Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-6: 1819-1826

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Special Issue-6 pp. 1819-1826
Journal homepage: http://www.ijcmas.com

Original Research Article

Influence of Soil and Foliar Application of Potassium Iodate (KIO3) on Nutrient Status of Soil

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A B S T R A C T

A field experiment was conducted during *kharif* 2014-15 in the farmer's field at Agadi village (Taluk: Hubli) in Dharwad district. The main objective of this work was to determine the effect of soil and foliar application of potassium iodate (KIO_3) on available macronutrients, DTPA extractable micronutrients and water soluble iodine content of experimental soil after the harvest of chilli. The experiment was carried out using different doses (5 or 10 mg/ kg to soil or 0.2 or 0.3 percent), methods (soil or foliar) and time of application (60 and 90 DAT) of KIO_3. The results obtained showed that available nitrogen was lowest (233.04 kg ha^{-1}) in treatment which received two sprays of 0.3 per cent KIO_3 and at par with treatments T_6, T_{11} and T_3, lowest available phosphorus (23.40 kg ha^{-1}) was recorded in the treatment (T_{11}) that received soil (10 mg kg^{-1}) plus foliar application (0.2%) of KIO_3 which was closely followed by T_4, T_5 and T_6 treatments, with regards to potassium all the treatments including control recorded higher available K in soil at harvest than initial value. With respect to DTPA extractable micronutrients Fe, Mn and Cu contents was significantly influenced by soil and foliar application of potassium iodate (KIO_3) except available Zn. Water soluble iodine content in soil increased with the increase in iodine concentration in soil. The treatments which received only soil application of KIO_3 (T_2 and T_3) as well as those treatments which received soil + foliar spray application of KIO_3 recorded higher residual iodine content in soil compared to initial value (1.68 mg/kg).

Keywords

Potassium iodate, Chilli, Water soluble iodine

Introduction

Iodine, one of the most important essential mineral element for human and animal health and at present is of much interest in nutritional research. The low consumption of iodine rich foods, the paucity of this element in cultivated soils, absence of iodine in the drinking and irrigation waters, strong fixation of this element by the soil organic matter coupled with lack of adequate enrichment in finished foods (Zhang *et al.*, 2002) cause iodine deficiency disorders [IDD]. Today one third of the human population were suffering from IDD. Its major manifestations are goitre, mental defects, still birth, miscarriages, weakness and paralysis of muscles.

In order to counteract iodine deficiency, its supplementation through iodised table salt is an efficient way of introducing this micro element into human diet. Commercial table salt contains 30 mg of iodine/kg of salt (0.003%) supplemented through potassium iodate (KIO_3). But excessive consumption of salt may lead to increased occurrence of cardiovascular diseases. To meet daily iodine requirements of body, the recommended iodine intake as per World Health Organization (WHO) is 150 µg for adults, for children 50 to 90 µg and for pregnant and lactating women is 200 µg. The average salt intake should be around 10 gms/day/person. It is observed that about 20 per cent of iodine present in salt is lost during cooking, another 20 per cent is lost during transportation and another 10 per cent is lost by exposure to light, heat and moisture, amounting to a total loss of 50 per cent. However in certain countries iodization of common salt is inefficient due to infrastructure or cultural problems.

Iodine concentration in soils, particularly mountainous areas and flood plains contain very low amount of iodine, it is estimated to be between 1.55-12.93mg/kg (Huan *et al.*, 2013) which negatively affect the iodine content of crops. Apparently to enrich iodine in edible plant food use of iodine carriers viz., potassium iodate (KIO_3) and potassium iodide (KI) through foliar sprays is an attractive approach for producing iodised foods through Biofortification.

Biofortification refers to the way of improving plant food nutritional quality and defined as the process of raising the concentration of Bioavailable essential elements in the edible parts of crops through plant breeding and agronomic biofortification.

Chilli occupies an important place in Indian diet it is indispensable item in the kitchen consumed daily as condiment in one or the other form. Iodised chilli powder can reduce salt intake to some extent and meet normal iodine requirement of the body.

Information on the content of improving iodine in chilli powder and its biofortification through foliar and soil application of iodine carriers is lacking. Further seldom researches have been conducted regarding the translocation, transformation, distribution of iodine from soil to plants as well as on residual status of soil. Hence present investigation is planned to study the impact of soil and foliar application of potassium iodate on available macro nutrients, DTPA extractable micro nutrients and water soluble iodine status in a soil.

Materials and Methods

A field experiment was conducted during *kharif* 2014-15 in the farmer's field at Agadi village (Taluk: Hubli) in Dharwad district to study the effect of soil and foliar application of potassium iodate KIO_3 on soil nutrient status at harvest. The soil of the experimental site was medium black with clay in texture, organic carbon 6.60g/kg, neutral in pH 7.20 and available N,P_2O_5 and K_2O were 175.6,17.44 and 268kg/ha respectively and the DTPA extractable micronutrients were sufficient. The initial Water soluble iodine content in the sample was 1.68 mg/kg. The experiment was laid out in complete randomized design with thirteen treatments and three replications. The treatment details are given in Table 1.

Transplanting

One month old chilli (Cv. Dyavnur) seedlings were transplanted in the main field. Two seedlings were planted per hill at 75 cm x 75 cm spacing. Gap filling was done within a week after transplanting wherever necessary in all the plots.

Fertilizer application

Nitrogen was supplied partly through DAP and urea while the entire doses of P and K were supplied through DAP and muriate of potash respectively.

Nitrogen was applied in two split doses, basal dose of 50 per cent at the time of transplanting and remaining half dose at 45 days after transplanting. The fertilizers were applied in ring method and mixed with soil.

KIO_3 application

Potassium iodate salt (KIO_3) was mixed with soil to get 5 mg kg^{-1} and 10 mg kg^{-1} dosage (53.33 mg and 106.66 mg of potassium iodate were mixed with 10 kg soil separately for each plot, respectively) a three days before application to soil.

The potassium iodate mixed with soil earlier was applied in ring method on 45^{th} day after transplanting to each plot.

Foliar application of potassium iodate

Potassium iodate was dissolved in water to get 0.2 per cent (0.2 g /100 ml) and 0.3 per cent (0.3 g /100 ml) concentration and sprayed on 60^{th} and 90^{th} day after transplanting as per the treatment details.

Collection and preparation of soil samples

Soil samples were collected from a depth of 0-20 cm from each treatment after the final picking stage.

The collected soil samples were shade dried, ground in wooden pestle and mortar, sieved (2 mm) and mixed thoroughly to get a composite soil sample for analysis. Details of the methods followed are given in Table 2.

Water soluble iodine analysis in soil sample

Take ten grams of 2mm sieved soil into 250 ml conical flask, add 100ml of distilled water and shake for 2hrs and keep it for overnight. Filter and collect the filterate upto 60 ml in 100 ml beaker. Quantification of the extracted iodine was made by titrating it against 0.01 N sodium thiosulphate solution with starch solution as indicator Weng *et al.,* (2013).

Results and Discussion

Available nitrogen

Significant differences existed between treatments due to soil and foliar application of potassium iodate with respect to available nitrogen status in soil at final picking stage. Available nitrogen was lowest (233.04 kg ha^{-1}) in treatment which received two sprays of 0.3 per cent KIO_3 and at par with treatments T_6, T_{11} and T_3 which recorded 234.28, 237.12 and 242.00 kg $ha^{-1}$of available nitrogen.

Low available nitrogen in these treatments might be due to greater uptake of N by plants because of high dry matter yield. Due to foliar spray of KIO_3 on 60 and 90 DAT, there was increased absorption of K directly by leaves and fruits, which led to increased concentration of K in plants. In order to maintain a stable and optimum N/K ratio in plants, plants might have taken more N from soil leading to reduced available N in soil. Treatments which received two foliar sprays recorded lower available N in soil than those which received one spray at 90 DAT. This was attributed to greater uptake of N in the former treatments because of increased K supply through KIO_3 (18% K in KIO_3) than in the latter treatments. Control (T_1) recorded highest available N in soil at harvest compared to other treatments. Since control treatment received only recommended dose of fertilizers, there was a balanced uptake of NPK nutrients by plants and fairly a constant ratios between N, P and K might have been maintained. But in other treatments applied K through KIO_3 has resulted in increased N uptake by plants to maintain a constant ratio of N/K in plants. This has resulted in low available N in soil at harvest in KIO_3 applied treatments.

Finally all the treatments recorded higher available N in soil at harvest when compared to initial value (175.6 kg ha^{-1}). This was because of recommended dose of N (150 kg ha^{-1}) applied through fertilizers and FYM applied to soil.

Available phosphorus

Similar to N status available phosphorus status was also significantly influenced by the application of KIO_3. Lowest available phosphorus (23.40 kg ha^{-1}) was recorded in the treatment (T_{11}) that received soil (10 mg kg^{-1}) plus foliar application (0.2%) of KIO_3 closely followed by T_4, T_5 and T_6 treatments but on par with each other. Low available P in soil at harvest might be due to increased absorption of P by plants to maintain a balanced N/P ratio in plants. Control (T_1) treatment recorded highest available P in soil.

All the treatments recorded higher available P in soil at harvest when compared to initial value (17.44 kg ha^{-1}). This is obvious because of recommended dose of NPK fertilizers applied in all the treatments along with FYM. Further all the applied P might not have been taken up by the plants and the organic acids liberated during decomposition of FYM might have solubilised P bearing minerals leading to release of P in soil thus increasing available P in soil. Patel (2014) reported higher values of available P in soil due to foliar application of mono potassium phosphate (MKP).

Available potassium

Data presented in Table 3 indicated that significant difference existed between treatments with regard to available potassium content in soil. Lowest available K (295.82 kg ha^{-1}) was registered in treatment (T_3) which received 10 mg kg $^{-1}$ of KIO_3 application to soil. This was mainly because of increased uptake of K by plants as chilli plants need more K for red colour synthesis.

Further, chilli is an indeterminate and exhaustive crop requires more K during flowering. Hence, there was greater uptake of K by plants. Treatments which received foliar spray of KIO_3 (0.2 or 0.3%) either alone (T_4 and T_5) or in combination with soil application (T_6 to T_{13}) recorded higher available K in soil compared to treatments (T_2 and T_3) which received only soil application of KIO_3.

Higher available soil K in foliar applied treatments was due to direct absorption of K by leaves and fruits supplied through KIO_3. Potassium supplied through foliar application might have met some K requirements of plants at 60 and 90 DAT. Consequently uptake of K by plant roots might have been reduced leading to increased available K in soil.

Finally all the treatments including control recorded higher available K in soil at harvest than initial value (268 kg ha^{-1}). This was because of recommended potassium applied to all the treatments through fertilizers. Results of available K closely agree with the values reported earlier by Somimol (2012).

Table.1 Treatment details

T_1	Control (water spray at 60 and 90 DAT)
T_2	KIO_3 soil application @ 5 mg/kg at 45 DAT
T_3	KIO_3 soil application @ 10mg/kg at 45 DAT
T_4	KIO_3 0.2% foliar spray at 60 and 90 DAT
T_5	KIO_3 0.3% foliar spray at 60 and 90 DAT
T_6	KIO_3 soil application @ 5 mg/kg at 45 DAT + 0.2% KIO_3 foliar spray at 60 and 90 DAT
T_7	KIO_3 soil application @ 5 mg/kg at 45 DAT + 0.2% KIO_3foliar spray at 90 DAT
T_8	KIO_3 soil application @ 5 mg/kg at 45 DAT + 0.3% KIO_3 foliar spray at 60 and 90 DAT
T_9	KIO_3 soil application @ 5 mg/kg at 45 DAT + 0.3% KIO_3 foliar spray at 90 DAT
T_{10}	KIO_3 soil application @ 10mg/kg at 45 DAT + 0.2% KIO_3 foliar spray at 60 and 90 DAT
T_{11}	KIO_3soil application @ 10mg/kg at 45 DAT + 0.2% KIO_3 foliar spray at 90 DAT
T_{12}	KIO_3 soil application @ 10mg/kg at 45 DAT + 0.3% KIO_3 foliar spray at 60 and 90 DAT
T_{13}	KIO_3 soil application @ 10mg/kg at 45 DAT + 0.3% KIO_3 foliar spray at 90 DAT

Note: RDF 150:75:75 kg N, P_2O_5, K_2O /ha respectively + FYM (25t/ha) is common for all the treatments.
DAT: Days after transplanting
KIO_3: Potassium iodate

Table.2 Methods employed for the analysis of soil samples

Sl. No.	Properties	Methods employed	Reference
Methods employed for the analysis of soil samples			
A.	**Physical properties**		
1	Particle size analysis	Hydrometer method	Piper (2002)
2	Bulk density	Clod method	Black (1965)
3	Particle density	Pycnometer method	Piper (2002)
B.	**Chemical properties**		
1	pH_w (1:2.5 soil water ratio)	Potentiometric method	Sparks (1996)
2	Electrical conductivity (1:2.5 soil water ratio)	Conductometric method	Sparks (1996)
3	Cation exchange capacity	Sodium saturation method	Jackson (1967)
4	Organic Carbon	Walkley and Black's wet oxidation method	Sparks (1996)
5	Available Nitrogen	Alkaline potassium permanganate method	Subbiah and Asija (1956)
6	Available Phosphorus	Olsen's method	Sparks (1996)
7	Available Potassium	Flame photometer method	
9	DTPA extractable Zn, Fe, Mn and Cu	DTPA extraction method followed by Atomic Absorption Spectrophotometer method	Lindsay and Norvell (1978)
C.	**Method for iodine estimation**		
1.	Water soluble iodine	Titrimetric method	Weng *et al.*,(2013)

Table.3 Effect of soil and foliar application of potassium iodate (KIO_3) on the available macronutrients status in experimental soil after harvest of chilli

Treatments	Nitrogen	Phosphorus (P_2O_5)	Potassium (K_2O)
	kg /ha		
T_1	250.67	31.62	310.12
T_2	249.79	30.27	313.12
T_3	242.00	27.55	295.82
T_4	240.67	25.43	303.28
T_5	233.04	25.39	305.96
T_6	234.28	23.44	298.52
T_7	249.67	30.35	305.15
T_8	247.11	26.33	303.47
T_9	248.32	29.25	309.30
T_{10}	249.00	30.67	306.19
T_{11}	237.12	23.40	305.13
T_{12}	244.19	29.18	306.32
T_{13}	246.24	28.20	307.13
S. Em ±	3.69	0.73	1.75
CD (0.05)	10.79	2.15	5.11
Initial values	**175.6**	**17.44**	**268.0**

Table.4 Effect of soil and foliar application of potassium iodate (KIO_3) on DTPA extractable micronutrients and water soluble iodine content of experimental soil after the harvest of chilli

Treatments	Fe	Zn	Mn	Cu	I*
	mg kg^{-1}				
T_1	2.09	0.53	10.98	0.98	0.44
T_2	2.00	0.51	10.83	0.96	2.33
T_3	1.93	0.48	9.99	0.91	2.91
T_4	1.79	0.42	10.37	0.95	0.61
T_5	1.78	0.41	10.30	0.94	0.72
T_6	1.69	0.42	10.00	0.96	2.66
T_7	1.97	0.52	10.90	0.94	2.48
T_8	1.76	0.49	10.56	0.96	2.80
T_9	1.83	0.51	10.79	0.93	2.63
T_{10}	2.02	0.51	10.87	0.97	3.19
T_{11}	1.63	0.40	10.59	0.97	2.97
T_{12}	1.93	0.51	10.85	0.95	3.07
T_{13}	1.94	0.50	10.81	0.94	2.98
S. Em ±	0.025	0.35	0.09	0.005	0.03
CD (0.05)	0.074	NS	0.27	0.015	0.09
Initial	**3.09**	**0.64**	**12.3**	**1.2**	**1.68**

NOTE: '*'water soluble iodine of experimental soil after the harvest of chilli

Micronutrients

Available iron

The available iron content in soil was significantly influenced by potassium iodate application. Application of KIO_3 to plants either through soil or foliar spray resulted in higher uptake of iron from soil. This has resulted in low iron content in soil at harvest when compared to initial value (3.09 mg kg^{-1}) as well as control (2.09 mg kg^{-1}).

Available zinc

Application of KIO_3 did not significantly influence residual zinc content in soil at harvest. This implied that neither potassium nor iodate ion of KIO_3 has effect on zinc uptake by plants irrespective of the dose method and time of application of KIO_3. However all the treatments recorded lower zinc content in soil at harvest than critical value (0.64 mg kg^{-1}). Results pertaining to zinc content in soil at harvest closely agree with the findings of Somimol (2012).

Available manganese

The available manganese content was significantly influenced by soil and foliar application of potassium iodate (KIO_3). Lowest available manganese (9.99 mg kg^{-1}) was due to soil application of KIO_3 at 10 mg kg^{-1} (T_3) that received. This might be because of higher dry matter yield that resulted in higher uptake by plants leading to low manganese content in soil. Data presented in Table 4 showed irrespective of the doses (5 or 10 mg/ kg to soil or 0.2 or 0.3 percent) methods (soil or foliar) and time of application (60 and 90 DAT) of KIO_3, the manganese content in soil did not varied much when compared to control (10.98 mg/ kg) which has not received KIO_3 application. Finally all the treatments recorded lower manganese content in soil at harvest than initial value (12.3 mg/kg).

Available copper

The available copper content was significantly influenced by KIO_3 application. Available copper content in soil at harvest ranged from 0.91 to0.98 mg kg^{-1}. All these treatments recorded lower copper contents in soil was lower than (1.2 mg/kg of initial value).

Water soluble iodine (mg kg^{-1})

Water soluble iodine content in soils was significantly influenced by soil and foliar application of potassium iodate (KIO_3). Highest iodine content (3.19 mg kg^{-1}) recorded in treatment (T_{12}) which received soil application (10 mg kg^{-1}) along with foliar spray of KIO_3 at 0.3 per cent concentration on 60 and 90 DAT and significantly superior over all other treatments. While lowest iodine content was recorded in control (T_1) 0.44 mg kg^{-1}. This is obvious because lack of application of KIO_3 in this treatment. It was observed that, water soluble iodine content in soil increased with the increase in iodine concentration in soil. Data clearly highlighted that, treatments which received only soil application of KIO_3 (T_2 and T_3) as well as those treatments which received KIO_3 application through soil and foliar spray recorded higher residual iodine content in soil compared to initial value (1.68 mg/kg). (Muramatsu *et al.*, 1990) reported that, iodine uptake by plants is mainly dependent on the availability of iodine in the soil and this mechanism is mainly governed by adsorption desorption processes in soil He also stated that, the decreased rates of available iodine in soil might be due to substantial iodine volatilization. Further, Whitehead (1978) reported that, other potential iodine sinks may be the microbial formation of organoiodides, the fixation of iodine into the soil organic matter as well as its adsorption on iron and aluminium oxides.

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