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EFFECT OF SOIL ZINC LEVEL ON PHYSIOLOGICAL ATTRIBUTES AND MAJOR BIOCHEMICAL CONSTITUENTS OF BASMATI RICE *CV* B-370

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ABSTRACT
Effect of different levels of zinc (Zn) in 20 different basmati growing soils of two different blocks of Jammu maintained with nitrogen (N), phosphorous (P) and potassium (K) with Zn sulphate treatments @ 0 , 10, 20 and 30 kg ha^{-1} was tested to assess the response of Zn on various physiological and biochemical constituents in basmati B-370 rice. For the physiological properties in Bishna block the maximum grain yield and dry matter yield (DMY) of 51.7 and 40.1 g pot^{-1} and in R.S.Pura 47.5 and 41.2 g pot^{-1} were observed, the maximum Zn in grain, Zn in culm and Zn in soil after harvest were 6.8, 22.4 and 1.8 mg kg^{-1} in Bishna and 8.6, 22.0 and 1.9 mg kg^{-1} in R.S.Pura were observed in treatment with Zn sulphate @ 30kg ha^{-1}. For the biochemical constituents in Bishna, the maximum total sugar, starch and soluble protein of 6.23, 75.99 and 8.03 percent and 6.95, 75.80 and 8.80 percent in R.S. Pura were observed in treatment with Zn sulphate @ 20 kg ha^{-1}. The physiological and biochemical constituents were observed to improve proportionally with an increase in Zn supply, however higher doses i.e. Zn sulphate 30 kg ha^{-1} registered a negative effect on the biochemical constituents.

INTRODUCTION

In plants, Zn acts as a functional, structural or regulatory co-factor. More than 70 different metallo-enzymes containing Zn has been identified which occur in all of the six classes of enzymes namely oxidoreductases, transferases, lyases, isomerases and ligases (Barak and Helmke, 1993). According to Srivastrava and Gupta (1996), it has a vital role in many important enzyme systems including, carbonic anhydrase (transport of CO_2 in photosynthesis), several dehydrogenases: alcohol dehydrogenase, glutamic dehydrogenase, L-lactic dehydrogenase, malic dehydrogenase, D glyceraldehyde-3-phosphate dehydrogenase, D-lactate dehydrogenase, aldolase carboxypeptidase, alkaline phosphatase, superoxide dismutase (converting superoxide radicals to hydrogen peroxide and water), RNA polymerase (protein synthesis), ribulose bi-phosphate carboxylase (important role in starch formation) and phospholipase (Alloway, 2008).

As a group, cereal crops are generally sensitive to Zn deficiency and have low (e.g. 20 mg kg^{-1}) grain Zn concentration. Cereals were chosen as the cornerstone of the green revolution (Alloway, 2008), this effort involved not only new, high-yielding varieties, but the use of much more doses of N and P fertilizers tended to decrease plant Zn uptake from soil and reduces its mobility within plants (Wissuwa *et al*., 2007; Welch *et al*., 1982). The north-western hills of Jammu and Kashmir suffer severely due to intensive soil erosion which is more than 20t ha^{-1} each year (Singh *et al*., 1997) which causes a huge loss of the fertility and nutrient content of the soil. The deficiency of some micronutrients especially Zn in particular, is becoming more conspicuous in some areas (Mondal *et al*., 2006a, 2006b). The soils of Jammu district show Zn deficiency and the available Zn content in these soils ranged between 0.1 to 0.61 mg kg^{-1}. Singh (2009) in his studies found that 12.0 % of the total samples from J&K were deficient in Zn where as 48.8 % samples from around India were deficient in zinc. Basmati rice grown in Bishna and R. S. Pura blocks contribute majorly in the economy of J&K state. The basmati growing areas of Jammu region have also been found to be Zn deficient (Ali, 2011; Mondal *et al*., 2006a,2006b; Jalali and Sharma, 2001; Jalali *et al*., 2002).

Rattan *et al*. (2008) reported that an average response of 760 kg ha^{-1} while as Patel (2011) reported similar but slightly less response of rice to Zn fertilization. Shukla and Behera (2012) predicted an increase of 11.68 million tons in rice due to Zn fertilization which can certainly help in increasing the productivity rate of rice in India. Therefore the present study was aimed to access the response of different levels of Zn treatments on various physiological and biochemical constituents on basmati (*Cv* basmati 370) in Jammu district.

MATERIALS AND METHODS

Analysis of soil and application of Zn in twenty soil samples in bulk from plough layer (0-20 cm) were collected from different basmati growing areas of Bishna and R. S. Pura block (10 each) respectively. The soils were analyzed for the various physico chemical properties following the standard procedures. Soil reaction (pH) of the samples were measured in 1:2.5 soil: water suspension with a digital glass electrode pH meter (Jackson 1973). Electrical Conductivity (EC) was determined by method given by Richards (1954). Walkley and Black's (1934) rapid titration method was used for determination of organic carbon (OC). The mechanical analysis of the soil samples was done by following the international Pipette method as described by Piper (1966). The international society of soil science textural triangle was used for determining the textural class. N was determined by method given by Subbiah & Asija (1956), P and K was determined by method given by Jackson (1973).

The experiment was conducted in polythene lined pots under open greenhouse conditions. The polythene lining was rinsed in 0.1N HCl followed by deionized water. Each pot was filled with 5kg of soil and six 30 days old basmati (var. basmati 370) were transplanted in each pot. A basal dose of N, P, and K were applied at the rate of 30:20:10 kg ha^{-1}. Half dose of N was applied at the sowing time and the remaining half at was applied at panicle initiation. Four treatments of Zn in the form of $ZnSO_4.7H_2O$ control (S1), 10 (S2), 20 (S3) and 30 kg ha^{-1} (S4) was applied and each treatment was replicated thrice. Watering with deionized water and intercultural operations like weed control, plant protection measures and gap filling were adopted uniformly in each pot as and when required (Anonymous, 2007). Supply of irrigation water was stopped one week before harvesting when signs of maturity appeared and was harvested at full maturity.

The plant samples after harvesting was first washed with tap water to remove soil residue and it was then sterilized with diluted HCl (0.001N) and then rinsed with distilled water to remove any contamination. Then the plant samples were dried for 10 days in the sun, and were placed in brown paper bags and dried at 60°C in a hot air oven till a constant weight was obtained. When dried and brittle, the samples were powdered in a thoroughly cleaned mechanical grinder. The total sugar and starch was determined following the methods of Dubios *et al*., (1951) and soluble protein was determined following the methods of Lowry *et al*., (1951). The grain and dry matter were weighed and then were digested in HNO_3:$HClO_4$:H_2SO_4 (10:4:1) (Jackson, 1973) on a hot plate and filtered. DTPA Zn in soil was determined following the methods of Lindsay and Norvell, (1978). Zn estimation in grain, culm and soil was done with the help of flame atomic adsorption spectrophotometer (AAS) model Z.2300 (Hitachi, Japan).

RESULTS AND DISCUSSION

Soil analysis

The results of the physico-chemical properties of Bishna and R. S. Pura block are given in (Table 1). In Bishna and R.S.Pura blocks the value of pH ranged from between 6.03-7.45 and 6.20-7.56 with an average value of 6.83 and 6.93. The soils exhibited near neutral to slightly alkaline reaction. The amount of OC ranged between 4.80-7.60 and 5.40-6.90 with an average value of 6.04 and 6.27 g kg^{-1}. The EC ranged between 0.14-0.41 and 0.13-0.38 with an average value of 0.28 and 0.29 dS m^{-1} with the soils being non saline in nature. The mechanical separate percentage revealed that the sand content ranged from 29.30-46.40 and 28.50-46.60 with an average value of 36.68 and 38.59 %. The silt content ranged between 22.20-32.80 and 22.10-36.30 with an average value of 28.35 and 28.49 %. The clay content ranged between 26.30-39.00 and 26.10-39.00 with an average value of 33.98 and 32.93 %. The divergent textural classes of the soils were noted from

Table 1: Physio chemical properties of Bishna and R.S.Pura block

Locations BlockBishna	pH	EC (dSm^{-1})	OC (gkg^{-1})	Mechanical separates Sand %	Silt %	Clay %	N Kg ha^{-1}	P	K	Zn mg kg^{-1}
Range	6.03-7.45	0.14-0.41	4.80-7.60	29.30-46.40	22.20-32.80	26.30-39.00	120.5-194.9	6.17-10.97	62.6-111.2	0.38-0.69
Mean	6.83	0.28	6.04	36.68	28.35	33.98	168.4	8.43	85.8	0.57
R. S. PuraRange	6.20-7.56	0.13-0.38	5.40-6.90	28.50-46.60	22.10-36.30	26.10-39.00	161.2-226.4	7.01-9.91	91.7-111.1	0.44-0.65
Mean	6.93	0.29	6.27	38.59	28.49	32.93	186.4	8.59	104.0	0.56

Table 2a: Physiological properties of basmati rice of Bishna block

Village name of Bishna	Grain yieldg pot^{-1}				DMY yield g pot^{-1}				Zn in grain mg kg^{-1}				Zn in culm mg kg^{-1}				Zn in soil after harvest mg kg^{-1}			
block	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Kulle	17.5	30.5	44.3	46.2	19.8	22.3	32.5	33.5	2.1	4.2	5.1	6.2	9.4	12.5	19.6	22.4	0.1	0.7	1.2	1.7
Dhinda	17.7	32.3	42.1	43.1	20.2	23.5	34.7	34.9	2.0	3.5	4.6	6.3	6.2	11.4	16.9	19.3	0.2	0.5	0.6	1.6
Bishnah	18.2	33.3	48.2	49.1	21.2	22.7	35.7	36.2	2.1	4.0	5.1	6.0	6.5	14.2	16.2	18.4	0.1	0.9	1.1	1.4
BanChak	19.7	35.7	47.5	46.2	19.6	23.5	37.8	38.5	1.8	4.4	5.0	5.7	8.8	13.6	15.8	17.8	0.4	0.4	1.0	1.7
Deoli	19.2	37.3	49.2	51.7	19.3	24.3	39.2	40.1	2.2	3.6	5.0	6.1	7.7	13.2	15.6	17.3	0.2	0.6	1.0	1.5
Kool	17.2	37.3	48.5	50.5	20.1	21.5	33.4	35.2	2.5	4.0	5.4	6.6	7.9	14.1	16.6	18.5	0.5	0.8	1.4	1.6
Chak Majra	17.2	31.2	44.5	45.2	20.3	24.6	35.2	33.5	2.0	4.2	5.1	6.0	6.5	10.5	13.5	16.8	0.4	0.9	1.1	1.8
Chorli	14.3	28.5	45.2	46.7	23.1	23.5	39.5	38.3	2.3	4.0	4.7	5.4	7.2	14.2	17.1	19.9	0.3	0.7	0.7	1.4
Dabbar	18.5	34.2	42.7	43.5	19.5	24.2	38.2	37.5	1.9	3.5	5.1	6.8	6.0	8.6	12.9	16.5	0.4	0.5	1.1	1.8
Daali	17.2	37.5	42.5	44.2	19.3	23.7	36.2	37.5	1.7	4.4	5.2	6.0	6.4	10.5	13.2	15.8	0.2	0.4	1.2	1.7
Mean	17.6	33.7	45.4	46.6	20.2	23.3	36.2	36.5	2.1	4.0	5.0	6.1	7.3	12.3	15.7	18.3	0.3	0.6	1.0	1.6
Range	14.3-19.7	28.5-37.5	42.1-49.2	43.1-51.7	19.3-23.1	21.5-24.6	32.5-39.5	33.5-40.1	1.7-2.5	3.5-4.4	4.6-5.4	5.4-6.8	6.0-9.4	8.6-14.2	12.9-19.6	15.8-22.4	0.1-0.5	0.4-0.9	0.6-1.4	1.4-1.8

$ZnSO_4.7H_2O$: 0 (S1), 10 (S2), 20 (S3) and 30 kg ha^{-1} (S4)

Table 2b: Physiological properties of basmati rice of R.S. Pura block

Village name of Bishna block	Grain yield g pot^{-1}				DMY yield g pot^{-1}				Zn in grain mg kg^{-1}				Zn in culm mg kg^{-1}				Zn in soil after harvest mg kg^{-1}			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Tinda	17.3	33.3	44.5	45.2	19.9	21.3	34.3	35.7	2.4	4.5	5.2	6.5	6.9	10.9	14.1	17.4	0.6	1.2	1.5	1.9
Rattian	17.3	30.5	43.5	45.2	21.3	25.7	35.2	34.5	1.9	3.8	4.7	6.4	6.9	12.7	15.3	18.6	0.4	0.8	1.2	1.4
Kir Pind	16.3	31.2	42.5	43.7	20.4	23.7	40.7	40.2	2.8	4.0	4.7	6.0	5.1	12.3	14.5	18.4	0.3	0.6	1.1	1.6
Mahlawal	17.2	31.1	40.2	42.7	16.8	23.7	40.1	41.2	2.1	4.5	6.2	8.2	4.9	11.1	14.9	17.4	0.1	0.5	1.2	1.7
Tanda	19.7	34.3	38.5	40.3	15.5	25.7	39.7	39.3	2.6	4.7	6.7	8.6	6.8	10.4	13.0	15.5	0.3	0.7	1.2	1.6
Kotli Shah	17.2	36.5	42.5	43.8	16.2	22.7	33.5	32.7	2.9	3.8	4.8	5.0	6.2	10.2	13.7	16.9	0.4	0.9	1.4	1.8
Mahlawal	15.3	34.5	41.2	43.1	18.2	24.3	37.2	36.7	2.5	3.9	4.5	5.0	6.3	13.1	16.8	19.0	0.5	0.9	1.2	1.5
Tikrian	18.5	34.2	44.5	45.7	19.2	25.7	31.1	38.2	2.8	3.7	4.1	5.4	6.8	11.7	14.6	16.7	0.3	0.7	1.1	1.4
Banota	19.5	30.1	45.2	47.5	19.8	21.5	37.6	39.5	2.3	4.2	5.8	7.2	6.1	13.4	19.9	22.0	0.3	0.8	1.3	1.6
Langarwal	17.2	34.5	44.5	43.7	20.3	26.5	37.5	36.2	2.5	3.9	4.7	6.7	6.5	14.9	18.4	21.7	0.5	0.9	1.4	1.7
Mean	17.5	33.0	42.7	44.0	18.7	24.0	36.6	37.4	2.5	4.1	4.9	6.7	6.3	12.1	15.5	18.4	0.4	0.8	1.3	1.6
Range	15.3-19.7	30.1-36.5	38.5-45.2	40.3-47.5	15.5-21.3	21.3-26.5	31.1-40.7	32.7-41.2	1.9-2.9	3.7-4.7	4.7 6.7	5.0-8.6	4.9-6.9	10.2-14.9	13.0-19.0	15.5-22.0	0.1-0.6	0.5-1.2	1.1-1.5	1.4-1.9

$ZnSO_4.7H_2O$: 0 (S1), 10 (S2), 20 (S3) and 30 kg ha^{-1} (S4)

Table 3a: Biochemical parameters of Bishna block

Treatment	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Parameters	Total sugar				Starch				Soluble protein			
Kulle	5.03	5.65	6.07	6.02	71.80	74.60	75.32	74.99	6.74	7.08	7.47	7.30
Dhinda	5.06	5.95	6.12	6.01	71.87	74.76	75.62	75.14	6.12	6.46	7.53	7.25
Bishnah	5.07	5.86	6.09	5.92	71.68	74.38	75.32	75.05	6.91	7.19	8.03	7.70
BanChak	5.15	5.7	6.23	5.77	71.89	74.36	75.43	73.95	5.62	6.12	7.42	7.02
Deoli	5.83	5.62	6.23	5.65	71.78	74.62	75.47	75.17	5.67	6.01	7.75	7.42
Kool	5.15	5.75	6.08	5.78	71.53	74.32	75.02	75.00	7.19	7.53	7.92	7.70
Chak Majra	5.19	5.71	6.11	5.89	71.30	73.12	75.99	75.86	6.18	6.40	7.70	7.57
Chorli	5.18	5.50	6.21	6.21	71.75	74.02	75.32	75.28	6.40	6.74	7.65	7.25
Dabbar	5.19	5.43	6.17	5.59	71.90	74.62	75.17	75.38	5.67	6.12	7.30	7.02
Daali	5.30	5.80	6.08	5.90	71.80	75.06	75.62	75.17	6.69	7.08	7.81	7.53
Mean	5.21	5.69	6.13	5.87	71.70	74.38	75.42	75.09	6.32	6.67	7.66	7.38
Range	5.03-5.83	5.43-5.95	6.07-6.23	5.59-6.21	71.30-71.90	73.12-75.06	75.02-75.99	73.95-75.86	5.62-7.19	6.01-7.53	7.30-8.03	7.02-7.70

$ZnSO_4.7H_2O$: 0 (S1), 10 (S2), 20 (S3) and 30 kg ha^{-1} (S4)

Table 3b: Biochemical Parameters of R.S.Pura Block

Treatment	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Parameters	Total sugar				Starch				Soluble protein			
Tinda	5.33	5.62	6.36	5.75	71.95	75.76	75.21	74.32	6.69	6.97	7.53	7.81
Rattian	5.37	5.72	6.08	5.80	71.50	75.32	75.80	74.14	5.96	6.46	7.92	8.37
Kir Pind	5.43	5.71	6.07	5.77	71.44	75.27	74.47	74.69	6.91	7.19	7.42	7.81
Mahlawal	5.41	5.67	6.41	5.80	71.22	75.21	75.80	74.63	5.90	6.29	6.97	7.25
Tanda	5.06	5.59	6.80	5.77	71.81	75.66	72.84	74.66	6.01	6.69	7.47	7.81
Kotli Shah	5.15	5.62	6.20	5.75	71.90	75.43	74.32	74.99	6.05	6.40	7.36	7.75
Mahlawal	5.18	5.68	6.23	5.77	71.83	75.17	74.33	74.80	5.90	6.52	7.02	7.30
Tikrian	5.31	5.81	6.66	5.92	71.16	75.14	73.46	74.85	6.12	6.46	7.53	7.81
Banota	5.43	5.62	6.05	5.72	71.48	75.46	74.32	74.43	5.96	6.57	6.91	7.25
Langarwal	5.36	5.65	6.95	5.50	71.96	75.47	74.63	74.75	5.66	6.76	8.80	7.19
Mean	5.30	5.67	6.38	5.76	71.60	75.40	74.50	74.6	6.12	6.63	7.49	7.64
Range	5.06-5.43	5.59-5.81	6.05-6.95	5.50-5.92	71.16-71.96	75.14-75.76	72.84-75.80	74.14-74.99	5.66-6.91	6.29-7.19	6.91-8.80	7.19-8.37

$ZnSO_4.7H_2O$: 0 (S1), 10 (S2), 20 (S3) and 30 kg ha^{-1} (S4)

sandy clay loam (SCL) to clay loam (CL) and the majority of soil samples were clayey loam in texture. These results are in close agreement with results reported by Singh and Mishra (2012) and Jalali *et al.* (1989). The availableN ranged from 120.5-194.9 and 161.2-226.4 with an average value of 168.4 and 186.4 kg ha^{-1}, the available P ranged between 6.17 - 10.97 and 7.01 – 9.91 with an average value of 8.43 and 8.59 kg ha^{-1} and the available K ranged between 62.6–111.2 and 91.7 – 111.1 with an average value of 85.8 and 104.0 kg ha^{-1}. The DTPA extractable Zn, ranged between 0.38 - 0.69 and 0.44-0.65 with an average of 0.57 and 0.56 mg kg^{-1}. DTPA extractable Zn was deficient in most of the areas this may be due to the intensive cropping pattern which has lead to the Zn deficiency in these basmati growing soils. Similar results have been reported by Jalali *et al*. (1989). According to Adriano (1986), Zn deficiency was not uncommon in paddy soils throughout Asia. Maximum of the soils were of clayey soils and Zn is predominantly bound to hydroxyl-Al interlayer's sandwiched between 2:1 vermiculite layers in the fine soil matrix and also Zn tends to associate with the ferromanganiferous mottles in paddy soils and also the clayey nature of the paddy soils in the study area would promote the formation of insoluble Zn in them which were also reported by Manceau *et al.* (2005).

Physiological attributes

Grain and dry matter yield (DMY)

The results of the physiological attributes of basmati rice are given in (Table 2a & 2b). Grain size is an important yield component which affects the weight of produce of cereals per unit area. All the Zn treatments showed a significant increase in grain yield and DMY. The treatment of Zn sulphate @ 30 kg ha^{-1} in both Bishna and R.S.Pura block gave the highest grain yield of 51.7 and 47.5 and DMY yield of 40.1 and 41.2 g pot^{-1}. The grain yield per plant in rice is associated with heterocyst due to panicle length, number of productive tillers per plant, no of grains per panicle and test weight, (Bodruzzaman *et al.*, 2002; Fageria and Baligar, 1999 and Nagesh *et al.*, 2012). Applying Zn promotes rice ear growth in anaphase. The number of seeded ears, the length and weight of ears and no of seeds increased significantly (Fageria *et al.*, 2011; Slaton *et al.*, 2005 and Muthukumararaja and Sriramachandrasekharan, 2012). Zinc application improved nutritional environment of rhizosphere as well as plant system as evident from greater uptake of nutrients and ultimately metabolic and photosynthetic activity, resulting in better development of yield attributes and yield. By comparing the four levels of Zn with each other it was found that both Zn sulphate @ 20 kg ha^{-1} and @ 30 kg ha^{-1} were significantly different from Zn sulphate @ control and @ 10 kg ha^{-1} and it can be stated that crop responded to the application of Zn sulphate at 20 kg ha^{-1} and it appeared to be an optimum level for rice crop as beyond this level the response was not significant (Keram *et al.*, 2014; Praneeth *et al.*, 2015 and Meena *et al.*, 2015)

Effect of Zn on the Zn content (mg kg^{-1}) of grain

The results showed that all the levels of Zn applied caused a significant increase of Zn in grain under control in both Bishna and R.S.Pura blocks. The highest Zn content in grain in Bishna and R.S.Pura block were 6.8 and 8.6 in treatment of Zn sulphate @ 30 kg ha^{-1}. The four levels of applied Zn were significantly different from one another showing the ability of Zn to enhance the availability of soil Zn which might be due to the improvement of enzymatic functions and the metabolic processes of the plant that increased Zn uptake in the plants. Similar results were reported by Devarajan and Ramanathan (1995, Srivastava *et al.*, (1999), Khan (2002), and Singh *et al.*, (1999).

Effect of Zn on the Zn content (mg kg^{-1}) of culm

The results revealed that all the levels of Zn applied showed a significant increase of Zn in culm over control in both Bishna and R.S.Pura blocks. The highest Zn content in culm in Bishna and R.S.Pura block were 22.4 and 22.0 in treatment of Zn sulphate @ 30 kg ha^{-1}. Application of Zn increased the Zn content of straw which might be owing to more vigor and greater root activity which favored the uptake of Zn. Similar results were reported by Tahir and Kausar (1994); Khan (2002) and Srivastava *et al.*, (1999).

Effect of Zn on the Zn content (mg kg^{-1}) of soil after harvest

The results regarding Zn content of soil after harvest of rice crop indicated that Zn treatments had a significant effect. The highest Zn content in soil after harvest in Bishna and R.S.Pura block were 1.8 and 1.9 in treatment of Zn sulphate @ 30 kg ha^{-1}. Zinc content showed a progressive increase in a linear pattern with an increase in Zn application which might be due to increase in available Zn by increasing Zn levels. However, the Zn content of soils was reduced at harvest time which was probably because of its uptake by plants or leaching and adsorption by soil particles. Similar results were observed by Srivastava *et al.*, (1999); Khan (2002) and Asad and Rafique (2002).

Biochemical constituents

Effect of Zn on the grain soluble protein (%) content

The results of the biochemical constituents of basmati rice are given in (Table 3a & 3b). Grain soluble protein was influenced by Zn application as it was noted that grain soluble protein content had a tendency to increase progressively with an increase in Zn levels, but the results also revealed that higher application of Zn had a tendency to decrease the nutritional value while a medium dose seems to be best. The highest content of grain soluble protein in Bishna and R.S.Pura block were 8.03 and 8.80 in treatment Zn sulphate @20 kg ha^{-1}. The mechanism by which Zn deficiency affects protein synthesis is considered due to a reduction in RNA and deformation and reduction of ribosomes. This was as at lower levels due to Zn deficiency and at higher levels due to Zn toxicity, the chlorophyll contents and net photosynthetic rates were significantly decreased and protein synthesis of rice was prevented as low Zn content soils forms auxins or indoleacetic acid (IAA) from tryptophan and ribonucleic acid synthesis, Abbas *et al.*, (2013); Sharma *et al.*, (2013); Hossain *et al.*, (2008); Vijayarengan (2012); Mishra (2012) and Nag *et al.*, (1981) reported similar results.

Effect of Zn on the grain total sugar (%) content

Grain total sugar content was influenced by Zn application, it was noted that grain total sugar content had a tendency to increase progressively with an increase in Zn levels, but the results also showed that higher application of Zn had a tendency to decrease the nutritional value while a medium dose seems to be best. The highest content of grain total sugar content in Bishna and R.S.Pura block were 6.23 and 6.95 in treatment Zn sulphate @ 20 kg ha^{-1}. Carbonic anhydrase is depressed as a result of Zn deficiency. Rabie *et al.* (1992) observed a decline in total sugar content with respect to the high levels of Zn which may be due to photo oxidative damage as a result of Zn stress, as Zn plays an role on the enzymatic reactions related to the cycles of carbohydrate catabolism or probably corresponded with the photosynthetic inhibition or stimulation of respiration rate. Pandey and Tripathi (2011) and Hemalatha *et al.* (1997) also reported similar results.

Effect of Zn on the grain starch (%) content

Zn application had a positive affected the starch content of grain as compared to control thus the grain starch content increased with the application of Zn fertilization but at higher levels the starch content went down (Table 3a and Table 3b). The highest content of grain starch content in Bishna and R.S.Pura block were 75.99 and 75.80 in treatment Zn sulphate

@ 20 kg ha^{-1}. This might be due to either decrease in formation or an increase in utilization of carbohydrates in tissue due to Zn toxicity. Similar results were observed by Rajub (1999); Khan (2002) and Khan *et al*. (2004).

REFERENCES

Abbas, M., Zahida, T. M., Uddin, R., Sajjid, I., Akhlaq, A., Moheyuddin, K., Salahauddin, J., Mari, A. H. and Panhwar, R. N. 2013. Effect of Zn and B fertilizers application on some physiochemical attributes of five rice varieties grown in agro-ecosystem of Sindh, Pakistan. *American Eurasian J. Agriculture and Environmental Science*. **13(4):** 433-439.

Adriano, D. C. 1986. Trace elements in the terrestrial environment. *Springer-Verlag.* New York.

Ali, A. 2011. Submergence effect on micronutrient availability in basmati growing soils of Jammu. *MSc. Thesis, SKUAST-Jammu, Chatha, Jammu, J&K.* (India).

Alloway, B. J. 2008. Zinc in Soils and Crop Nutrition. *IInd edition. IZA and IFA Brussels, Belgium and Paris, France.*

Anonymous. 2007. *Package of practices for kharif crops*, Directorate of extension, SKUAST-Jammu, Jammu, J&K, India.

Asad, A. and Rafiq, R. 2002. Effect of Zn, Cu, Fe, Mn and B on the yield components of wheat crop in tehsil Peshawar. *Pakistan J. Biological Science*. **3:**1615-1620.

Barak, P. and Helmke, P. A. 1993. The Chemistry of Zinc. Chap 1 in Robson, A.D. (ed.) *Zinc in Soils and Plants.* pp. 90-106.

Bodruzzaman, M., Sadat, M. A., Meisner, C. A., Hossain, A. B. S. and Khan, H. H. 2002. Symposium No 05, Paper no, 781, 17th WCSS, 14-21 Aug, Thailand.

Devarajan, R. and Ramanathan, G. 1995. Direct, residual and cumulative effect of applied zinc for rice in red soils. *Madras Agricultural J. India.* **82(2):** 90-92.

Dubios, M., Gilles, K., Hammilton, J. K., Robbers, P. A. and Smith, F. 1951. A colorimetric method for the determinatation of sugars. *Nature*. **168:** 167.

Fageria, N. K. Baligar, V. C. 1999. Growth and nutrient concentrations of common bean, lowland rice, corn, soybean, and wheat at different soil pH on an inceptisol. *J. Plant Nutrition*. **22:** 23-32.

Fageria, N. K., Dos Santos, A. B. and Cobucci, T. 2011. Zinc nutrition in lowland rice. *Communications in Soil Science and Plant Analysis*. **42:** 1719-1727.

Hemalatha, S., Anburaj, A. and Francis, K. 1997. Effect of heavy metals on certain biochemical constituents and nitrate reductase activity in *Orzya sativa* L. seedlings. *J. Environmental Biol*ogy. **18:** 313-319.

Hossain, M. A., Hannan, M. A. Talukder, N. M. and Hanif, M. A. 2008. Effect of different rates and methods of Zn application on the yield and nutritional qualities of rice cv. BR11. *J. Agro forestry and Environment*. **2(1):** 1-6.

Jackson, M. L. 1973. Soil chemical analysis: Advanced course. *The author, Madison, Wisconsin, USA.*

Jalali, V. K. and Sharma, M. P. 2001. Status of available micronutrients cations in soils of mid-hill intermediate zone of Jammu region. *Indian J. Agricultural Science*. **72:** 616-618.

Jalali, V. K., Sharma, R. K. and Koul, R. K. 2002. Soil characteristics and nutrient indexing of mango orchids of Jammu region (J&K state). *J. Research, SKUAST-J.* **1:**143-149.

Jalali, V. K., Talib, A. R. and Takkar, P. N. 1989. Distribution of micronutrients in some benchmark soils of Kashmir at different altitudes. *J. the Indian Society of Soil Science*. **37:** 465-469.

Keram, K. S. Sharma, B. L. Kewat, M. L. and Sharma, G. D. 2014. Effect of zinc fertilization on growth, yield and quality of wheat grown under agro-climatic condition of kymore plateau of Madhya Pradesh, India. *The Bioscan*. **9(4):** 1479-1483.

Khan, M. U. Qasim, M. and Jamil, M. 2004. Effect of Zn on starch content of paddy and Zn content of soil, leaf and root of rice growth in calcareous soils. *International J. Agricultural and Biology*. **6(6):** 1132-1135.

Khan, M. U. 2002. Yield and quality of rice (Oryza sativa L.) as affected by different levels and methods of zinc application. *PhD. thesis, Gomal University, D.I.Khan* (Pakistan).

Lindsay, W. L. and Norvell, W. A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American J.* **42:** 421-428.

Lowry, O. H., Rosebrough, N. J. Farr, L, A. and Randall, R, J. 1951. Protein measurement with the Follin Phenol reagent. *J. Biological Chemistry*. **193:** 265-275.

Manceau, A., Tommaseo, C., Rihs, S., Geoffroy, N., Chateigner, D., Schleges, M., Tisserand, D., Marcus, M, A., Tamura, N. and Chen, Z. S. 2005. Natural speciation of Mn, Ni and Zn at the micrometer scale in a clayey paddy soil using X-ray fluorescence, absorption and diffraction. *Geochimica et Cosmochimica Acta*. **16:** 4007-4034.

Meena, R. N., Verma, V. K., Gautam, A., Gaurav. Tyagi, V. and Kumar, A. 2015. Effect of crop establishment method and different source of zn on growth, yield and quality of rice (*Oryza sativa L.*) *The Ecoscan.* **9(3&4):** 873-876.

Mishra, L. K. 2012. Effect of phosphorus and zinc fertilization on biochemical composition of wheat. *The Bioscan*. **7:** 445-449.

Mondal, A. K. Jalali, V. K. Sharma, V. 2006b. Distribution of Boron and primary micronutrients in orchids soils of temperate Jammu. *Environment & Ecology*. **24S(3):** 611-613.

Mondal, A. K. Sharma, V. Jalali, V. K. Arora, S. Wali, P. and Kher, D. 2006a. Distribution and relationship of macro and micronutrients in soils of Chattha the newly established location of SKUAST of Jammu. *Jo. Research, SKUAST-J.* **6(2):** 234-242.

Muthukumararaja, T. and Sriramachandrasekharan, M. V. 2012. Effect of zinc on yield, zinc nutrition and zinc use efficiency of lowland rice. *J. Agricultural Technology*. **8(2):** 551-561.

Nag, P., Paul, A. K. and Mukherjee, S. 1981. Heavy metal effects in plant tissues involving chlorophyll, chlorophyllase, hill reaction activity and gel electrophoresis patterns of soluble proteins. *Indian J. Experimental Biology*. **19:** 702-706.

Nagesh, V., Ravindrababu, U. G. and Reddy, T. D. 2012. Heterosis studies for grain iron and zinc content in rice (*Oryza sativa L*). *Annals of Biological Research*. **3(1):** 179-184.

Pandey, P. and Tripathi, A. K. 2011. Effect of heavy metals on the Morphological and Biochemical characteristics of Albizia procera *(Albizia julibrissin)* Seedlings. *International J. Environmental Science*. **1(5):** 1009-1018.

Patel, K. P. 2011. Crop response to zinc-cereal crops. *Indian J. Fertilizers*. **7(10):** 84-100.

Piper, C. S. 1966. *Soil and Plant Analysis*, Hans Publisher. Bombay, India

Praneeth, K. S., Narender, S. R., Shiv Sankar, A. and Sharath Kumar Reddy, Y. 2015. Effect of zinc nutrition on dry matter production, yield and uptake of zinc by aromatic rice. *The Ecoscan.* **9(1&2):** 513-516.

Rabie, M. H., Eleiwa, M. E., Aboseoud, M. A. and Khalil, K. M. 1992. Effect of nickel on the content of carbohydrate and some mineral in corn and broad bean plant. *J. King Abdulaziz University-Science*. **4:** 37.

Rajub, A. S. 1999. Effect of zinc on the chemical composition of rice. *M.Phil. thesis, Agriculture faculty university. D.I.Khan* (Pakistan).

Rattan, R. K., Datta, S. P. and Katyal, J. C. 2008. Micronutrient management–research achievements and future challenges. *Indian J. Fertilizers*. **4(12):** 93-118.

Richards, L. A. 1954. Diagnosis and improvement of saline and alkaline soils. *USDA Handbook* No.60.

Sharma, G. D., Thakur, R., Som Raj. Kauraw, D. L. and Kulhare, P. S. 2013. Impact of Integrated Nutrient Management on Yield, Nutrient Uptake, Protein Content of Wheat (*Triticum Astivam*) and Soil Fertility in a Typic Haplustert. *The Bioscan*. **8(4):** 1159-1164.

Shukla, A. K. and Behera, S. K. 2012. Micronutrient fertilizers for higher productivity. *Indian J. Fertilizers*. **8(4):**100-117

Singh, A. K. Thakur, S. K. and Singh, V. P. 1999. Effect of N with and without FYM and Zn on yield, uptake and economics of rice. *J. research agricultural university*. **8:**175-176.

Singh, G. Babu, R. Narain, P. Bhushan, L. S. and Abrol, I. P. 1997. Soil erosion rates in India. *J. Soil and Water Conversation*. **47(1):** 97-99.

Singh, M. V. 2009. Micronutrient nutritional problems in soils of India and improvement for human and animal health. *Indian J. Fertilizers*. **5(4):** 11-26.

Singh, R. P. and Mishra, S. K. 2012. Available macronutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi (U.P.) in relation to soil characteristics. *Indian J. Soil Research.* **3(1):** 97-100.

Slaton, A. N. A. Normon, R. J. and Wilson, C. E. 2005. Effect of Zn sources and application time on Zn uptake and grain yield of flood irrigated rice. *Agronomy J.* **92:** 272-278.

Srivastava, P. C., Gosh, D. and Singh, V. P. 1999. Evaluation of different Zn sources for lowland rice production. *Biology and fertility of soils*. **30:** 168-172.

Srivastava, P. C. and Gupta, U. C. 1996. *Trace Elements in Crop Production,* Science Publishers, Lebanon, NH. p. 356.

Subbiah, B, V. and Asija, G. L. 1956. A ripid procedure for the determination of available nitrogen in soils. *Current Science*. **25:** 259-260.

Tahir, M. and Kausar, M. A. 1994. Fertilizer zinc efficiency for rice and subsequent wheat as affected by urea and manure application. Protocol of 4th national congress soil science. On efficient use of plant nutrients. Islamabad, May 24-26, 347-354.

Vijayarengan, P. 2012. Changes in growth, biochemical constituents and antioxidant potentials in cowpea (*Vigna unguiculata* (L.) Walp.) under cobalt stress. *International J. Research in Environmental Science and Technology*. **2(3):** 74-82.

Walkey, A. and Black, I. A. 1934. An experimentation of the Degtjareff method for determining soil organic matter, and proposed modification of the chromic acid titration method. *Soil Science*. **37:** 29-38.

Welch, R. M. Webb, M. J. and Loneragan, J. F. 1982. Zinc in membrane function and its role in phosphorus toxicity [Crops]. *In Plant Nutrition,* Proceedings of 9th International plant Nutrition Colloquium, Warwick University, England, pp. 710-715.

Wissuwa, M. Ismail, A. M. and Graham, R. D. 2007. Rice grain zinc concentrations as affected by genotype, native soil-zinc availability, and zinc fertilization. *Plant and Soil*. **306(1):** 37-48.