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Short Research Article

Growth, Nodulation, Yield and Nutrient Uptake of Urdbean (*Vigna mungo* L. Hepper) as Influenced by Sulphur and Iron Fertilization in Light Textured Soil

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Abstract

In recent days, continuous rotation of cereals like rice-wheat without judicious use of chemical fertilizer put agricultural sustainability and environmental safety under trouble. Keeping these aspects on minda thrice replicated field trial conducted on sandy loam soil of S.V.P.U.A. & T. Meerut (Uttar Pradesh) in *kharif* season 2013. Nine treatments viz.,T_1 [Control (RDF-20:40:0)], T_2 (RDF+Sulphur 20 kg ha^{-1}), T_3 (RDF+Sulphur 40 kg ha^{-1}), T_4 (RDF+Fe 2.5 kg ha^{-1}), T_5 (RDF+Fe 5 kg ha^{-1}), T_6 (RDF+Sulphur 20+Fe 2.5 kg ha^{-1}), T_7 (RDF+Sulphur 20+Fe 5.0 kg ha^{-1}), T_8 (RDF+Sulphur 40+Fe 2.5 kg ha^{-1}) and T_9 (RDF+Sulphur 40+Fe 5.0 kg ha^{-1}) were tested in RBD with three replications by using F test. The data on growth, nodulation and yield with its attributing trait were recorded on net plot area basis. (18 m^2), moreover, nutrient uptake was calculated as per the standard procedure. The results revealed that plant height (51.57 cm), number of branch plant^{-1} (22.94), dry weight (12.10 g plant^{-1}) number of nodules plant^{-1} at 30 DAS (54.39), biological yield (25.68) and nutrient uptake in straw were significantly maximum by the application of RDF along with Sulphur 40 kg ha^{-1} and Fe 5.0 kg ha^{-1} while test weight (44.60 g), harvest index (42.33%) and nutrient uptake in grain was more with under RDF along with Sulphur 40 kg ha^{-1} and Fe 2.5 kg ha^{-1}. However, Biological yield was positively related to all growth parameters. As its legume in nature, so it is highly eco-friendly and useful for sustainable agriculture besides maintain health of soil.

1. Introduction

Pulse crops, also called grain legumes, have been valued as food, fodder and feed and have remained as a mainstay of Indian agriculture for centuries. Urdbean (*Vigna mungo* L.) is a rich source of carbohydrate (60%), protein (24.04%), fat (1.5%), phosphoric acids, amino acids, vitamins and minerals. Being a cheap source of vegetable protein for direct human consumption it is also known as *poor man's meat* (Singh et al., 2008). its ha^{-1} yield is very low this might be due to poor fertility status of soil, therefore fertility management is imperative to ensure better crop production on exhausted soil. Out of total pulse area, the urdbean occupies an area of 8.22 million hectare and production is 7.24 mt with the productivity of 881 kg ha^{-1}. The total area under pulse crop in India is 23.97 mha and production 15.86 mt with the productivity of 662 kg ha^{-1}, (Anonymous, 2012−13).

Micronutrients viz., zinc and iron deficiencies, now a day's becoming major limiting factor in harvesting higher yields of crops. Hence, optimum mineral nutrients management including sulphur and micronutrients is a basic requirement to realize potential yield of major crops. Urdbean not only have higher requirements but also have potentiality to remove sulphur from soil nutrient pool *vis a vis* fertilizer applied, as is evident from radio sulphur investigation. Sulphur uptake by several crops revealed that the highest sulphur requirement (12 kg t^{-1} of yield) has been attributed to oil seeds followed by pulses (8 kg t^{-1}), millets (5−8 kg t^{-1}) and cereals @ 4 kg t^{-1}. Likewise, iron plays an important role for plant growth and development. The soils of western Uttar Pradesh are slightly moderate alkaline in reaction, sandy loam textured and low in organic matter. A field survey on iron chlorosis problem in groundnut carried out in various locations of the state clearly indicated suffering multi nutrients deficiencies including sulphur and iron (Sahu et al., 2008). Effects on nodule number were smaller (100 and 140% increases for -N and +N, respectively. Fertilizer-N depressed nodulation at all rates of soil-applied Fe. Nitrogen fixation activity at flowering was low in all treatments; there were no responses to either Fe or N (Holland and Herridge, 2011). Although, RDF can be reduced to 85% by supplying nutrients through organics and foliar spray. (Manasa et al., 2015).

Sulphur application @ 40 kg ha^{-1} was beneficial to increase growth and yield of green gram (Patil et al., 2011). Whereas, maximum dry matter accumulation, yield attributes and seed yield of black gram with the application of 30 kg K_20 ha^{-1}, 30 kg S ha^{-1} (Mandal, 2014). Application of 40 kg S ha^{-1} as gypsum+elemental sulphur (1:1) and 25 kg $FeSO_4$ ha^{-1} as basal application significantly increased the nitrogen, phosphorus, potassium, Sulphur and Iron uptake in grain and straw (Meena et al., 2013). Application of sulphur @ 20 kg ha^{-1} was also recorded significantly highest plant height at harvest (37.07 cm), number of branches (5.17), number of pods $plant^{-1}$ (20.93), number of seeds pod^{-1} (6.30), grain (1153 kg ha^{-1}) and stover yield (2548 kg ha^{-1}) over control, respectively (Kokani et al., 2014).

2. Materials and Methods

2.1. Experimental details and site descriptions

A field experiment was conducted during *kharif* season 2012 at Crop Research Centre (Chirauri), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), located at a latitude of 29° 40′ North and longitude of 77° 42′ East with an elevation of 237 metres amsl. The mean weekly maximum temperature was 35.8 °C which was recorded in the last week of June. It decline gradually and reached to its minimum at the time of harvest. Minimum temperature follows the same trend as of maximum temperature, though the lowest temperature was 16.6 °C during the third week of October. The mean weekly relative humidity at 7.00 and 14.00 hrs varied from 84.8 to 58.0 and 71.7 to 22.9%, respectively. The total rainfall received during crop period was 609.6 mm. The soil of experimental field was alkaline pH 8.2, EC 0.21 dS m^{-1}, OC 0.47%, Available nitrogen 151.20 kg ha^{-1}, available phosphors 13.30 kg ha^{-1}, available Potassium 139.82 kg ha^{-1}, available Sulphur 8.3 kg ha^{-1} and available Iron 12.5 mg kg^{-1} and sandy loam in texture. 9 treatments viz., T_1 [Control (RDF-20:40:0)], T_2 (RDF+Sulphur 20 kg ha^{-1}), T_3 (RDF+Sulphur 40 kg ha^{-1}), T_4 (RDF+Fe 2.5 kg ha^{-1}), T_5 (RDF+Fe 5 kg ha^{-1}), T_6 (RDF+Sulphur 20+Fe 2.5 kg ha^{-1}), T_7 (RDF+Sulphur 20+Fe 5.0 kg ha^{-1}), T_8 (RDF+Sulphur 40+Fe 2.5 kg ha^{-1}) and T_9 (RDF+Sulphur 40+Fe 5.0 kg ha^{-1}) were tested in RBD with three replications. The recommended dose of fertilizers (RDF) for urdbean was 20:40:20 kg of N, P_2O_5 and K_2O ha^{-1}, respectively. The whole quality of NPK fertilizer was applied as basal at the time of final ploughing. Seed inoculation was done with biofertilizer namely phosphate solubilising bacteria and Rhizobium @ 20 g kg^{-1} seed. Urdbean (Azad urd-3) was sown in rows 30 cm apart on 14th August 2013 using a seed rate of 20 kg ha^{-1}. The crop was grown as per recommended package of practices and harvested on 7th November 2013. The experimental field was well drained, sandy loam in texture (46.2% sand, 18.4% silt and 17.4% clay, Bouyoucos hydrometer method). All the physic-chemical properties were analyzed as per the slandered procedures (Jackson, 1973).

2.2. Data collection

Observations on various growth parameters viz., plant height; Number of Branches and dry matter accumulation $plant^{-1}$ were recorded at maturityof the crop. 1000-grains were counted for recording their weight in grams and biological yield was estimated by the produce (grain+straw) obtained from net plot area, treatment wise and finally expressed at 14% in case of grain (18 m^2) moisture. Harvest index (%) was calculated as dividing the economic yield by biological yield and then multiply with 100.

2.3. Plant sampling and analysis

The plants measured for growth and yield were used for analyzing the N, P and K content in grains and straw. The grain and straw samples were dried at 70 °C in a hot air oven. The dried samples were ground in a stainless steel Thomas Model 4 Wiley ® Mill. The N content in grains and straw was determined by digesting the samples in sulfuric acid (H_2SO_4), followed by analysis of total N by the Kjeldahl method (Page, 1982) using a Kjeltec™ 8000 auto analyzer (FOSS Company, Denmark), the P content in grains and straw was determined by the vanadomolybdo-phosphoric yellow colour method and the K content both in grains and straw was analyzed in di-acid (HNO_3 and $HClO_4$) digests by the flame photometeric method (Page, 1982). Iron in grains and straw was determined by Atomic Absorption Spectrophotometer (GBC Avanta PM Modal) and Sulphur in grains and straw was determined by turbidimetric method (Page, 1982). The uptake of the nutrients in grains and straw was calculated by multiplying the nutrient content (%) by respective yield (kg ha^{-1}) and was divided by 100 to get the uptake values in kg ha^{-1}.

2.4. Statistical analysis

The data obtained during course of investigation were subjected to statistical analysis as outlined by Gomez and Gomez (1984). The treatment differences were tested by using "F" test and critical differences (at p=0.05).

3. Results and Discussion

3.1. Performances of urdbean

At harvesting plant height did not responded different treatments and effect was not significant (Table 1). Neither iron nor sulphur application over recommended NP resulted any significant effect on plant height during all the growth stages although height was more with the application of higher level of iron or sulphur. Though, tallest plant (51.57 cm) was recorded in T_9 [RDF+Sulphur 40+Fe 5.0 kg ha^{-1}], whereas, shortest plant measured under control plot (42.50 cm). However, branches and dry weight outyielded significant differences among S and Fe fertilization. Furthermore, the maximum number of branches plant^{-1} 22.94 recorded in T_9 (RDF+Sulphur 40+Iron 5.0 kg ha^{-1}) which was statistically at par with T_7 and T_8 but significantly superior than rest of the treatments, while minimum number of branches plant^{-1} was found (14.82) in T_1 (control). Moreover, dry matter accumulation plant^{-1} varied from 8.93 to 12.10 g in different treatments. The maximum dry matter accumulation plant^{-1} (12.10 g) was recorded in T_9 (RDF+Sulphur 40+Fe 5.0 kg ha^{-1}) which was statistically superior to all of the treatments, while minimum dry matter accumulation (8.93 g) was recorded in T_1 (control) which was significantly lower with all the treatments. The similar trend was observed by Mandal et al. (2003); Meena et al. (2013).

Table: 1: Effect of sulphur and iron fertilization on growth at maturity, number of nodules, test weight, biological yield and harvest index

Treatment	Plant height (cm)	No. of branches plant^{-1}	DMC (g plant^{-1})	No. of nodule plant^{-1} at 30 DAS	Biological yield (q ha^{-1})	HI (%)
T_1	42.50	14.82	8.93	29.90	14.15	41.69
T_2	44.25	15.50	10.33	33.33	17.81	39.58
T_3	45.13	16.70	11.30	37.62	19.41	40.03
T_4	45.57	18.55	11.32	40.46	20.17	39.81
T_5	47.53	20.32	11.30	42.70	21.31	40.87
T_6	47.92	19.94	11.46	46.06	22.53	40.61
T_7	49.31	21.25	11.48	49.63	23.33	41.02
T_8	50.34	21.75	11.50	52.29	25.58	42.33
T_9	51.57	22.94	12.10	54.39	25.68	40.07
SEm±	2.518	0.78	0.056	2.571	0.571	-
CD*	NS	2.37	0.170	7.774	1.724	-

T_1: Control (RDF 20:40:0); T_2: RDF+Sulphur 20 kg ha^{-1}; T_3: RDF+Sulphur 40 kg ha^{-1}; T_4: RDF+Fe 2.5 kg ha^{-1}; T_5: RDF+Fe 5.0 kg ha^{-1}; T_6: RDF+Sulphur 20+Fe 2.5 kg ha^{-1}; T_7: RDF+Sulphur 20+Fe 5.0 kg ha^{-1}; T_8: RDF+Sulphur 40+Fe 2.5 kg ha^{-1}; T_9: RDF+Sulphur 40+Fe 5.0 kg ha^{-1}; DMC: Dry matter accumulation; *p=0.05; HI: Harvest index

3.2. Number of nodules plant^{-1}

The maximum number of nodules plant^{-1} (54.39) recorded in T_9 (RDF+Sulphur 40+Iron 5.0 kg ha^{-1}) at 30 DAS which were statistically at par with T_7 and T_8 but significantly superior than rest of the treatments (Table 1), while minimum number of nodules plant^{-1} was found (29.90) in T_1 (control) and number of nodules plant^{-1} in T_8 and T_9 increased by 74.88 and 81.90% over control. Number of nodules increased due to application of higher doses of Fe and S. because it increases the hemoglobin content in living nodules while S improved significantly plant biomass, number of nodules and biological yield. Similar observation was found by Singh and Syeed (2003).

3.3. Test weight

The S and Fe application had significant effect on test weight (g) of urdbean (Figure 1). The maximum number of test weight (44.60 g) recorded in T_8 (RDF+Sulphur 40+Fe 2.5 kg ha^{-1}) was statistically at par with T_4, T_6, T_7 and T_9 but significantly superior than rest of the treatments, while minimum test weight was found (35.80 g) under control plot.

3.4. Yields

The maximum grain yield (10.83 q ha^{-1}) and straw yield (15.39 q ha^{-1}) was recorded in T_8 (RDF+Sulphur 40+Fe 2.5 kg ha^{-1}) which were statistically *on par* with T_9, (10.83) and significantly superior to all the treatments (Figure 2) then it was reduced by reducing the level of S and Fe and reached to minimum under control plot (5.90 q ha^{-1}). Grain yield of treatment T_8 and T9 increased by 83.56 and 74.40%, respectively over control. While, minimum straw yield was also found (8.25 q ha^{-1}) in T_1 Due to higher sulphur and iron growth parameter and yield increased significantly. Iron is essential for plant functions such as, chlorophyll development, energy transfer within the plant, as a constituent of certain enzymes and proteins and also for plant respiration, and plant metabolism. Similar observation was found by Singh et al. (2008); Meena et al. (2013).

The data indicated that S and Fe application had significant effect on biological yield of urdbean (Table 1). The maximum biological yield 25.68 q ha^{-1} recorded in T_9 (RDF+Sulphur 40+Fe 5.0 kg ha^{-1}) which was statistically at par with T_8 but significantly superior than rest of the treatments, while

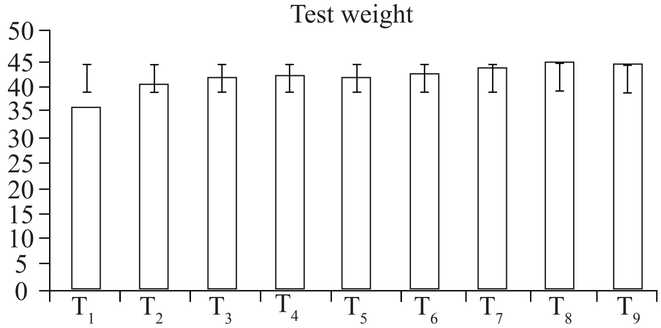

Figure 1: Test weight of urdbean as influenced by various treatments

minimum biological yield was found (14.15 q ha^{-1}) in T_1 (control). Biological yield increased by 80.77 and 81.48% in T_8 and T_9 respectively over control. The probable due to Iron is Essential element for plant functions such as, chlorophyll development, energy transfer within the plant, as a constituent of certain enzymes and proteins besides, above it also for plant metabolism and plant respiration. Similar observation was found by Karwasra et al. (2006); Meena et al. (2013).

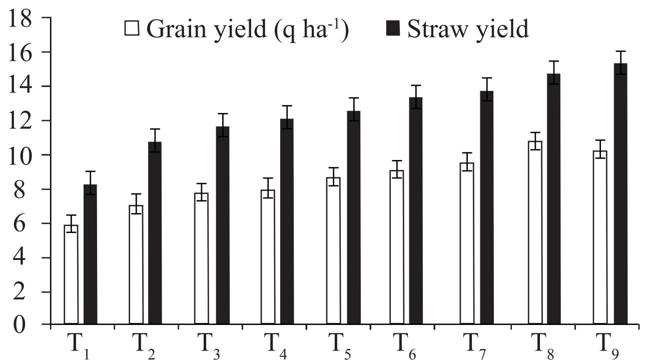

Figure 2: Grain and straw yield of urdbean as influenced by various treatments

The data pertaining on harvest index of urdbean as influenced by different sulphur and iron treatments are presented in Table 1. In urdbean, the maximum harvest index 42.33% recorded in T_8 (RDF+Sulphur 40+Fe 2.5 kg ha^{-1}) and minimum harvest index 39.58% recorded in T_2 (RDF+Sulphur 20 kg ha^{-1}).

3.5. Nutrients (N, P, K, S and Fe) uptake

Result showed that the application of higher level of iron and sulphur over RDF result a significant effect on nitrogen uptake (Table 2). Among sulphur and iron fertilization the maximum nitrogen uptake by urdbean grains recorded 36.77 kg ha^{-1} in RDF+Sulphur 40+Fe 2.5 kg ha^{-1} (T_8) was significantly higher than the nitrogen uptake recorded in T_2, T_3,T_4, T_5, T_6, T_7 and statistically at par with RDF+Sulphur 40+Fe 5.0 kg ha^{-1} (T_9) treatment. However, maximum nitrogen uptake (24.25 kg ha^{-1}) by urdbean straw recordedin RDF+Sulphur 40+Fe 5.0 kg ha^{-1} (T_9) was significantly higher than the nitrogen uptake recorded in T_1, T_2, T_3, T_4, T_5 and statistically at par to rest of the treatments. Moreover, the lowest nitrogen uptake by urdbean grains (17.14 kg ha^{-1}) and straw (9.07 kg ha^{-1}) recorded in Control (RDF) (T_1). Application of S resulted in significant increase in N uptake. The similar trends were observed by Singh and Prakash, (2000); Srivastava et al. (2006); (Kokani et al., 2014).

It is clear from the data that significantly highest phosphorus uptake by urdbean grains was observed in (2.77 kg ha^{-1}) RDF+Sulphur 40+Fe 2.5 kg ha^{-1} (T_8) than the phosphorus uptake recorded in T_1, T_2, T_3, T_4, T_5, T_6 and statistically at par to rest of the treatments. Application of higher level of iron and sulphur over RDF results a significant effect on phosphorus uptake. Moreover, maximum phosphorus uptake by urdbean straw was observed in RDF+Sulphur 40+Fe 5.0 kg ha^{-1} (T_9) followed by T_9, T_7 and T_6. The lowest phosphorus uptake was recorded in T_1 Control (RDF). Application of higher level of iron and sulphur over RDF results a significant effect on phosphorus uptake by straw due to P increased the root growth and development. Same observation was also found by Singh and Singh (2004); (Ganie et al., 2014).

The result shows that the application of higher level of sulphur and iron over RDF (control) results a significant effect on potassium uptake, although maximum potassium uptake by urdbean grains was observed in 5.87 kg ha^{-1} RDF+Sulphur 40 +Fe 2.5 kg ha^{-1} (T_8) as well as RDF+Sulphur 40+Fe 5.0 kg ha^{-1} (T_9) was significantly higher than the potassium uptake

Table: 2: Effect of sulphur and iron fertilization on N uptake, P uptake, K uptake, S uptake and Fe uptake

Treatment	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})		S uptake (kg ha^{-1})		Fe uptake (g ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1- Control (RDF 20:40:0)	17.14	9.07	1.18	0.82	2.08	11.19	0.88	0.85	74.25	305.49
T_2- RDF+Sulphur 20 kg ha^{-1}	22.00	12.72	1.543	1.16	2.98	13.68	1.27	1.16	90.75	381.11
T_3- RDF+Sulphur 40 kg ha^{-1}	24.61	16.33	1.81	1.51	3.57	16.81	1.55	1.51	100.54	493.35
T_4- RDF+Fe 2.5 kg ha^{-1}	25.57	17.26	1.69	1.32	3.29	17.52	1.27	1.33	105.84	515.50
T_5- RDF+Fe 5.0 kg ha^{-1}	28.58	18.25	1.84	1.51	4.20	18.80	1.49	1.50	126.98	548.26
T_6- RDF+Sulphur 20+Fe 2.5 kg ha^{-1}	30.96	20.67	2.09	1.87	4.73	20.39	1.92	1.87	133.71	595.60
T_7- RDF+Sulphur 20+Fe 5.0 kg ha^{-1}	32.80	21.84	2.36	2.19	5.35	21.27	2.22	2.11	142.23	621.72
T_8- RDF+Sulphur 40+Fe 2.5 kg ha^{-1}	36.77	23.26	2.77	2.49	5.87	22.47	2.63	2.34	162.79	679.22
T_9- RDF+Sulphur 40+Fe 5.0 kg ha^{-1}	35.26	24.25	2.58	2.76	5.87	24.34	2.61	2.61	156.81	714.76
SEm±	0.899	1.247	0.134	0.078	0.248	1.204	0.067	0.100	4.248	17.521
CD (p=0.05)	2.719	3.770	0.404	0.237	0.751	3.641	0.204	0.301	12.847	52.982

recorded in T_1, T_2, T_3, T_4, T_5, T_6 and statistically at par with RDF+Sulphur 20+Fe 5.0 kg ha^{-1} (T_7) treatment. However, RDF+Sulphur 40+Fe 5.0 kg ha^{-1} (T_9) noticed maximum potassium uptake by urdbean straw 24.34 kg ha^{-1} which was significantly higher than the potassium uptake recorded in T_1, T_2, T_3, T_4, T_5, T_6 and remained statistically at par with T_7 and T_8 the treatments, whereas lowest phosphorus uptake was recorded under T_1 Control. Application of higher level of iron and sulphur over RDF result a significant effect on potassium uptake, due to K use efficiency. Same observation was found by (Sharma et al., 2008).

The data revealed that the significant differences in sulphur uptake by grain and straw of urdbean were recorded owing to different sulphur and iron treatments. The sulphur uptake of grain and straw varied from 0.88 to 2.63 kg ha^{-1} and 0.85 to 2.61 kg ha^{-1}, respectively. The maximum sulphur uptake (2.63 kg ha^{-1}) was recorded in T_8 [RDF+Sulphur 40+Fe 2.5 kg ha^{-1}], which was significantly superior to other treatments, except T_9 which remained at par. However, the maximum sulphur uptake by straw (2.61 kg ha^{-1}) was recorded in T_9 (RDF+Sulphur 40+Fe 5.0 kg ha^{-1}) which were significantly superior to all of the treatments and at par with T_8. While whereas, minimum uptake in grain (0.88 kg ha^{-1}) and (0.85 kg ha^{-1}) straw was recorded in T_1, which was significantly lower than the all of the treatments. T_2 and T_3 were superior to T_1, T_2 and T_4 was significant to each other and lower than T_3 and T_5. The combination of higher level of sulphur and iron with RDF shows significant effect on sulphur uptake. It might be due to nutrient uptake favorably influenced by the residual effect of S which was evidenced through increased S use efficiency. The results are also supported by Bharathi and Poongothai (2008) and (Patil et al., 2010).

It is evident from the data that the significant differences in iron uptake by grain of urdbean were recorded owing to different sulphur and iron treatments. The iron uptake of grain varied from 74.25 to 162.79 g ha^{-1} while iron uptake of straw varied from 305.49 to 714.76 g ha^{-1}. The maximum iron uptake in grain (162.79 g ha^{-1}) was recorded in T_8 [RDF+Sulphur 40+Fe 2.5 kg ha^{-1}] which was significantly superior to other treatments and at par with T_9. However, maximum iron uptake in straw (714.76 g ha^{-1}) was found in T_9 [RDF+Sulphur 40+Fe 5.0 kg ha^{-1}], which was at par with T_8 (RDF+Sulphur 40+Fe 2.5 kg ha^{-1}) and significantly superior to rest of the treatments. While minimum iron uptake in grain (74.25 g ha^{-1}) and straw (305.49 g ha^{-1}) was recorded in T_1, which was significantly lower than the all of the treatments. Further more, T_2 and T_3 were superior then T_1, T_4 and T_5 were superior to T_2 and T_3, respectively in grain and in straw, T_3 is higher than T_2 and at par with T_4. T_5 is superior than T_1, T_2 and T_3 and at par with T_4 and T_6. Application of higher level of iron and sulphur over RDF a significant effect on iron uptake of urdbean straw. Higher active Fe content in basal application Fe treatments was assigned to reduction in rhizosphere pH due to the application of elemental S in the soil. Application of higher level of iron and sulphur over RDF gave significant effect on iron uptake. The similar trend was observed by (Meena et al., 2013); (Manasa et al., 2015).

4. Conclusion

RDF+S 40+Fe 5.0 kg ha^{-1} may be preferred over other treatments. So, Sulphur @ 40 kg ha^{-1} and Fe @ 5.0 kg ha^{-1} may be used along with nitrogen @ 20 kg and phosphorous @ 40 kg ha^{-1} for higher production of urdbean crop.

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