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Influence of Mn on dry yield and nutrient uptake by new jute variety BJRI Tossa-7

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ABSTRACT

A field experiment was conducted during the year 2018-2019 at the vital place of Bangladesh Jute Research Institute (BJRI), Dhaka. The aim of the study was to evaluate the influence of Mn fertilizer on the dry matter yield and potential nutrient uptake of the newly developed jute variety BJRI Tossa jute-7. The treatments used in the experiments were T_1: Control, T_2: RDF sole ($N_{90}P_{10}$ K_{30} S_{20}kg/ha), T_3: RDF + 1 kg Mn/ha, T_4: RDF + 2 kg Mn/ha, T_5: RDF + 3 kg Mn/ha and T_6: RDF + 4 kg Mn/ha. Mn application had a favorable effect on the dry matter yield of jute. Among the fertilizers of Mn with RDF, interaction promoted the dry yield biomass compared to sole RDF and control. Maximum dry matter yield (leaves + shoots + roots) achieved (20000 kg/ha) with T_5 (RDF + 3 kg Mn/ha) and minimum (6421 kg/ha) in T_1 (control). Study indicated that it needs to apply Mn to obtain optimum yield production. The interaction effect of Mn, NPK and S fertilizer significantly influenced nutrient uptake by the jute plant. The uptake of nutrient found highest N (218.9 kg/ha) in T_5, P (92.75 kg/ha) in T_3, K (239.73 kg/ha) with T_6, S (19.59 kg/ha) in T_4, Fe (0.64 kg/ha) in T_5, Zn (0.38 kg/ha) in T_5 and Mn (0.63 kg/ha) recorded in T_6. The amount of micro nutrient uptake may be arranged in the order of Mn >Zn> Fe. Considering the highest uptake of major element, it can be kept as in the order of K > N>P>S. Study indicated that a higher rate of nutrient uptake was promoted dry matter accumulation in jute. Research revealed that the rate of nutrient uptake maximized with the addition of Mn in the RDF treatment. Hence, it could be concluded that applying RDF + 3 kg Mn/ha may be a suitable dose for optimum yield production of jute. Yet, in order to draw a sound conclusion, repeating the experiment is needed. In the future, the study will be a guideline for further investigation.

Keywords: Manganese, Jute, *Corchorus olitorius*, Dry yield, Nutrient uptake

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Introduction

Nutrient availability has a direct impact on agricultural productivity and output. Adequate plant nutrition with micronutrients depends on many factors, including the ability of soil to supply these nutrients, the rate of absorption of nutrients to functional sites and nutrient mobility within the plants (Abbas *et al.,* 2011). Availability of nutrients sometimes increases with the presence of some specific nutrient, which work together to increase soil productivity. Marschner *et al.* (1991) demonstrated that increased Mn concentration has a marked effect on the growth of rhizosphere bacteria and plant growth by developing the availability of nutrients. Manganese (Mn) stimulates germination and plant development and is essential for growth (Clark and Fly, 1930). There are references that due to deficiency of Mn can cause a considerable reduction in crop yield (Soltanghersi *et al.,* 2014). The earlier worker reported that the Mn supply with essential NPK and S is one of the most important factors in increasing crop yield (Abbas *et al.,* 2011).

The Mn interacts with the major elements and boosts up the crop plants. One of the factors influencing crop yield is nutrient interaction in crop plants. The interaction of nutrients in terms of crop growth and nutrient concentrations in plant tissue can be either positive, negative or neutral (Fageria and Baligar, 1997). One example of this type of the interaction is the decrease in the concentration of Fe, Zn, Cu and Mn with liming of acid soils (Fageria, 2000; Fageria *et al.*, 2002). Generally, the inter-action effect is measured in terms of growth response and change in the concentration of nutrients (Fageria, 2001).

Interaction between nutrients in crop plants occurs when the supply of one nutrient affects the absorption and utilization of other nutrients. An interaction occurs when the level of one nutrient influences the other in relation to plant growth (Olsen, 1972). Interaction between two nutrients may take place in the soil or within the plant. A nutrient may reduce the translocation rate of the other nutrient, cause the enhancement of the yield and decrease the concentration of the other nutrient (dilution effect), or reduce the uptake of the other nutrient at the site of absorption by the roots. This type of interaction is most common when one nutrient is in excess concentration in the growth medium (Fageria *et al.*, 1997). Nutrient interaction is influenced by factors such as concentration of nutrients, temperature, light intensity, soil aeration, soil moisture, pH, architecture of root, the rate of plant transpiration and respiration, plant age and growth rate, plant species and internal nutrient concentration of plants (Fageria, 2001). Various studies have shown that micronutrients significantly affect other nutrient availability.

Like other micronutrients, Mn has also been observed to affect nutrient uptake through some studies. Mn is an essential nutrient that markedly influences the availability of N, P, K, S, Fe and Zn (Abbas *et al.*, 2011). However, the literature contains very few studies that are focused on the interaction between Mn and other nutrients. The few published studies show that Mn sources influence nutrient availability and uptake by potato plants grown in sand cultures (Cheng and Ouellette, 1970). Moreover, no prior reports, for jute crop, could be found on the impact of Mn on the availability of other nutrients, which is globally important cash crop. Crop productivity growth depends on soil fertility, which is relied on the availability of all essential macro- and micronutrients.

Considering the above facts, a study was initiated to evaluate the influence of Mn fertilizer on the dry matter yield and nutrient uptake capacity of newly developed jute variety BJRI Tossa jute-7.

Materials and Methods

Location

The field experiment was conducted during the year 2018- 2019 at the central station of Bangladesh Jute Research Institute (BJRI), Manik Mia Avenue, Dhaka. The experimental field is situated between Latitude 23º45′26″N and 90º 22′ 33″ E longitude at normal flood level. The sea level of the study area is 32 meters and the soil of the experimental field belongs to the Tejgoan series under the Agro-ecological zone-12.

Land preparation

The land was prepared with power tiller, followed by harrowing and laddering. The individual plots were surrounded by 7.5 cm dikes to restrict the lateral runoff of irrigation and/or rainwater. Besides the plots, 10 cm deep furrows were made for easy passage of excess water. The total experimental area was divided into three blocks, and within each block, there were six experimental plots, following a randomized complete block design (RCBD). The dimension of each plot was 3.0 m × 2.1 m having one-meter space between the plots, blocks, and around the field.

Collection of jute seeds

The jute seed was collected from the breeding division of BJRI for sowing in the experimental field.

Variety used

Newly developed *Chorchorus olitorius* jute variety, BJRI Tossa Jute-7 was the test crop in this experiment.

Treatments

The experiment consisted of six treatments, *viz.*,

T_1: Control (no application of any fertilizer)
T_2: RDF sole ($N_{90}P_{10}$ K_{30} S_{20} kg/ha) (Fertilizer Recommendation Guide, BARC, 2012).
T_3: RDF + 1 kg Mn/ha
T_4: RDF + 2 kg Mn/ha
T_5: RDF + 3 kg Mn/ha
T_6: RDF + 4 kg Mn/ha

(RDF= Recommended dose of inorganic fertilizer)

Fertilizer application

Half of the total amount of N from urea and a full dose of P, K, S and Mn were applied from TSP, MoP, Gypsum and Manganese sulfate, respectively, at the time of sowing as per treatment. The rest of the N from urea was top-dressed after 6 weeks of sowing.

Sowing

Before sowing the seeds, a germination test was done in the laboratory. One hundred pure seeds of were placed in Petri dish containing filter paper soaked with distilled water. The Petri dishes were placed in room temperature (30 ± 2 °C) for 5 days for germination. A seed was considered to be germinated as the seed coat ruptured and plumule and radicle came out up to 2 mm in length. (Krishnasamy and Seshu, 1990). The seeds of the newly developed *Chorchorus olitorius* jute variety, BJRI Tossa Jute-7 were capable to germinate up to 95%. The seeds were sown in line. The line-to-line and plant-to-plant distances were kept at 30 cm and 10 cm, respectively.

Intercultural operations

After the sowing, watering was done through a furrow irrigation system to maintain the water supply to the plots for good germination. Soil was loosened in the line by using a hoe at 25 days of sowing (DAS) for weed suppression, allowing air and rain-fed water to penetrate in the soil for healthy plants. Gap filling activities was done by re-sowing seeds immediately. The weeding and thinning were done at 8, 25 and 45 days after the sowing of seeds. Pesticides were applied as and when necessary.

Harvesting and processing of the plant samples

The jute plants were harvested 120 days after the date of seed sowing. The weight of the stick, fiber, and green plants was taken by a simple weight machine. The plants were uprooted during the harvest, and the roots were washed with distilled water to remove any adhering particles from the root surface. The collected plants were separated into different plant parts like roots, stems and leaves. The fresh weight of the samples was taken and retained these materials in an envelope (made from paper). After that, the plant samples were kept in an oven at 65^{o} C for 48 hours because of well dried. The oven dry weight was taken. The dried samples were then ground separately and preserved properly in plastic bottles for chemical analysis.

Data collection

The following data were collected throughout the experimental periods to determine plant uptake: Oven dry weight of the plant parts, total biomass, total N, P, K, S, Mn, Fe, and Zn.

Chemical analysis of plant sample

Plant Sample processing

Oven-dried roots and stems were chopped into small pieces by a local chopping device. Jute plant components, such as leaves, roots, and stems, were ground independently. In addition, airtight plastic containers held the ground materials.

Digestion of plant samples with Conc. nitric acid and perchloric acid

An amount of 0.5 g of plant sample was taken into a clean dry 50 ml beaker, and 15 ml of nitric acid was added and kept overnight. Then the beaker was heated in the sand bath until the solution reduced up to 1 ml. Then 5 ml of perchloric acid was added after cooling the solution and then again heated until the solution turned white. After cooling the solution, every sample was filtered with distilled water and stored in a plastic bottle. Th extract was used to determine total P, K, S, Fe, Zn and Mn.

Phosphorus

Phosphorus content in plant samples was determined by the yellow colour method (Jackson, 1962) with the help of a spectrophotometer.

Potassium

Potassium was determined directly by flame photometer, as described by Jackson (1973).

Sulphur

Sulphur content in the digest was estimated by the turbidimetric method as described by Hunt (1980) using a spectrophotometer.

Total Mn, Zn and Fe

Total Zinc, Iron and Manganese contents in the samples were determined through atomic absorption spectrophotometer from digested soil followed by standard method. (Huq and Alam, 2005).

Digestion and distillation process for total nitrogen in plant sample

The total nitrogen of the plant was determined by the micro Kjeldahl method, where samples were digested with 3 g digestion mixture (460 g Na_2SO_4+ 20 g $CuSO_4$+ 3 g Selenium powder) and sulfuric acid. After getting the white solution, samples were poured into 50 ml plastic bottle and then distilled with 40%NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01N H_2SO_4 (Black, 1965).

Nutrient uptake

Nutrient uptake (kg/ha) of different plant parts was calculated from the data of dry matter yield and nutrient content of different plant samples using the following formula:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Percent nutrient content} \times \text{Total dry matter (Kg/ha)}}{100}$$

Table 1. Oven dry wt. of plant parts.

Treatments	Oven dry weight of plant parts (kg/ha)			
	Leaves	Shoot	Root	Total biomass (leaves + shoot + roots)
T_1- Control	820	4440	1170	6421 e ± 0.53
T_2-RDF sole ($N_{90}P_{10}$ K_{30} S_{20}Kg/ha)	1580	7230	2110	10920 d ±1.13
T_3-RDF + 1 kg Mn/ha	2670	12000	3480	18150 c ±0.95
T_4-RDF + 2 kg Mn/ha	2900	12520	3510	18930 ab ±0.72
T_5-RDF + 3 kg Mn/ha	2940	13820	3240	20000 a ±1.24
T_6-RDF + 4 kg Mn/ha	2880	12700	2760	18340 bc ±0.71

In a column, means with the same letter do not differ significantly, whereas means with dissimilar letters differ significantly at 5% level (by Tukey).

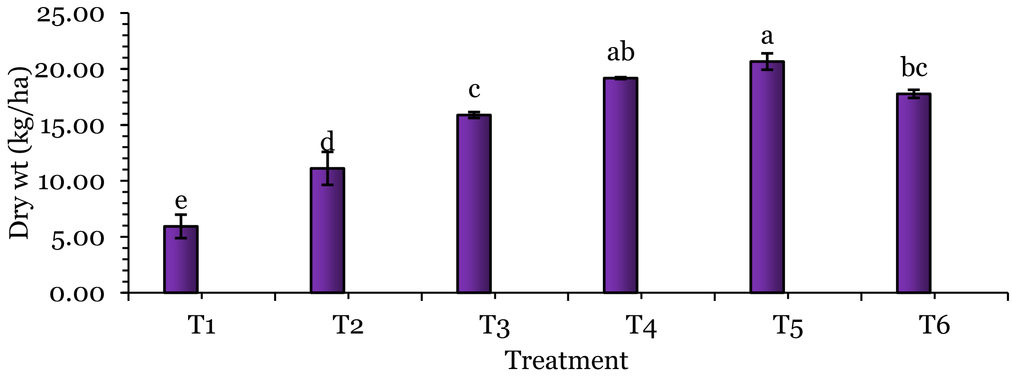

Fig. 1. Dry weight of jute plant after Mn application.

Statistical analysis

Statistical analysis was done by using Minitab 17. Analysis of variance (ANOVA) was done following the principle of F-statistics and the mean values were separated by Least Significant Difference (LSD) (Gomez and Gomez, 1984). Tukey method for grouping information was done by using Minitab 17. The graphical presentation of the data was performed using the statistical software Minitab v.18 and Microsoft Excel 2016.

Results and Discussion

Dry matter yield

There was a highly significant effect of Mn nutrient on dry matter yields of different plants parts of jute with successive increases in Mn level (Table 1).

The most important factor is dry matter yield to estimate the nutrient uptake. All the Mn treated plots yielded higher dry materials over the control (T_1) and sole RDF (T_2) applications. The maximum dry matter yield (leaves + shoots + roots) achieved (20000 Kg/ha) with T_5 (RDF + 3 kg Mn/ha) (Fig.1) and minimum (6421 Kg/ha) in T_1 (control). Highest dose of Mn in T_6 (RDF + 4 kg Mn/ha) yielded lower (18930 Kg/ha) than T_4-RDF + 2 kg Mn/ha were achieved 18340 Kg/ha dry yield. Findings of the dry matter yield found similar with 1, 2 and 4 kg/ha Mn. In fact, Mn added treatments enhanced the dry yield of jute biomass. The results are the consent of Fageria (2002), who found that the dry matter yield of upland rice was significantly increased with the micronutrient application. Increased biomass (Table 1) realizes that fiber yield, green yield and stick yield will also increase with Mn fertilizer (Gani *et al.*, 1999).

The result showed that Mn application played a significant role in the uptake of N, P, K, S, Fe and Zn (Table 3 and 4). The uptake of nutrients in plants is important for determining the growth rate and interactions between the nutrients. There have been many previous experiments on the effects of macronutrients on the uptake of nutrients. However, there was little evidence of the act of Mn on nutrient uptake by jute plants. The uptake of N, P, K, S, Fe and Zn by jute is influenced by applied Mn fertilizers as shown in Table 3 and 4.

Nitrogen (N) uptake

The uptake of N was increased by the different treatments (Table 3). In all the treatments, N uptake was increased significantly except for T_1 and T_6 treatments. The uptake ranged from 48.84 kg/ha to 218.9 kg/ha. The highest amount of nitrogen (218.9 kg/ha) uptake was recorded in T_5 (3 kg Mn), which was about 348.2% higher than T_1 (Control) and the second highest (199.29 kg/ha) was found in T_4 (2 kg Mn) which was 308.05% over control. The lowest amount of N (48.84 kg/ha) was taken up in the control treatment where no Mn fertilizer was applied which indicated that Mn fertilizer is required to increase the uptake of N in jute. The results were also supported by El-Fouly *et al.*, 2012. They found that using micronutrients like Mn, Zn with NPKS enhanced the uptake of N with other nutrients in maize.

Phosphorus (P) uptake

Mn fertilizers influenced the P uptake by jute plants. Total uptake of P varied due to the treatment variation. Phosphorus uptake under manganese added treatments initially increased and showed a decreasing trend with the gradually incremental doses of Mn (Table 3). The study correlates with the findings in potato (Sarkar *et al.* 2004) and in tomato (Gunes *et al.* 1998). The P uptake ranged was 13.83 kg/ha to 92.75 kg/ha. The highest amount of P (92.75 kg/ha) uptake was recorded in T_3 (1kg Mn), which was about 570.64% higher over T_1 (Control) and the second highest (51.88 kg/ha) was found in T_4 treatment (2 kg Mn) which was 275.13% over control. The lowest amount of P (13.83 kg/ha) was taken up in the control treatment where no Mn fertilizer was applied which revealed that Mn fertilizer has an antagonistic relationship with P. Nogueira *et al.* (2004) reported increased Mn reduced P in soybean shoots and roots. They also reported that an increase amount of Mn can retard the uptake of phosphorus due to pH changes in soil and form complexity of phosphorus.

Table 3. Effect of Mn fertilizer on Macronutrient uptake.

Treatments	Plant parts	Uptake of nutrient kg/ha			
		N	P	K	S
T_1 - (Control)	Leaves	15.58	2.29	16.56	0.41
	Shoot	27.53	9.32	36.41	1.78
	Root	5.73	2.22	6.32	0.23
	Total	48.84 f	13.83 f	59.29f	2.42f
T_2 - RDF sole ($N_{90}P_{10}$ K_{30} S_{20} Kg/ha)	Leaves	38.86	6.79	35.08	1.58
	Shoot	47.72	28.92	73.75	5.06
	Root	11.61	4.85	11.39	1.27
	Total	98.19 e	40.56 e	120.22 e	7.91e
T_3- RDF + 1 kg Mn/ha	Leaves	57.41	12.01	59.54	3.20
	Shoot	109.2	69.6	136.8	13.2
	Root	15.66	11.14	19.84	1.39
	Total	182.07 c	92.75 a	216.18 d	17.79 c
T_4-RDF + 2 kg Mn/ha	Leaves	73.37	13.05	73.66	5.51
	Shoot	107.67	30.05	127.70	11.27
	Root	18.25	8.78	20.71	2.81
	Total	199.29 b	51.88 b	222.07 c	19.59 a
T_5-RDF + 3 kg Mn/ha	Leaves	76.44	14.41	73.79	4.12
	Shoot	128.53	26.26	140.96	12.44
	Root	13.93	9.07	18.14	2.27
	Total	218.9 a	49.74 c	232.89 b	18.83 b
T_6-RDF + 4 kg Mn/ha	Leaves	73.15	15.55	74.30	4.32
	Shoot	88.9	22.86	148.59	10.16
	Root	14.63	8.56	16.84	1.10
	Total	176.68 d	46.97 d	239.73 a	15.58 d

In a column, means with the same letter do not differ significantly, whereas means with dissimilar letters differ significantly at 5% level (by Tukey).

Potassium (K) uptake

Results of the experiment showed that the uptake of K was increased with increasing doses of Mn. There was a significant variation in the amounting of up taken of K between the maximum (239.73 kg/ha) with T_6 and the minimum (59.29 kg/ha) in T_1.

In all the Mn fertilized treatments, K uptake was increased significantly over T_1 (Control) and T_2 (RDF). The highest amount of K (239.73 kg/ha) uptake was recorded in T_6 (4 kg Mn) 304.33% higher over T_1 (Control) and the next highest (232.89 kg/ha) was found in T_5 (3 kg Mn) which was 292.79% over control. The Lowest amount of K (59.29 kg/ha) was taken up in control (T_1) where no Mn addition. It revealed that Mn fertilizer has a synergistic relationship with K. Similar trends of results were obtained by Heenan *et al.* (1981), who reported that the manganese containing (275 µM) solutions increased the solution concentration of potassium from 1 µM to 10 µM alleviated symptoms of manganese toxicity, decreased manganese concentration in the leaves and increased dry matter yields of the plant. Although Xu *et al.* (2007) found no significant influence of Mn on K uptake.

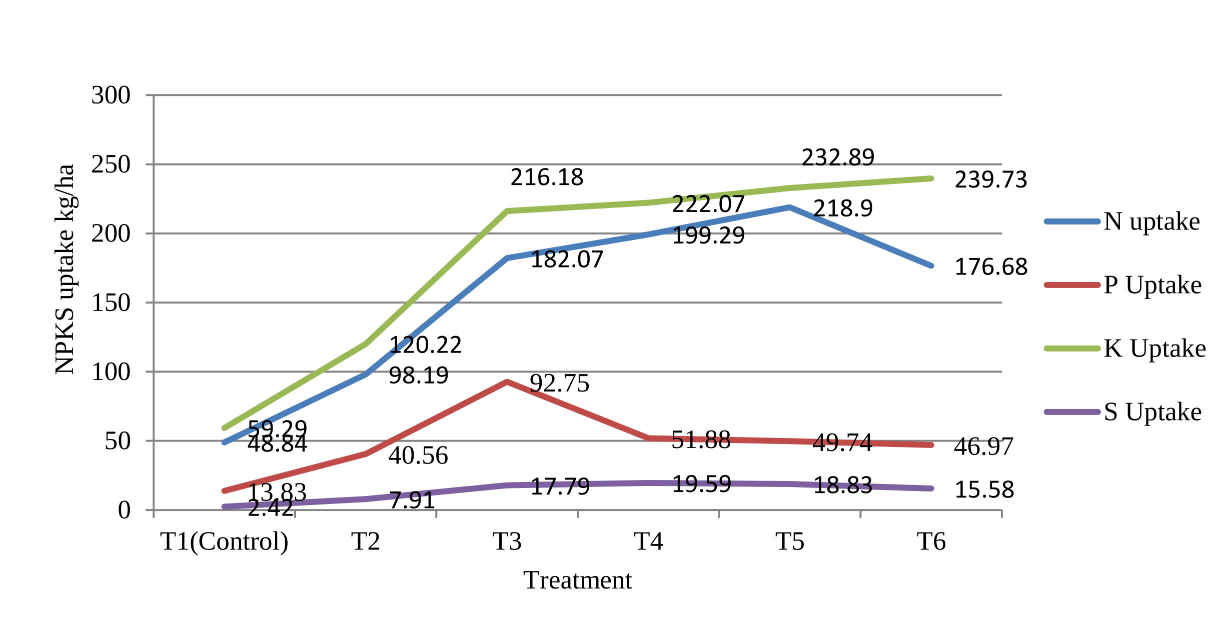

Fig. 2. Graphical presentation of NPKS uptake by jute plant.

Fig. 2 shows that Mn applications have different effects on different macronutrients. The highest uptake of K (239.93 kg/ha) was found under T_6 (RDF + 4 kg Mn/ha) treatment, but the highest content N (218.9 kg/ha) was found in T_5 (RDF + 3 kg Mn/ha) treatment where P was recorded with T_3 (RDF + 1 kg Mn/ha) treatment and S (19.59 kg/ha) with T_4 (RDF + 2 kg Mn/ha) treatment.

Sulfur (S) uptake

The uptake of S pronounced (Table-3) with the Mn treatments. Results showed that the jute plants up taken adequate amount of S in the presence of Mn. Peng *et al.* (2008) and Yadav (2010) reported that some species capable of high manganese accumulation, such as *Phytolacca americana* show a positive relationship between sulfur and manganese. The findings of the study reflected that the maximum dose of Mn in T_6- (RDF + 4 kg Mn/ha) reduced the S uptake. The highest amount of S uptake was taken by the jute plants in T_4 (19.59 kg/ha), which was about 709.50% higher than T_1 (Control) (2.42 kg/ha). After T_4 treatment S uptake gradually decreased, which revealed that Mn fertilizer has an effective role on S uptake up to a certain amount of Mn. This is the agreement of Lee *et al.* (2011), who conducted an experiment with *Brassica rapa* and he observed that the availability of sulfur decreases with Mn toxicity. These results are supported by similar findings of Neves *et al.* (2017). They found a negative interaction between sulfur and manganese at toxic levels of Mn, but positive relation was also noticeable at elevated Mn^{2+} levels.

Iron (Fe) uptake

Results showed that the uptake of Fe increased with the doses of Mn at a certain limit (3 kg/ha) and decreased with the supreme dose 4 kg /ha Mn addition (Table 4). The uptake ranged from 0.09 kg/ha to 0.64 kg/ha. The highest amount of Fe (0.64 kg/ha) uptake was recorded in T_5 (RDF+ 3 kg Mn/ha), which was 611.11% higher than T_1 (Control) and the second highest (0.36 kg/ha) was found in T_4 (2 kg Mn) which was 300% higher over control. The lowest amount of Fe (0.09 kg/ha) was taken up in control, where no Mn fertilizer was applied, which revealed that Mn fertilizer is required to increase the uptake of Fe in jute. A similar result was also obtained by Beauchamp and Rossi (1972). They observed that most iron is retained in the roots at high Mn concentration, which is related to Moosavi and Ronaghi (2011) observation. They stated that a high level of Mn application decreases Fe translocation from root to shoot. This kind of Mn-Fe interaction is also noticeable in this experiment, showing that iron uptake increased from T_3 to T_5 and decreased with overdoses T_6. It might be the cause of the Mn toxicity or oxidation of iron by manganese. This result also supports the findings of Wallace (1943); Chinnery and Harding (1980); Zahariea (1986); Roomizadeh and Karimian (1996); Dokiya *et al.*, (1968) and Fageria, (1990).

Zinc (Zn) uptake

The effect of Mn fertilizer on Zn concentration in plants and the correlation between Zn and Mn in plants seems optimistic. The present study revealed that the plants of treatment T_5 uptake the highest amount of Zn (0.38 kg/ha) when using 3 kg Mn fertilizer, which support the experiment of Soltangheisi *et al.*, (2014). They found the effective impact of Mn fertilizer on Zn uptake in sweet corn. The second highest (0.36 kg/ha) amount of Zn was obtained in T_4, which was about 220.07% over control. The lowest (0.113 kg/ha) amount of Zn was found in T_1 (Control). Similar results were obtained by Yoshiaki and Ando (1968), Olsen (1972), and Foy *et al.* (1978).

Manganese (Mn) uptake

The experiment demonstrated that manganese uptake was increased with the application of Mn fertilizer. Mn uptake was poor in T_1 (Control) and T_2 (RDF). The uptake was ranged from 0.14 kg/ha to 0.63 kg/ha. The highest amount of Mn (0.63 kg/ha) uptake was recorded in T_6 (RDF+4 kg Mn) and 356.49% higher over T_1 (Control). The lowest amount of Mn (0.14 kg/ha) was taken up in control, where no Mn fertilizer was applied. This is similar to the findings of Wang *et al.* (2019). They demonstrated that the concentration of Mn was enhanced in the leaf with the presence of Mn in soil.

Table 4. Micronutrient uptake.

Treatments	Plant parts	Uptake of nutrients (kg/ha)		
		Mn	Fe	Zn
T_1- Control	Leaves	0.087	0.06	0.05
	Shoot	0.024	0.02	0.038
	Root	0.027	0.01	0.024
	Total	0.14 f	0.09 f	0.113 f
T_2-RDF sole ($N_{90}P_{10}$ K_{30} S_{20} Kg/ha)	Leaves	0.14	0.05	0.08
	Shoot	0.13	0.02	0.06
	Root	0.07	0.04	0.05
	Total	0.34 e	0.11 e	0.19 e
T_3-RDF + 1 kg Mn/ha	Leaves	0.19	0.24	0.19
	Shoot	0.16	0.11	0.07
	Root	0.18	0.01	0.07
	Total	0.53 d	0.36 c	0.33 d
T_4-RDF + 2 kg Mn/ha	Leaves	0.23	0.42	0.21
	Shoot	0.17	0.03	0.07
	Root	0.17	0.10	0.08
	Total	0.57 c	0.55 b	0.36 b
T_5-RDF + 3 kg Mn/ha	Leaves	0.28	0.46	0.22
	Shoot	0.17	0.12	0.08
	Root	0.17	0.06	0.08
	Total	0.62 b	0.64 a	0.38 a
T_6-RDF + 4 kg Mn/ha	Leaves	0.22	0.26	0.21
	Shoot	0.14	0.01	0.07
	Root	0.27	0.02	0.07
	Total	0.63 a	0.29 d	0.35 c

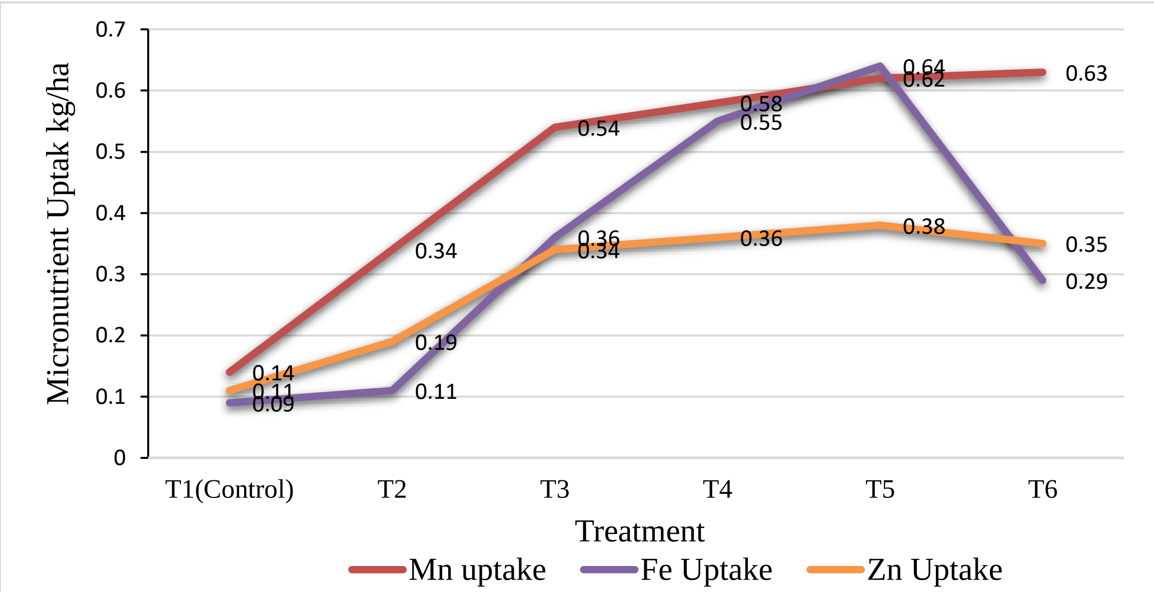

Fig. 3. Graphical representation of Fe, Zn and Mn uptake by jute plant.

Figure 3 shows that the maximum amount of Fe, Zn and Mn have been uptake by the plant of T_5 treatment, which discloses that 3kg Mn will be the best dose for the jute plant.

Conclusions

All the Mn treatments produced a higher rate of dry matter yield over RDF (T_2). Maximum dry matter yield (leaves + shoots + roots) achieved (20000 kg/ha) with T_5 (RDF + 3 kg Mn/ha) and minimum (6421 kg/ha) in T_1 (control). Nutrient uptake by the jute plant was significantly influenced by the interaction effect of Mn, NPK and S fertilizer. Study indicated that a higher rate of nutrient uptake was promoting dry matter accumulation in jute. Research revealed that Mn is needed to optimize jute yield. To draw a sound conclusion, repeating the experiment is needed. In the future, the study will be a guideline for further investigation.

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