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Productivity and Profitability of Fodder Cowpea Cultivars under Various Zinc Management Practices in IGP of India

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ABSTRACT

Background: Soils of North-Western Indo-Gangetic plains (IGP) are deficient in zinc content which may lead to lower forage yield of cowpea. Henceforth, the adequate supply of zinc either through soil or foliar spray and selection of suitable cultivar of cowpea could enhance the fodder productivity.

Methods: A field experiment was laid out in factorial randomized block design during *Kharif* season, 2019 to assess the effect of different zinc management practices (control; 10 kg $ZnSO_4$; 20 kg $ZnSO_4$; 0.5% $ZnSO_4$ foliar spray at 20 DAS; 0.5% $ZnSO_4$ foliar spray at 20 and 40 DAS) on productivity and profitability of cowpea cultivars (C-152; MFC-08-14; MFC-09-1) and post-harvest fertility status of soil.

Result: Cowpea cv. C-152 showed the highest growth attributes, green fodder yield, nutrient content as well as uptake and net returns. Among different zinc management practices, the application of 20 kg $ZnSO_4$ as basal application or 0.5% $ZnSO_4$ foliar spray at 20 and 40 DAS recorded significantly highest growth, green fodder yield, nutrient content as well as uptake and net returns. Significantly highest soil OC, available N, K and Zn were also noted under these treatments. It is inferred that cowpea cv. C-152 and application of either 20 kg $ZnSO_4$ as basal or 0.5% $ZnSO_4$ as foliar spray at 20 and 40 DAS were found the most productive and profitable approach and sustained the soil fertility status.

Key words: Cultivars, Fodder cowpea, Nutrient content, Productivity, Profitability, Soil fertility, Zinc.

INTRODUCTION

Zinc deficiency has received great attention in India because the average level of its deficiency in soils is 49% and the value is projected to increase from 49 to 63% by 2025 (Arunachalam *et al*., 2013). It was concluded from a study that zinc would become so deficient by 2025 that to maintain satisfactory zinc status in crop plants, it should be applied annually to 325000 tons of zinc in India (Singh, 2008). Zinc is indispensable element for the synthesis of tryptophan that is a component of some proteins and a compound needed for the production of growth hormones (auxins) like indole acetic acid. It plays a key role in carbohydrate metabolism and imparts resistance in plants against diseases (Prasad, 2007). The metabolism of proteins, nucleic acids, carbohydrates and lipids depends on Zn to a large extent. Its deficiency causes reduced growth hormone production in plants causes shortening of internodes and smaller than normal leaves (Hafeez *et al*., 2013). Inactive RNAs and starch accumulate in plants as a result of Zn deficiency (Zargar *et al*., 2015). Henceforth, adequate supply of zinc is essential to achieve higher crop productivity.

Cowpea (*Vigna unguiculata*) is one of the crucial food legume crops originated across semiarid regions of Asia and Africa. Being a good soil renovator, the cowpea is well known as fodder because of its quick growing habits and good tonnage of fodder yield (Mallikarjun *et al*., 2020). Since, cowpea green manure contains 0.7% N, 0.1-0.2% P_2O_5 and 0.6% K_2O, the incorporation of its residues increases the primary macronutrient content. It is capable for accumulation of 5-6 tonnes/ha of dry biomass (Hindoriya *et al*., 2019) and 100 kg N/ha in 50-60 days if it is well-managed. It has good root nodules and thus, supplies atmospheric N to available form in soil and improves the soil rhizosphere conditions. Though, cowpea is sensitive to Zn content and shows Zn deficiency symptoms within 10 days after sowing (DAS). Its deficiency causes orange-yellow colour in the inter-veinal region of new leaves. At later stage, dull brown spots develop on leaf blades towards the margin of the leaf tip (Singh *et al*., 2011). Cowpea can grow in the potentially Zn deficient soil but the Zn concentration in shoot and biomass yield of cowpea remarkably decreased due the deficiency of Zn below the critical level. Centre for World Food Studies, Amsterdam (Netherlands) has indicated direct linkages between soil micronutrient contents and micronutrient

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contents of forage and fodders. The positive effect of zinc on crop yield/animal produce is possible due to zinc management (Kumar *et al*., 2016 and Rathore *et al*. 2015a and b).

Selection of suitable cultivars is also an important aspect of fodder production as fodder quality is a function of genetic makeup and environment. Increased efficiency of uptake and utilization of soil nutrients will aid to reduce the chemical fertilizers usage in agriculture. With respect to physiological aspect, nutritional efficiency is the ability of the genotype to absorb the nutrient from the soil, distribute it and use it internally (de Oliveira *et al*., 2012). The capacity of a genotype to grow in the zinc-deficient soil is expressed as zinc efficiency or the ratio of shoot dry weight under Zn deûciency soil over that soil having adequate Zn nutritional status (Gao *et al*., 2005). Cowpea cultivars responded differently in uptake of zinc under different level of zinc (Mfeka, 2017). Concerning all these facts, the present experiment was undertaken to study the effect of zinc management practices on cowpea cultivars in improving the yield and fodder quality along with sustaining the soil fertility.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of Agronomy Section, ICAR-National Dairy Research Institute, Karnal, India during *Kharif*, 2019. Soil of the experimental field was clay loam having pH 7.48 and electrical conductivity 0.309 dS/m. Available N, P and K content of soil was 188.9, 30.5 and 192.4 kg/ha, respectively. The experiment was laid out in factorial randomized block design with three cultivars, *i.e.*, V_1: C-152, V_2: MFC-08-14 and V_3: MFC-09-1 and five zinc management practices, *i.e.*, Zn_1: Control, Zn_2: 10 kg $ZnSO_4$/ha, Zn_3: 20 kg $ZnSO_4$/ha, Zn_4: 0.5% $ZnSO_4$ foliar spray at 20 DAS, Zn_5: 0.5% $ZnSO_4$ foliar spray at 20 and 40 DAS and replicated thrice. Nitrogen and phosphorus were applied to each plot uniformly through DAP as basal dose (RDF: $N_{20}P_{60}$). Zinc was applied in the form of zinc sulphate heptahydrate. Seeds of cowpea varieties were treated with liquid rhizobium culture @ 50 ml/ seeds required for one acre. Then, seeds were mixed well with culture using one litre water and kept in shade on a clean *Pakka* floor for drying. After half an hour of drying, seeds were used for sowing. The crop was sown on August 06, 2019. A pre-emergence application of Pendimethalin @ 1 liter a.i./ha was used to check weeds at initial crop growth stage. Two irrigations were given at 25 and 45 DAS. Cowpea was harvested for fodder purpose on October 02, 2019.

The standard agronomic methods were used to measure growth attributes of fodder cowpea. The fodder samples taken at harvest stage were dried in hot air oven at 60-70°C for 72 hrs till it attains a constant weight and grounded (Wiley mill) to pass through one mm screen for the estimation of nutrient content. Total nitrogen, phosphorus and potassium content were estimated using modified Kjeldhal method (Jackson, 1967), ammonium vanadomolybdo phosphoric acid yellow colour method (Richards, 1968) and Flame Photometer method (Jackson, 1973), respectively. While, the zinc content in fodder samples was analysed using di-acid ($HClO_4$ + HNO_3 in 3:10 ratio) digestion followed by reading at Atomic Absorption Spectrophotometer (Jackson, 1967). The uptake of N, P, K and Zn were calculated by multiplying their concentrations with respective yield of cowpea fodder. Soil samples taken at 0-15 cm depth after crop harvest were used for estimation of chemical properties. Wet oxidation method (Walkley and Black, 1934), alkaline permanganate method (Subbiah and Asija, 1956), 0.5 M sodium bicarbonate method (Olsen *et al*., 1954) and ammonium acetate extraction method (Jackson, 1967) were used for estimation of soil organic carbon, available N, P and K, respectively. DTPA-$CaCl_2$-TEA method (Lindsay and Norvell, 1978) was used for micronutrients estimation.

Experimental data were analyzed using analysis of variance (ANOVA) as per factorial randomized block design (Gomez and Gomez, 1984). Significance of the treatment means were tested using F test with 5% level of significance (P<0.05) and means were compared using the least significant difference (LSD) test at α = 0.05.

RESULTS AND DISCUSSION

Growth attributes

Results (Table 1) indicated that the cultivar C-152 showed significantly best plant growth in terms of plant height, number of leaves, leaf length, number of branches and total root nodules per plant at both 30 DAS and harvest stage amongst cultivars. The cultivar C-152 was found at par with MFC-09-1 for number of branches and total root nodules per plant at harvest stage, whereas, the lowest growth performance was noted with the cultivar MFC-08-14. Though, the leaf width was remained statistically unaffected among the cultivars. The differences in growth attributes could be associated with genetic potential of cultivars and also the response of cultivars to local climatic conditions. Win and Oo (2015) also concluded in their studies that cowpea genotypes exhibited variable shoot length. Varying degree of genetic variability for number of branches per plant (Hedge and Mishra, 2009) and nodulation (Ayisi *et al*., 2000) were recorded in cowpea genotypes.

The effect to Zn management on all the growth attributes was found significant, except leaf width at 30 DAS (Table 1). At initial crop growth stage (30 DAS), the application of 20 kg $ZnSO_4$ (Zn_3) significantly recorded the highest plant height, number of leaves, leaf length, number of branches and total root nodules per plant amongst zinc management practices. Though, it remained statistically at par with 10 kg $ZnSO_4$ (Zn_2) for the leaf length, number of branches and total root nodules. At the harvesting stage, the application of 20 kg $ZnSO_4$ (Zn_3) exhibited significantly superior growth which remained at par with 10 kg $ZnSO_4$ (Zn_2). The higher plant growth with zinc application might be due to the fact that zinc acts as cofactor of several enzymes and helps in cell division and elongation, metabolism of auxin and nucleic

Table 1: Effect of different varieties and zinc management practices on the growth attributes and green fodder yield of cowpea.

Treatments	Plan height (cm)		No. of leaves /plant		Leaf length (cm)		Leaf width (cm)		No. of branches /plant		Total root nodules/plant		Green fodder yield (t/ha)
	30 DAS	Harvest	30 DAS	Harvest	30 DAS	Harvest	30 DAS	Harvest	30 DAS	harvest	30 DAS	Harvest	Harvest
Varieties													
V_1: C-152	51.32	143.16	43.57	123.17	10.23	11.78	6.95	9.02	4.64	7.57	9.31	70.80	30.23
V_2: MFC-08-14	43.94	112.51	34.64	98.51	9.18	10.78	6.74	8.76	4.00	6.92	7.49	63.53	25.32
V_3: MFC-09-1	47.26	124.75	35.48	104.88	9.35	10.94	6.60	8.63	4.24	7.07	7.63	69.87	26.95
SEd±	1.23	3.89	0.90	3.84	0.27	0.38	0.17	0.26	0.14	0.25	0.19	1.80	0.72
LSD (*P*=0.05)	2.52	7.97	1.84	7.86	0.56	0.79	NS	NS	0.28	0.51	0.38	3.69	1.47
Zinc management practices													
Zn_1: Control	43.99	112.19	35.85	96.86	9.00	10.17	6.59	8.15	4.07	6.44	7.30	51.89	23.68
Zn_2: 10 kg $ZnSO_4$ as basal	48.49	125.17	38.33	106.28	9.77	11.00	6.87	8.86	4.40	7.08	8.74	70.67	27.43
Zn_3: 20 kg $ZnSO_4$ as basal	51.96	139.21	41.07	119.55	10.43	12.05	7.02	9.19	4.62	7.78	9.24	77.56	29.75
Zn_4: 0.5% $ZnSO_4$ as foliar spray at 20 DAS	46.73	121.77	37.26	103.99	9.32	10.82	6.70	8.78	4.21	6.93	7.71	64.00	27.25
Zn_5: 0.5% $ZnSO_4$ as foliar spray at 20 and 40 DAS	46.36	135.69	36.98	117.58	9.41	11.80	6.63	9.04	4.17	7.69	7.73	76.22	29.39
SEd±	1.59	5.03	1.16	4.96	0.35	0.50	0.22	0.34	0.18	0.32	0.24	2.32	0.93
LSD (*P*=0.05)	3.26	10.29	2.37	10.15	0.73	1.02	NS	0.69	0.36	0.66	0.50	4.76	1.90

Table 2: Effect of different varieties and zinc management practices on the chemical properties of soil after the harvest of fodder cowpea.

Treatments	pH	EC (dS/m)	OC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Mn (ppm)	Cu (ppm)	Fe (ppm)	Zn (ppm)
Varieties										
V_1: C-152	7.53	0.312	0.75	218.0	26.28	219.6	8.02	0.733	9.95	0.810
V_2: MFC-08-14	7.53	0.315	0.71	202.0	30.80	210.3	7.80	0.751	10.12	0.854
V_3: MFC-09-1	7.52	0.314	0.72	208.6	29.20	212.7	7.78	0.724	10.04	0.861
SEd±	0.06	0.007	0.02	2.2	0.50	3.3	0.13	0.015	0.11	0.02
LSD (*P*=0.05)	NS	NS	NS	4.4	1.02	6.8	NS	NS	NS	0.04
Zinc management practices										
Zn_1: Control	7.55	0.298	0.66	195.4	31.21	199.5	8.14	0.768	10.26	0.57
Zn_2: 10 kg $ZnSO_4$ as basal	7.53	0.318	0.74	207.8	27.76	210.0	7.89	0.741	10.13	0.95
Zn_3: 20 kg $ZnSO_4$ as basal	7.52	0.322	0.77	222.8	26.21	228.3	7.62	0.703	9.82	1.05
Zn_4: 0.5% $ZnSO_4$ as foliar spray at 20 DAS	7.54	0.312	0.72	203.3	29.70	212.5	7.98	0.743	10.08	0.80
Zn_5: 0.5% $ZnSO_4$ as foliar spray at 20 and 40 DAS	7.52	0.318	0.75	218.4	28.92	220.6	7.70	0.724	9.89	0.83
SEd±	0.08	0.009	0.02	2.8	0.64	4.3	0.17	0.020	0.15	0.02
LSD (*P*=0.05)	NS	NS	0.04	5.7	1.32	8.8	0.34	0.041	0.30	0.05

acid as well as carbohydrate and protein synthesis by activating particular enzymes in plants. Our results are in conformity with the findings of Pandya and Bhatt (2007) and Kumar *et al*. (2016).

Green fodder yield

Results (Table 1) showed that cowpea cv. C-152 recorded significantly highest green fodder yield (30.23 t/ha) as compared to MFC-08-14 and MFC-09-1. Further results revealed that MFC-09-1 (26.95 t/ha) cultivar showed significantly higher green fodder yield than MFC-08-14 (25.32 t/ha). The significant variations in cultivars might be due to the differences in growth pattern resulted from their genetic makeup. Kumar (2017) also reported the significant variations in cowpea varieties due to their genetic potential.

Among zinc management practices (Table 1), the application of 20 kg $ZnSO_4$ was found at par with foliar spray of 0.5% $ZnSO_4$ at 20 and 40 DAS and both produced significantly maximum green fodder yield (29.75 and 29.39 t/ha, respectively) as compared to remaining practices. The biomass yield is a function of other growth parameters like plant height, number of leaves *etc.* The differentiation in cell growth and development of plant was evidenced under adequate Zn supply because zinc protect cells from oxidative degradation of growth hormone indole-3-acetic acid (IAA). The present results are in line with earlier findings of Kumar *et al*. (2016).

Nutrient content and uptake

The primary nutrient contents were significantly differed among cowpea cultivars (Fig 1 and 3). Significantly the highest N, P and K contents (2.77, 0.310 and 1.95%, respectively) were noted with C-152 as compared to MFC-08-14 and MFC-09-1. Though, zinc content was found statistically similar with all the three cultivars (Fig 5). The nitrogen fixation depends upon nodule count of the plant which reflects the N content in the plant shoot (Rhoden and Allen, 1982). Genotypic characters were the prime cause of differences in nutrient content. Safaya and Singh (1977) also reported the varying P accumulation capacity of cowpea genotypes. In case of uptake (Fig 2, 4 and 6), significantly the highest N, P, K and Zn uptake were noted with C-152 as compared to other cultivars. The higher nutrient uptake could be attributed to their higher nutrient content and dry fodder yield.

Zinc management practices caused significant variations on the N, P, K and Zn content (Fig 1, 3 and 5). Significantly the higher N and Zn contents were noted with 0.5% $ZnSO_4$ at 20 and 40 DAS, which was at par with Zn_2 and Zn_3 for N and Zn_3 for Zn. Likewise, application of 0.5% $ZnSO_4$ at 20 and 40 DAS (Zn_5) and 0.5% $ZnSO_4$ at 20 DAS (Zn_4) recorded the highest P content, while all the zinc applied plots showed statistically similar and higher K content over control. For nutrient uptake (Fig 2, 4 and 6), the application of 20 kg $ZnSO_4$(Zn_3) and foliar spray of 0.5% $ZnSO_4$ at 20 and 40 DAS (Zn_5) recorded considerably maximum uptake of N, K and Zn as compared to the remaining practices. Though, significantly the highest P uptake was noted with 0.5% $ZnSO_4$ at 20 and 40 DAS (Zn_5) which was at par with 20 kg ZnSO4 (Zn_3) and 0.5% ZnSO4 at 20 DAS (Zn_4). Addition of Zn to soil enhanced the content and uptake of N, K and Zn resulting from synergistic effect of Zn with these nutrients. Similar findings were also observed by Keram *et al*. (2012) in wheat. The higher nutrient content due to foliar application of Zn under present investigation was also supported by Yilmaz *et al*. (1997) who reported significantly higher Zn content in plants due to foliar application than basal. It might be due to easily penetration of Zn through leaves *via.* stomatal pathway or transportation and homogenization of spray cause higher diffusion of Zn in leaves. Higher absorption of Zn is due to combined application of zinc through soil and foliar application which leads to higher absorption of zinc (Oseni, 2009). Our results of zinc uptake are in consonance with finding of Debnath *et al*. (2018).

Post-harvest fertility status of soil

Data presented in Table 2 indicated that the pH, EC and soil organic carbon and available micronutrient content in soil (Mn, Cu and Fe) were not affected significantly. Though, available N, P and K and DTPA extractable Zn were differed significantly due to cultivars. Significantly highest levels of available N and K status after cowpea harvest were noted with C-152 as compared to rest of both cultivars. However, MFC-08-14 showed the maximum levels of available P content in soil. Likewise, significantly the highest DTPA-extractable Zn content in the soil was noted under MFC-09-1 which was at par with MFC-08-14. The variations in soil nutrient content may be due to differences in root volume, release of chemical exudates and nutrient uptake of cultivars. Adjei-Nsiah *et al.* (2008) observed a wide range of nitrogen recycling by the roots assuming that 30% of nitrogen in plant contained in roots.

Table 3: Effect of different varieties and zinc management practices on economics of fodder cowpea.

Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B: C ratio
Varieties				
V_1: C-152	22495	54416	31921	1.42
V_2: MFC-08-14	22695	45580	22885	1.01
V_3: MFC-09-1	22695	48504	25809	1.13
SEd±	-	1296	1296	0.06
LSD (*P*=0.05)	-	2654	2654	0.12
Zinc management practices				
Zn_1: Control	22066	42628	20562	0.93
Zn_2: 10 kg $ZnSO_4$ as basal	22576	49382	26806	1.19
Zn_3:20 kg $ZnSO_4$ as basal	23086	53542	30456	1.32
Zn_4:0.5% $ZnSO_4$ as foliar spray at 20 DAS	22493	49054	26561	1.18
Zn_5:0.5% $ZnSO_4$ as foliar spray at 20 and 40 DAS	22921	52894	29973	1.31
SEd±	-	1673	1673	0.07
LSD (*P*=0.05)	-	3427	3427	0.15

Table 4: Correlation matrix of green fodder yield vs. growth attributes.

Pearson	Correlations										
	GFY	PH	NoL	LL	LW	NoB	NoRN	N	P	K	Zn
GFY	1										
PH	0.879**	1									
NoL	0.872**	0.989**	1								
LL	0.849**	0.923**	0.945**	1							
LW	0.806**	0.755**	0.787**	0.902**	1						
NoB	0.861**	0.857**	0.876**	0.942**	0.904**	1					
NoRN	0.831**	0.741**	0.713**	0.823**	0.821**	0.849**	1				
N	0.860**	0.817**	0.819**	0.912**	0.879**	0.852**	0.907**	1			
P	0.628*	0.618*	0.632*	0.551*	0.630*	0.462	0.360	0.521*	1		
K	0.890**	0.947**	0.946**	0.838**	0.726**	0.771**	0.630*	0.766**	0.778**	1	
Zn	0.650**	0.594*	0.593*	0.795**	0.853**	0.767**	0.892**	0.889**	0.276	0.466	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Note: GFY- Green fodder yield; PH- Plant height; NoL- Number of leaves; LL- Leaf length; LW- Leaf width; NoB- Number of branches; NoRN- Number of root nodules; N- Nitrogen content; P- Phosphorus content; K- Potassium content; Zn- Zinc content.

Zinc application did not significantly affect the soil pH and EC. However, all others studied soil fertility parameters were significantly differed due to zinc application (Table 2). All the zinc applied plots (Zn_2 to Zn_5) showed significantly highest available N and K content and DTPA-extractable Zn status in soil. Amongst all Zn management practices, the highest values of these nutrients (N, K and Zn) were found with basal application of zinc @ 20 kg/ha (Zn_3). Available P status was significantly higher with foliar spray of 0.5% $ZnSO_4$ at 20 DAS as compared to soil application, though, significantly lower than control. Similarly, DTPA-extractable Mn, Cu and Fe content also indicated a decreasing trend from control to zinc application. Significantly the lowest DTPA-extractable Mn, Cu and Fe content were noticed under Zn_3 and Zn_5 which might be due to negative interaction with Zn. The increased N and K content due to Zn application in present experiment are also supported by findings of Kumar *et al*. (2017). Decreasing trend of P with increase in Zn concentration of soil might be due to increased negative surface charges on P which ultimately increased the sorption of Zn in soil lead to reduced DTPA-extractable Zn (Prasad *et al*., 2016). Keram *et al*. (2012) reported that application of 20 kg $ZnSO_4$/ha recorded significantly higher DTPA-extractable Zn under wheat crop. As far as method of application is concerned, the basal application enhanced the Zn content in soil as it directly contributes to nutrient pool and increase availability through complexion. The results are in line with the findings of Das *et al*. (2005). The lower DTPA-extractable Cu could be due to the fact that both Cu and Zn cations compete with each other for adsorption site on soil clay minerals and interact negatively (Prasad *et al*., 2016).

Economics

Growing of cowpea cv. C-152 incurred the lowest cost of cultivation (INR 22495/ha), but highest gross returns, net returns and benefit cost ratio among all the tested cultivars (Table 3). The variations in cost of cultivation and gross returns were due to differences in their seed price and green fodder yield, respectively. Velayudham *et al*. (2015) also observed significant variation in economics due to differential yield of cowpea varieties.

In case of zinc management practices (Table 3), the maximum cost of cultivation was noted with application of

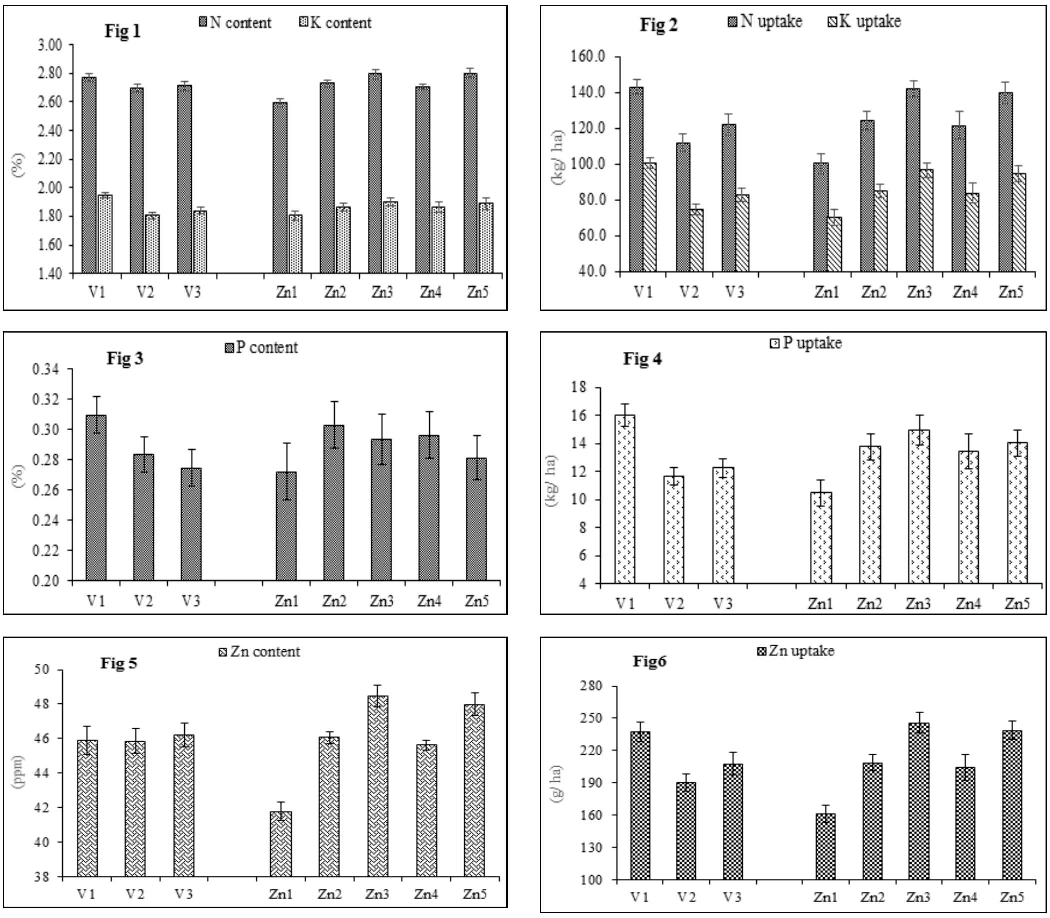

Fig 1 to 6: Effect of different varieties and zinc management practices on the content and uptake of N, P, K and Zn of fodder cowpea

Note: V_1: C-152; V_2: MFC-08-14; V_3: MFC-09-1; Zn_1: control; Zn_2: 10 kg $ZnSO_4$ as basal; Zn_3: 20 kg $ZnSO_4$ as basal; Zn_4: 0.5% $ZnSO_4$ as foliar spray at 20 DAS; Zn_5: 0.5% $ZnSO_4$ as foliar spray at 20 and 40 DAS.

20 kg $ZnSO_4$ as basal (Zn_3). Similarly, significantly the highest gross (INR 53542/ ha) as well as net returns (INR 30456/ha) of cowpea were obtained with application of 20 kg $ZnSO_4$ (Zn_3) which remained at par with foliar spray of 0.5% $ZnSO_4$ at 20 and 40 DAS (INR 52894 and 29973/ ha, respectively). Our findings are analogues with the findings of Soni and Kushwaha (2020) who reported that foliar spraying of 0.5% $ZnSO_4$ at different growth stages exhibited the maximum net return in mungbean. Similar results have also been observed by Rathore *et al*. (2015c) who reported highest BCR under 20 kg $ZnSO_4$ as soil application.

Correlation studies

Correlation studies (Table 4) indicated that the growth attributes of cowpea, *i.e.*, plant height (r=0.879), number of leaves (r=0.872), leaf length (r=0.849), leaf width (r=0.806), number of branches (r=0.861), number of root nodules (r=0.831), N content (r=0.860) and K content (r=0.890) were strongly and positively correlated with green fodder yield. However, moderate positive correlation was noted between the green fodder yield *vs*. P (r=0.628) and Zn content (r=0.650). The non-significant correlation was noted between Zn *vs.* P (r=0.276) and K content (r=0.466). Likewise, the correlation between the number of branches (r=0.462) and the number of root nodules (r=0.360) with P content were found non-significant.

CONCLUSION

Results from the present study revealed that fodder cowpea cv. C-152 along with application of either 20 kg $ZnSO_4$ as basal or 0.5% $ZnSO_4$ as foliar spray at 20 and 40 DAS was found to be most productive as well as profitable approach to attain quality fodder with sustaining the soil fertility.

REFERENCES

Adjei-Nsiah, S., Kuyper, T.W., Leeuwis, C., Abekoe, M.K., Cobbinah, J., Sakyi-Dawson, O. and Giller, K.E. (2008). Farmers' agronomic and social evaluation of productivity, yield and N_2-fixation in different cowpea varieties and their subsequent residual N effects on a succeeding maize crop. Nutrient Cycling in Agroecosystems. 80(3): 199-209.

Arunachalam, P., Kannan, P., Prabukumar, G. and Govindaraj, M. (2013). Zinc deficiency in Indian soils with special focus to enrich zinc in peanut. African Journal of Agricultural Research. 8(50): 6681-6688.

Ayisi, K.K., Nkgapele, R.J. and Dakora, F.D. (2000). Nodule formation and function in six varieties of cowpea [*Vigna unguiculata* (L.) Walp.] grown in a nitrogen-rich field soil in South Africa. Symbiosis. 28: 17-31.

Das, K., Dang, R., Shivananda, T.N. and Sur, P. (2005). Interaction effect between phosphorus and zinc on their availability in soil in relation to their contents in stevia (*Stevia rebaudiana*). The Scientific World Journal. 5: 490-495.

de Oliveira A,É., dos Santos, F.E., de Oliveira, Q.G., Camacho, M.A. and Dresch, M.D. (2012). Nutritional efficiency of cowpea varieties in the absorption of phosphorus. Agronomia Colombiana. 30(3): 419-424.

Debnath, P., Pattanaaik, S.K., Sah, D., Chandra, G. and Pandey, A.K. (2018). Effect of boron and zinc fertilization on growth and yield of cowpea (*Vigna unguiculata* Walp.) in *Inceptisols* of Arunachal Pradesh. Journal of the Indian Society of Soil. 66(2): 229-34.

Gao, X., Zou, C., Zhang, F., van der Zee, S.E. and Hoffland, E. (2005). Tolerance to zinc deficiency in rice correlates with zinc uptake and translocation. Plant and Soil. 278(1-2): 253-261.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. (2nd Edn.). John Wiley and Sons, New York, NY.

Hafeez, B., Khanif, Y.M. and Saleem, M. (2013). Role of zinc in plant nutrition - A review. American Journal of Experimental Agriculture. 3(2): 374-391.

Hegde, V.S. and Mishra, S.K. (2009). Landraces of cowpea, [*Vigna unguiculata* (L.) Walp.], as potential sources of genes for unique characters in breeding. Genetic Resources and Crop Evolution. 56(5): 615-627.

Hindoriya, P.S., Meena, R.K., Kumar, R., Singh, M., Ram, H., Meena, V.K., Ginwal, D. and Dutta, S. (2019). Productivity and profitability of cereal-legume forages vis-a-vis their effect on soil nutrient status in Indo-Gangetic plains. Legume Research. 42(6): 812-817.

Jackson M.L. (1973). Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi, 498.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi, pp. 111-203.

Keram, K.S., Sharma, B.L. and Sawarkar, S.D. (2012). Impact of Zn application on yield, quality, nutrients uptake and soil fertility in a medium deep black soil (*Vertisol*). International Journal of Science, Environment and Technology. 1(5): 563-571.

Kumar, B. (2017). Genetic variability of cowpea (*Vigna unguiculata*) genotypes to varied levels of phosphorus under rainfed condition of Jharkhand. Chemical Science Review and Letters. 6(23): 1970-1974.

Kumar, R., Rathore, D.K., Singh, M., Kumar, P. and Khippal, A. (2016). Effect of phosphorus and zinc nutrition on growth and yield of fodder cowpea. Legume Research. 39(2): 262-267.

Kumar, R., Singh, M., Meena, B.S., Ram, H., Parihar, C.M., Kumar, S., Yadav, M.R., Meena, R.K., Kumar, U. and Meena, V.K. (2017). Zinc management effects on quality and nutrient yield of fodder maize (*Zea mays*). Indian Journal of Agricultural Sciences. 87(8): 1013-17.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal. 42(3): 421-428.

Mallikarjun, Ram, H., Kumar, R., Singh, M., Meena, R.K. and Kumar, R. (2020). Effect of rhizobium inoculation and tillage practices on fodder cowpea (*Vigna unguiculata*). Legume Research, accepted on 25-5-2020 (doi: 10.18805/LR-4373).

Mfeka, N. (2017). Morphology and mineral content of cowpea lines in response to planting date and zinc application rate. Ph.D. thesis submitted to Cape Peninsula University of Technology, Wellington, p. 108.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium carbonate. USDA, Washington D.C., (Vol. 939), p. 19.

Oseni, T.O. (2009). Growth and zinc uptake of sorghum and cowpea in response to phosphorus and zinc fertilization. World Journal of Agricultural Sciences. 5(6): 670-674.

Pandya, C.B. and Bhatt, V.R. (2007). Effect of different nutrient levels on yield and nutrient content of fodder cowpea. Legume Research. 30: 218-220.

Prasad, R. (2007). Zinc. In: Crop Nutrition-Principle and Practices. New Vishal, Publications, New Delhi. pp. 191-218.

Prasad, R., Shivay, Y.S. and Kumar, D. (2016). Interactions of zinc with other nutrients in soils and plants- A review. Indian Journal of Fertilisers. 12(5): 16-26.

Rathore, D.K., Kumar, R., Kumar, P., Meena, V.K., Kumar, U., Joshi and Yadav, T. (2015a). Economics analysis of phosphorus and zinc nutrition in fodder cowpea (*Vigna unguiculata*). Agricultural Science Digest. 35(4): 311-313.

Rathore, D.K., Kumar, R., Singh, M., Meena, V.K., Kumar, U., Soni, P.G., Yadav, T. and Makarana, G. (2015b). Phosphorus and zinc fertilization in fodder cowpea- A review. Agricultural Reviews. 36(4): 333-338.

Rathore, D.K., Kumar, R., Singh, M., Kumar, P., Ttyagi, N., Datt, C., Meena, B., Soni, P.G. and Makrana, G. (2015c). Effect of phosphorus and zinc Application on nutritional characteristics of fodder cowpea (*Vigna unguiculata*). Indian Journal of Animal. Nutrition 32(4): 388-392.

Rhoden, E.G. and Allen, J.R. (1982). Effect of B, Mn and Zn on nodulation and N_2-fixation in southern peas. Communications in Soil Science and Plant Analysis. 13(4): 243-258.

Richards, L.A. (1968). Diagnosis and improvement of saline and alkali soils. Agriculture Handbook. 60: 210-220.

Safaya, N.M. and Singh, B. (1977). Differential susceptibility of two varieties of cowpea [*Vigna unguiculata* (L.) Walp.] to phosphorus-induced zinc deficiency. Plant and Soil. 48(2): 279-290.

Singh, K.K., Praharaj, C.S., Choudhary, A.K., Kumar, N. and Venkatesh, M.S. (2011). Zinc response in pulses. Indian Journal of Fertilisers. 7(10): 118-126.

Singh, M.V. (2008). Micronutrient Deficiencies in Crops and Soils in India. In: Micronutrient Deficiencies in Global Crop Production. [(Ed.) Alloway, B.J.] Springer, Netherlands. pp. 93-125.

Soni, J. and Kushwaha, H.S. (2020). Effect of foliar spray of zinc and iron on productivity of mungbean [*Vigna radiata* (L.) Wilczeck]. Journal of Pharmacognosy and Phytochemistry. 9(1): 108-111.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for assessment of available nitrogen in rice soils. Current Science. 25: 259-260.

Velayudham, K., Babu, C. and Iyanar, K. (2015). Influence of phosphorus levels on green fodder yield and quality of fodder cowpea genotypes. Madras Agricultural Journal. 102(1-3): 40-42.

Walkley, A.J. and Black, I.A. (1934). An examination of the Degtjareff method for determination of soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 37(1): 29-38.

Win, K.T. and Oo, A.Z. (2015). Genotypic difference in salinity tolerance during early vegetative growth of cowpea [*Vigna unguiculata* (L.) Walp.] from Myanmar. Biocatalysis and Agricultural Biotechnology. 4(4): 449-455.

Yilmaz, A., Ekiz, H., Torun, B., Gultekin, I., Karanlik, S., Bagci, S.A. and Cakmak, I. (1997). Effect of different zinc application methods on grain yield and zinc concentration in wheat cultivars grown on zinc deficient calcareous soils. Journal of Plant Nutrition. 20(4-5): 461-471.

Zargar, S.M., Mahajan, R., Farhat, S., Nazir, M., Mir, R.A., Nazir, M. and Mallick, S.A. (2015). Understanding the role of iron and zinc in animals and crop plants from genomics perspective. Current Trends in Biotechnology and Pharmacy. 9(2): 181-196.