharif* crops. Least amount of iodine content was recorded in crops as well as soil in hill zone of Assam. Foliar vegetable was found to have more iodine accumulating capability than fruit vegetables. Observation concluded that uptake of iodine by crop dependent on the availability of iodine content in soil.

Citation: Indrani P Bora and Arundhati Baruah, 2017. "Status of iodine in soil and vegetables crops grown in different agro climatic zones of Assam", *International Journal of Current Research, Vol. 9, Issue, 11, pp.61646-61650, November, 2017*

INTRODUCTION

Iodine plays an important role in the health of human as it is a vital component of the hormones produced in the thyroid gland. This hormone regulates a variety of important physiological processes including the cellular oxidation. Deficiency of iodine resulting from inadequate dietary intake leads to visible and invisible spectrum of health consequences collectively called iodine deficiency disorders (Hetzel, 1983; Liao, 1992). Approximately 1.9 billion people worldwide were estimated to be at risk of iodine deficiency disorders (Benoist *et al*., 2003). A daily intake of 150 µg of iodine per adult is recommended to prevent iodine deficiency(Delange, 1993; WHO, 2004). A series of thyroid functional and developmental abnormalities occur when consumption is below 100 µg/day (Hetzel, 1989. Dunn, 1998). Iodine is present in soils as iodide, iodate and organic iodine compounds. In most of the soil iodine is associated with organic matter, clays and oxides of Fe and Al although small amount of iodine is present in the soil solution in the form of iodide (Fuge and Johnson, 1986). Generally the concentration of this trace element in the soil will affect the concentration in the food products produced from that soil.

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Therefore, it is important to know the status of these elements in soils in order to identify areas where health problems associated with deficiencies. Presently in many areas of the world, the surface soil becomes progressively poorer in iodide mainly because of accelerated deforestation, flooding and soil erosion (Singh, 2004). The loss of iodine may occur either by vertical transport down into deeper layers of the soil or is released to the atmosphere through volatilization. Iodine content of food depends on the iodine content of the soil in which it is grown and since iodine is irregularly distributed over the earth's crust, there are variations in the iodine content of food in different geographical locations (Koutras *et al.*, 1985). Thus, the food grown in iodine deficient areas cannot provide enough iodine for the people living there, especially in areas where the surface soil have progressively become poorer in iodide through erosion and leaching processes (Singh, 2004). It was reported that Iodine in the edible parts of vegetable increased with the increasing iodine addition in soil. Moreover, leafy vegetable was found to the strongest capability in iodine enrichment than was stem vegetable. On the other hand, fruit vegetable was the most weak to the iodine accumulation (Mayer, 2008). North eastern region of India is known as iodine deficient area and the population is prone to dreaded and endemic disease like goitre. Recently, due to population explosion and to meet the basic needs people are gradually adopting scientific ways to conserve soil and moisture and shifted to agroforesty system. There is a lack of current information on the status of iodine in different agroclimatic zones of Assam and relationships between iodine in soils and levels in food grown in different agroforestry systems. In this study, iodine content in soil in different agro-climatic zones of Assam and accumulation of iodine in the edible portion of vegetables grown in this region under agroforestry was evaluated. Experimental results provide theoretical and technical evidence for identifying efficient vegetable crops as target crops for iodine biofortification in further study.

MATERIALS AND METHODS

Study site

Assam**,** situated in the north eastern part of India, lies between 24^{0} and 28^{0} 18' N latitudes and 89^{0} 4' and 96.0^{0} E longitudes, having boundaries with Bhutan and Arunachal Pradesh in the north; Nagaland, Manipur and a part of Arunachal Pradesh in the east; Mizoram, Tripura and Meghalaya in the south and West Bengal in the west. The total geographical area of 78438 sq. km. and the mighty Brahmaputra and the Barak with their 121 small and tiny tributaries and branches flow through the two valleys. There are six different agro-climatic zone viz., North bank plane zone, Lower Brahmaputra valley zone, Central Brahmaputra valley zone, Upper Brahmaputra valley zone, Barak valley and Hill zone.

Climate

Climate of Assam is humid subtropical with mean annual rainfall varying from 1,500 mm to 3,750 mm. The average annual rainfall in the state was 2300 mm, of which nearly 60 to 70% received within a span of three to four months (May to August). Mean annual maximum temperature varies from 23.6^{0}C - 31.7^{0}C and minimum temperature varies from 10^{0}C - 25.2^{0}C.

Soil

The texture of the soil in the state varies considerably depending on physiography and different agro-climatic conditions. Alluvial, piedmont, hill and lateritic groups of soil are available in the state. The alluvial soils are extensively distributed over the Brahmaputra and Barak plain and are very fertile. The alluvial soils may be young alluvial and old alluvial. Old alluvial soils occur in some patches of Kokorajar, Barpeta, Nalbari, Kamrup, Darrang, Sonitpur, Lakhimpur and Dhemaji district. Generally, the old alluvial soils are very deep with fine loams to coarse loams in texture. The piedmont soils are confined to the northern narrow zone along the piedmont zone of the Himalayan foothills. The soils are very deep and fine to coarse loamy in texture. The hill soils are generally found in the southern hill regions of the state. These soils are deep, dark grayish brown in colour and fine to coarse loamy in texture. The lateritic soils are extensively occurred in North Cacher Hills district and in some parts of the southern part of Karbi Plateau. These soils are dark and finely textured with heavy loams.

Physiography

The state has three distinct physiographic units – the plain, the plateau and the hills. The Brahmaputra and Barak valleys accounting for 80.8% of total geographic area are the two priority zones for agricultural development in the plain. The Brahmaputra valley is an alluvial plain surrounded by hills and interspersed with small hillocks, uplands, lowlands and swampy lowlands subject to annual flooding. The Barak valley has an undulating topography with small hillocks and swamps.

Survey of sites in different agro climatic zones of Assam

Extensive tours were conducted during 2014-2015 to Lakhimpur, Dhemaji, Tezpur in North Bank Plains zone; Sarupather, Jorhat and Dibrugarh in Upper Brahmaputra valley zone; Nowgong, Morigaon and Roha in Central Brahmaputra Valley zone; Boko, Nalbari and Kokorajar in Lower Brahmaputra valley zone; Badarpur Ghat, Karimgang, Udharbund in Barak valley zone and Deohari Rongpi, Phumen Ingti and Bey Killing village of Karbi Anglong district under Hill zone (Table-1).

Collection and analysis of total and available iodine content in soil

Composite soil samples (0-25 cm) were randomly collected from selected sites, air dried ground and sieved through 1mm sieve and analyzed for total and available iodine content of following colorimetric method of Basu *et al.,* (1986).

Collection of agro forestry crop plants (*Kharif* and *Rabi*)

Cropping season is generally classified into *Kharif* and *Rabi*. The *Kharif* season is from July to October during the south-west monsoon and the *Rabi* cropping season is from October to March. In Assam, the major *Kharif* crops are autumn rice, winter rice, maize, pulses, kharif oilseeds like sesame, castor, soybean, groundnut, kharif vegetables such as Lady's Finger, Cucumber, Long Bean, Pointed gourd, Teasle gourd etc. On the other hand major *Rabi* crops cultivated are summer rice, cereals, wheat, grams, rape and mustard, various rabi oilseeds, rabi vegetables such as spinach, cabbage, reddish, brinjal, potato etc. Agricultural crops were cultivated along with some economically important fruit as well as forest tree species grown in different agro-climatic zone such as different species of bamboo Areca nut (*Areca catechu*), Mango (*Mangifera indica*), Litchi (*Litchi chinensis*), Banana (*Musa paradisiaca*), Plum (*Ziziphus mauritiana*), Jack fruit (*Artocarpus heterophyllus*), Jamun (*Syzygium cumini*), Olive (*Olea europaea*), Guava (*Psidium guava*), Citrus (*Citrus reticulata*), Gomari (*Gmelina arborea*), Sissoo (*Dalbergia sisso*), Kadam **(***Anthocephalus cadamba),* Teak (*Tectona grandis*), Neem (*Azadiracta indica*), Hilika (*Terminalia chebula*), Arujun (*Terminalia arjuna*) etc. Crops grown under agro-forestry were collected in both Kharif and Rabi season from identified sites of different agro climatic zones of Assam for determination of iodine content.

Preparation of sample

Collected samples were oven dried at 40°C, ground to powder using warring blender, packaged in an air-tight glass jar and stored at room temperature until analysis was carried out.

Analysis of Iodine content in crops

Iodine content in different crops was determined by adding 0.5 g of each sample into nickel crucibles. 1 ml of a mixture of 0.5 M sodium hydroxide and 0.1 M potassium nitrate was added to the samples, mixed and allowed to dry.

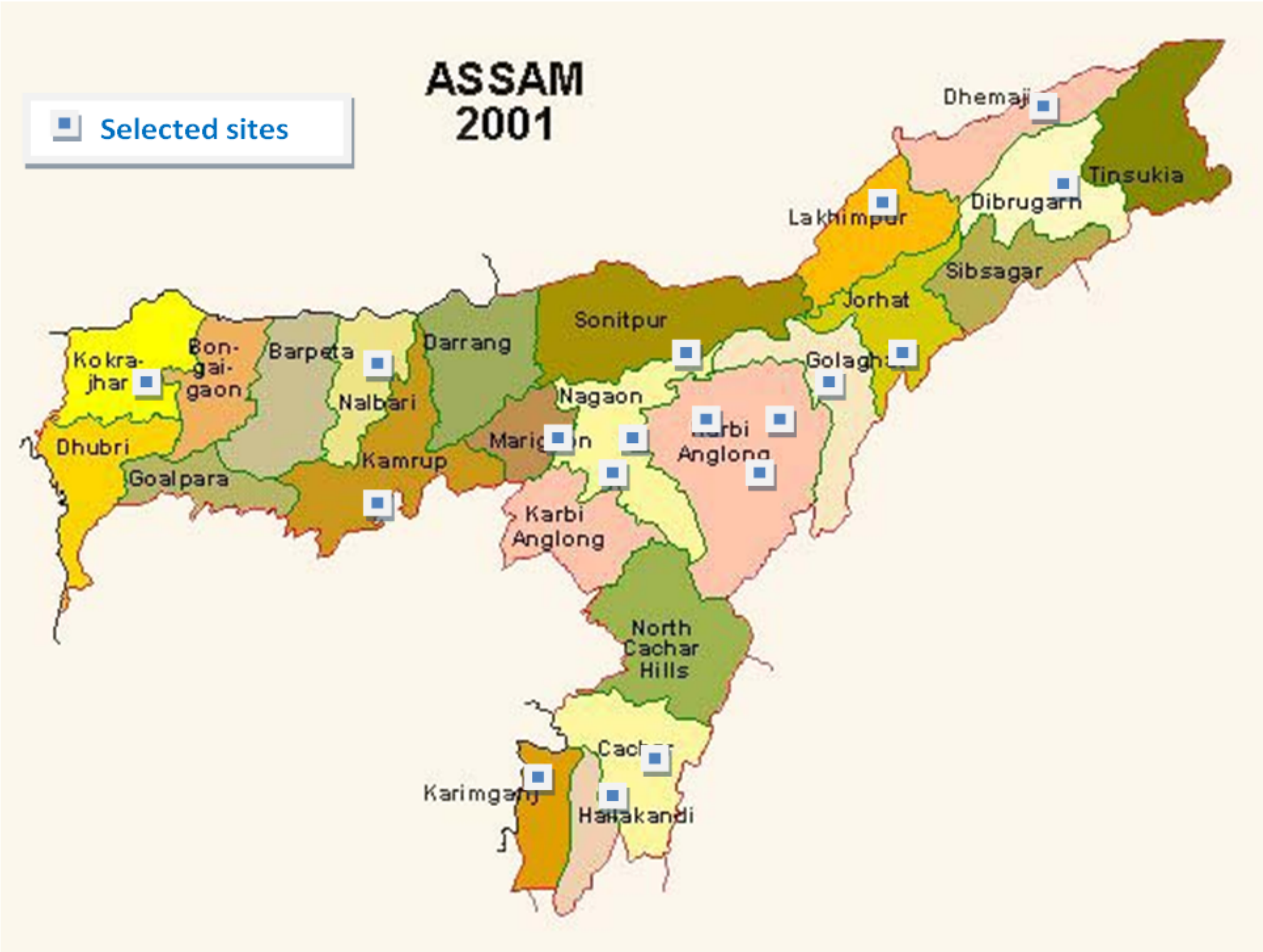

Table 1. Agro Ecological Zone of Assam

Agro ecological Zone	Districts	Area (Sq. km)	Selected sites
Lower Brahmaputra zone	Kamrup, Dhuburi, Nalbari, Borpeta, Bongaigaon, Goalpara, Kokorajar	20148	Nalbari, Kokorajar, Boko
Central Brahmaputra zone	Nagaon, Morigaom	5561	Nowgong, Morigaon, Roha
Upper Brahmaputra zone	Sibsagar, Jorhat, Golaghat, Dibrugarh, Tinsukia	16192	Sarupather, Nacachari, Chennimari
Barak valley zone	Cacher, Hailakandi, Karimgang	6922	Badarpur ghat, Karimganj, Udarband
North Bank plain zone	Lakhimpur, Dhamaji, Darrang, Sonitpur	11421	Lakhimpur, Dhemaji, Tezpur
Hill Zone	Karbi Anglong, North Cacher Hills	15322	Deohari Rongpi, Bey Killing Phumen Ingti,

Table 2. Total and available Iodine content of soil in selected sites under different agro climatic zones of Assam

Agro climatic zone	Site	Total Iodine (mg kg^{-1})		Available Iodine (mg kg^{-1})	
		Kharif	*Rabi*	*Kharif*	*Rabi*
North Bank Plain zone	Lakhimpur	2.58±0.02	2.56±0.032	0.629±0.0016	0.624±0.0032
	Dhemaji	2.56±0.03	2.46±0.025	0.527±0.0024	0.521±0.0024
	Tezpur	2.71±0.01	2.78±0.01	0.531±0.003	0.534±0.003
Upper Brahmaputra valley zone	Sarupathar	3.17±0.04	3.09±0.03	1.124±0.003	0.928±0.0032
	Nakachari	3.24±0.022	2.85±0.04	1.143±0.002	0.885±0.002
	Chennimari	3.09±0.03	3.21±0.05	0.998±0.0008	1.017±0.0024
Central Brahmaputra valley zone	Nagaon	2.68±0.05	2.76±0.01	0.614±0.006	0.728±0.003
	Marigaon	2.69±0.04	2.66±0.03	0.654±0.005	0.669±0.0044
	Roha	2.61±0.02	1.61±0.05	0.559±0.003	0.619±0.0052
Lower Brahmaputra valley zone	Boko	2.84±0.01	2.78±0.06	0.823±0.002	0.829±0.0022
	Nalbari	2.76±0.028	2.70±0.01	0.728±0.004	0.827±0.0026
	Kokrajar	2.84±0.03	2.68±0.02	0.876±0.002	0.728±0.003
Barak valley zone	BadarpurGhat	2.46±0.02	2.22±0.03	0.433±0.006	0.325±0.0024
	Karimganj	2.83±0.04	2.14±0.03	0.524±0.014	0.228±0.0026
	Udharbund	2.29±0.03	2.37±0.01	0.335±0.023	0.198±0.0018
Hill zone	Deohari Rongpi	2.04±0.02	1.88±0.02	0.239±0.005	0.294±0.0004
	Phumen Ingti	1.87±0.02	1.59±0.003	0.136±0.001	0.221±0.0006
	Bey Killing	1.72±0.01	1.36±0.02	0.229±0.002	0.197±0.0015

Table 3 (a). Iodine content of different agro forestry crops (*Kharif*) in different agro-climatic zones of Assam

Agro climatic zone	Site	Lady's Finger	Cucumber	Long Bean	Pointed gourd	Teasle gourd
North Bank Plains zone	Lakhimpur	6.48 ±0.024(A)	3.56 ±0.002(J)	3.67 ±0.024(B)	3.05 ±0.002(M)	3.11 ±0.018(M)
	Dhemaji	6.42 ±0.016(J)	3.77 ±0.020(A)	3.47 ±0.004(K)	3.41 ±0.018(M)	3.14 ±0.014(A)
	Tezpur	6.40 ±0.008(A)	4.01 ±0.025(J)	3.56 ±0.021(B)	3.13 ±0.002(M)	3.26 ±0.002(M)
Upper Brahmaputra valley zone	Sarupathar	6.81 ±0.024(T)	4.21 ±0.006(R)	4.46 ±0.030(A)	3.56 ±0.004(M)	3.36 ±0.004(A)
	Nakachari	7.09 ±0.024(B)	4.41 ±0.002(A)	4.05 ±0.004(K)	3.47 ±0.003(M)	3.16 ±0.002(J)
	Chennimari	6.75 ±0.016(A)	4.16 ±0.014(B)	4.11 ±0.003(M)	-	3.31 ±0.001(J)
Central Brahmaputra valley zone	Nagaon	6.70 ±0.022(K)	4.26 ±0.022(R)	4.10 ±0.004(J)	3.49 ±0.002(K)	-
	Marigaon	6.60 ±0.028(A)	3.81 ±0.026(A)	3.86 ±0.002(A)	-	3.35 ±0.002(J)
	Roha	6.52 ±0.004(A)	3.87 ±0.003(A)	3.91 ±0.016(A)	3.29 ±0.003(M)	3.95 ±0.003(A)
Lower Brahmaputra valley zone	Boko	6.78 ±0.020(A)	-	4.16 ±0.014(K)	-	4.12 ±0.018(A)
	Nalbari	6.88 ±0.032(R)	4.28 ±0.028(M)	3.97 ±0.002(M)	-	3.26 ±0.002(A)
	Kokrajar	6.95 ±0.020(A)	4.29 ±0.002(M)	4.47 ±0.003(K)	3.47 ±0.004(M)	3.06 ±0.014(B)
Barak valley zone	Badarpur Ghat	6.55 ±0.034(A)	3.89 ±0.008(M)	3.86 ±0.004(M)	-	-
	Karimganj	6.51 ±0.026(M)	3.91 ±0.016(A)	3.91 ±0.016(A)	-	-
	Udharbund	6.46 ±0.005(J)	4.06 ±0.002(K)	-	-	3.05 ±0.003(R)
Hill Zone	Deohari Rongpi	5.12 ±0.008(A)	3.12 ±0.020(A)	3.41 ±0.002(K)	3.11 ±0.014(M)	3.04 ±0.002(A)
	Phumen Ingti	5.25 ±0.002(A)	3.34 ±0.003(A)	-	3.14 ±0.002(M)	-
	Bey Killing	5.44 ±0.028(A)	3.31 ±0.030(A)	3.39 ±0.002(K)	3.25 ±0.003(M)	-

Table 3(b). Iodine content of different agro forestry crops (*Rabi*) in different agro-climatic zones of Assam

Agro climatic zone	Site	Spinach	Cabbage	Reddish	Brinjal
North Bank Plains zone	Lakhimpur	5.74 ±0.004(G)	8.72 ±0.001(B)	5.92 ±0.014(L)	5.25 ±0.004(M)
	Dhemaji	5.01 ±0.012(M)	8.42 ±0.018(N)	5.87 ±0.008(G)	5.12 ±0.018(G)
	Tezpur	4.88 ±0.004(A)	-	5.16 ±0.008(B)	5.14 ±0.004(N)
Upper Brahmaputra valley zone	Sarupathar	6.98 ±0.002(G)	9.53 ±0.025(A)	6.81 ±0.020(B)	5.81 ±0.014(L)
	Nakachari	7.25 ±0.004(M)	9.12 ±0.006(M)	6.54 ±0.002(M)	5.11 ±0.003(G)
	Chennimari	7.12 ±0.016(A)	10.12 ±0.004(A)	-	5.10 ±0.002(B)
Central Brahmaputra valley zone	Nagaon	5.81 ±0.012(A)	9.15± 0.024(A)	6.81 ±0.018(M)	-
	Marigaon	5.78 ±0.018(A)	8.89± 0.020(B)	6.74 ±0.002(L)	4.88 ±0.014(L)
	Roha	5.41 ±0.002(A)	8.55± 0.026(B)	6.11 ±0.010(L)	4.52 ±0.003(L)
Lower Brahmaputra valley zone	Boko	6.25 ±0.010(B)	10.23± 0.003(L)	6.88 ±0.014(A)	-
	Nalbari	6.67 ±0.012(M)	10.45± 0.016(L)	6.43 ±0.004(N)	5.60 ±0.004(G)
	Kokrajar	6.12 ±0.020(A)	11.10± 0.022(A)	6.78 ±0.003(A)	-
Barak valley zone	Badarpur Ghat	6.22 ±0.002(A)	9.71 ±0.002(L)	6.33 ±0.004(L)	-
	Karimganj	6.10 ±0.006(M)	9.05 ±0.008(M)	6.12 ±0.018(B)	4.90 ±0.002(A)
	Udharbund	5.97 ±0.008(M)	9.11 ±0.016(A)	-	-
Hill Zone	Deohari Rongpi	4.91 ±0.012(A)	8.41 ±0.004(B)	5.12 ±0.018(A)	5.43 ±0.004(L)
	Phumen Ingti	5.06 ±0.002(L)	7.98 ±0.020(A)	5.50 ±0.002(B)	-
	Bey Killing	4.12 ±0.018(L)	8.14 ±0.004(A)	4.12 ±0.004(A)	-

A-under Areca nut; B-under bamboo; M-under Mango; J- under Jamun; K-under Jack fruit; R-under Olive plant

The samples were heated to 250°C in a muffle furnace, held for 15 min, heated further to 480°C, again held for 15 min, and finally brought to 580°C. Temperature was maintained at 580°C for 3 hours, after which they were allowed to cool to room temperature. The resultant ash was extracted with three successive 2 ml portions of a 1.0 mM sodium hydroxide solution, made up of double-distilled water. The solution was centrifuged at 2500 g for 20 min using polypropylene centrifuge tubes and the supernatant solution collected for iodine determination. The heat destroyed the organic matrix. Sodium hydroxide was used to keep the iodine in a non volatile form, while the potassium nitrate is used to increase the oxidation of the organic matter. Then, 1 ml of sample solution was added to a cuvette at 35°C and 1 ml of arsenic reagent was added. The reaction was started by the addition of 1 ml of ceric reagent. The initial reaction rate was calculated from the change in absorbance at 420 nm. The iodine concentrations of the samples were determined from a standard curve (Fisher *et al.,* 1986).

RESULTS AND DISCUSSION

Total and available iodine content in soil in different agro climatic zones of Assam in *Kharif* season ranged from 1.72 mg kg^{-1} to 3.24 mg kg^{-1} and 0.136 mg kg^{-1} to 1.143 mg kg^{-1} respectively (Table 2). During *Kharif* season both total and available iodine content in soil was recorded significantly more in upper Brahmaputra valley zone followed by lower Brahmaputra valley and north bank zone respectively. Least value was observed in hill zone. More or less same trend was noticed in *Rabi* season also. No remarkable variation observed among the site of each zone. Total and available iodine content in soil during *Rabi* season ranged from 1.36 mg kg^{-1} to 3.21 mg kg^{-1} and 0.196 mg kg^{-1} to 1.017 mg kg^{-1} respectively. Iodine content in *Kharif* crops *i.e.* lady's finger (*Abelmoschus esculentus*), cucumber (*Cucumis sativas*), pointed gourd (*Trichosanthes dioica),* Teasle gourd (*Momordica dioica)* and yard long bean (*Vigna unguiculata*) under agro forestry was represented in Table 3a. Highest amount of iodine content was found in lady's finger (7.09 mg kg^{-1}) followed by cucumber (4.41 mg kg^{-1}), long bean (4.46 mg kg^{-1}), pointed gourd (3.56 mg kg^{-1}) and teasel gourd (4.12 mg kg^{-1}) respectively. Weng *et al.,* (2008 c) also stated that uptake of exogenous iodine by vegetables controlled by intensity of iodine fertilizer application and individual characteristics of plant. The value of iodine content in crop varies depending upon the sites. Highest iodine content was recorded in lady's finger (7.09 mg kg^{-1}), cucumber (4.41 mg kg^{-1}) and pointed gourd (3.56 mg kg^{-1}), grown in upper Brahmaputra valley while in long bean (4.47mg kg^{-1}) and teasle gourd (4.12 mg kg^{-1}) iodine content was found more in Lower Brahmaputra valley. The result correlated with the iodine content in soil.

Table 3b represents the iodine content in *Rabi* crops *i.e.* Spinach (*Spinacia oleracea*), Cabbage (*Brassica oleracea*), Raddish (*Raphanus sativus*) and Brinjal (*Solanum melongena)* grown under agro forestry. It was recorded that iodine content in different crops ranged from 4.12 mg kg^{-1} to 11.10 mg kg^{-1}. Among the different crops collected from different agroforestry regions cabbage (11.10 mg kg^{-1}) showed highest iodine content followed by Spinach (7.25 mg kg^{-1}), Raddish (6.88 mg kg^{-1}) and Brinjal (5.81mg kg^{-1}). Weng *et al.,* (2008 c) also reported that the total uptake of iodine by leafy vegetables was 50-70 folds higher than fruit vegetables. Results also revealed that iodine content was comparatively more in rabi crops (7.25 mg kg^{-1}) than kharif crops (7.09 mg kg^{-1}) in Upper Brahmaputra valley zone. Likewise, the highest value of iodine was observed in cabbage (11.10 mg kg^{-1}) grown in Lower. Brahmaputra valley zone and lowest in hill zone (7.98 mg kg^{-1}). Iodine uptake also varied between the same species grown on different agro climatic zones of Assam. Koustras *et al.,* (1985) stated that quantity of iodine content may be varied on geographical location. Total and available iodine content in soil also showed significant variance depending upon the soil type.

Conclusion: Results concluded that, both total and available iodine content in the soil differs in different agro climatic zones of Assam. Upper Brahmaputra valley zone recorded highest value and lowest was observed in hill zone. Iodine concentration in different agro forestry crops studied both *Rabi* and *Kharif* season showed considerable variation in the iodine concentration. Some crops have greater ability to concentrate iodine in their tissues. *Rabi* crops showed remarkably more iodine content than *Kharif* crop. Screening of these crops grown and consumed in regions of different agro climatic zones for their iodine content is of nutritional importance which may help to manage the risk of Iodine deficiency disorder.

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