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Response of micronutrients and urea foliar spray on yield and nutrient uptake of safflower (*Carthamus tinctorius* L.) in Chhattisgarh plan

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Abstract
The present investigation was conducted in order to augment yield and yield attributes of safflower through foliar spray of micronutrients combination and nitrogen foliarapplication along with General Recommended dose GRD(55:25:20). The experiment was carried out during *rabi*2013-14 and 2014-15 at the Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh in randomized block design with three replications and twelve treatments namely absolutely control, 100% GRD (withoutspray),100% GRD with tap-water spray, 100% GRD+ 1% N foliar spray, 100% GRD+ 0.2% Fe foliar spray, 100% GRD+ 0.5% Zn foliar spray,100%GRD+ 0.3% Mnfoliar spray, 100% GRD+Fe 0.2% + Mn 0.3% foliar spray, 100% GRD+ Fe 0.2%+ Zn 0.5% foliar spray, 100% GRD+ Mn 0.3%+ Zn 0.5% foliar spray, 100% GRD+Fe 0.2% + Mn 0.3%+ Zn 0.5% foliar spray and 100% GRD Fe 0.2% + Mn 0.3%+ Zn 0.5% + 1% ureafoliar spray. The treatment100%GRD + Fe 0.2% + Mn 0.3%+ Zn 0.5% + 1% ureafoliar spray would be a sound combination of nutrients to get higher capitulum plant^{-1}, seed, number of seeds capitulum^{-1} seed and stover yields, and sustained the soil physico-chemical properties. The treatments Fe 0.2% + Mn 0.3%+ Zn 0.5% + 1% urea foliar spray with GRD and Fe 0.2% + Mn 0.3%+ Zn 0.5% with GRDwere superiorto application of GRD alone with respect to capitulum plant^{-1}, number of seeds capitulum^{-1} seed and stover yields, uptake of macronutrientsnitrogen, phosphorus and micronutrients iron, manganese and zinc by safflowerplant and increases seed yield by 28.24 percent over GRD alone.

Keywords: Foliar spray, micronutrient and macronutrient uptake GRD, biological yield, safflower

Introduction

Safflower (*Carthamus tinctorius* L.) is an important annual winter oilseed crop grown in dry and semi dry lands with ability to withstand drought, salinity and cold stress of Southern Asia and India. India stands first in area (51%) and production (37%) in the world. Itsaverage productivity is 498 and 286 kg/ha in India and Chhattisgarh state, respectively (Annual Research work shop on safflower, 2013) [1]. The seed oil content consisting of about 90% unsaturated fatty acid (oleic acid and linoleic acid) which placing it as one of the best oil for human consumption (Rahamattala. *et al*., 2001). [14]

It is grown by the poor farmers on rained marginal lands with limiting nutrients availability which are the main reasons for the low acreage, yield and economic outcome. Therefore, the variety with high production potential and nutrient management along with support price can be effective in country's oil needs.

Therefore, under such conditions foliar fertilizers as desired necessary in turn to enhance plant growth, yield and quality og the crop. In rainfed, arid and semiarid regions, foliar application of nutrients is a more suitable option compared with soil fertilization when the roots are unable to provide necessary nutrients. Other advantages are quick compensation of nutrient deficiency and application of lesser rates and thus, reducing toxicity arises from excessive accumulation of elements and preventing nutrients fixation in the soil.

In biological system, the micronutrients are needed in low enough concentrations but no way are micro in their role, rather they play major role in enhancing efficiency of other nutrients there by it helps in the physiological processes of growth and development (Shukla *et al*., 2009), [45] yield and quantitative parameters of crops (Tavassoli *et al*., 2010; Nagaraj, 1987; Mosavi *et al*., 2007; Paygozar *et al*., 2009) [13, 9, 7, 10] and manganese and zinc can play an important role in nutrition of oil plants. Production of biomass, grain yield, quality and quantity of oil (Kaya and Higgs, 2002; Cakmak, 2008) [3, 2].

Among micronutrients, Zinc (Zn) is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes (Grotz and Guerinot, 2006) [15] manganese (Mn) in turn, is regarded as an activator of many different enzymatic reactions and takes part in photosynthesis.

Manganese activates decarboxylase and dehydrogenase and is a constituent of complex PSII-protein, SOD (superoxide dismutases) and phosphatase. Deficiency of Mn induces inhibition of growth, chlorosis and necrosis, early leaf fall and low reutilization (Kabata-Pendias and Pendias, 1999) [16] Several researches indicated a positive influence of micronutrient (Zn, Mn) application in increase of yield and quantitative parameters of crops viz. potato (Mosavi *et al*., 2007) [7], pearl millet (Paygozar *et al*., 2009) [10]. Seifi Nadergholi *et al* (2011) [17] indicated that Zn and Mn foliar application noticeably raised common bean yield components. Berglund (2002) [18] noted that Zn foliar application particularly increased soybean seed yield. Bozoglu *et al* (2007) [19] stated that foliar application of micronutrients (Zn) on chickpea could be implemented for higher yield and quality. Randall *et al* (1970) [20] reported that foliar application of 0.17 to 0.51 kg Mn-EDTA ha^{-1} resulted in higher yield of soybean.

Foliar application of micronutrients (iron and zinc)in growth various stages of sunflower had significant positive effect on 1000-seed weight, plant height, biological yield, grain yield, harvest index and oil content (Babaeian *et al*., 2011) [21] Research results of Rashid *et al*. (1994) [22] and Prasad and Prasad (1994) [23] reported that with foliar spraying of copper and zinc, the yield of rapeseed and oil and protein content of the seeds increased significantly. Movahedi-Dehnavi *et al*. (2009) [24] and Lewis and McFarlane (1986) [25] reported that in micronutrients deficiency condition, use of micronutrients on shoots lead to increasing quantity and quality of safflower. Sangale *et al*. (1981) [26] reported that safflower plants sprayed with B, Fe, Zn and a combination of B+Zn showed significant increment of grain yield, and among these treatments the most seed yield was achieved from spraying with B micronutrient.

Micronutrients such as manganese and zinc can play an important role in nutrition of oil plants. In plants, zinc fertilizer should use at least once, twice or three times at one year and manganese can be used at least once at one year for field and horticulture crops (Khoshgoftar Manesh *et al*., 2010) [4]. It seems that critical level of zinc and manganese in soil is 1mg kg^{-1} and less than 10mg kg^{-1}, respectively (Marschner, 1995) [6]. Zinc also plays an important role in the production of biomass, grain yield, quality and quantity of oil (Kaya and Higgs, 2002; Cakmak, 2008) [3, 2].

The availability of applied macro and micro-nutrients is affected by the various soil environmental factors. Nutrients feeding through foliar technique to supply the nutrients can avoid these factors and results in rapid absorption. Foliar feeding of nutrients generally is more effective, less costly and also improves nutrient use efficiency and lower environmental pollution through reducing the amount of fertilizers added to soil. On the other hand, foliar feeding of a nutrient may actually promote root absorption of the same nutrient (Oosterhuis, 1998) [27] or other nutrients through improving root growth and increasing nutrients uptake (El-Fouly 1997, and El-Sayed, 1999) [28] Soil application of N fertilizers may lead to losses of the nutrient especially through leaching and denitrification, however foliar spray application may decrease such losses.

Methods and materials

Field experiment was carried out during *rabi* seasons of 2013-2014 and 2014-2015 at the Research Farm, Indira Gandhi Agricultural University, Raipur (C.G.) Theclimate of this region is dry moist, sub humid and the region receives 1200-1400 mm rainfall annually, out of which about 88 per cent is received during the months from June to September and 8 per cent during October to February) The experimentalsoil isclayey withpH 7.2,available N,P,K and S levels were 228, 22.7, 478 and 23 kg ha^{-1},micronutrients viz., Fe, Mn and Zn were 8.83, 8.37 and 0.8 mg kg^{-1}, respectively.The fertilizer doses GRD was 50-25-20 kg N, P_2O_5 and K_2O ha^{-1} respectively applied in all the treatments. Phosphorus and potash were applied as basal through di-ammonium phosphate and muriate of potash, respectively. Urea foliar spray as per treatments applied thrice, first at 45 days after sowing (i.e. during branching stage), followed by the second and third at 15 days interval. Micronutrients were foliarly applied at branching stage only (45 DAS) though individual EDTA salt.

Number of capitulum per plant and seeds in capitulum was counted from marked five plants at 90 DAS. Test weight of 100 seeds, seed and stover yield was also recorded from net plot. Initial and after harvest soil sample were collected and analysed for soil pH, EC, macro and micronutrients status by adopting standard laboratory methods.

Results and discussion

Number of capsules $plant^{-1}$ and number of seeds $capitulum^{-1}$

Effect of nitrogen and micronutrients foliar spray onnumber of capitulum $plant^{-1}$ is presented in table 1 and fig.1 which showed that it was significantly higher when compared with control treatment (N0:P0:K0), while non significant when compared with GRD. The highest number of capitulum $plant^{-1}$ was recorded in T9 (Fe 0.2% + Zn 0.5%, followed by T10 GRD + Mn 0.5%+ Zn 0.3%,T12 GRD +Fe 0.2% + Zn 0.5%+ Mn 0.3%+N 1%, T8 GRD+ Fe 0.2% +Mn 0.3%, T11GRD+ Fe 0.2% +Zn 0.5%+Mn 0.3%, T7 GRD+ Mn 0.3%, T6 GRD+ Zn 0.5%and T5 GRD+ Fe 0.2%.

The effect of different treatments on number of seed $capitulum^{-1}$ was significant when compared with control treatment (N0:P0:K0), while the treatments i.e T12 GRD +Fe 0.2% + Zn 0.5%+ Mn 0.3%+N 1% and T11GRD+ Fe 0.2% +Zn 0.5%+Mn 0.3%, had significantly higher seed per capitulum when compared to GRD.

The highest number of seeds $capitulum^{-1}$ was recorded in T12 GRD +Fe 0.2% + Zn 0.5%+ Mn 0.3%+N 1% followed by T11GRD+ Fe 0.2% +Zn 0.5%+Mn 0.3%, T-9 Fe0.2% + Zn 0.5%, T10 GRD + Mn 0.5%+Zn 0.3%, T-9 Fe 0.2% + Zn 0.5%, T8 GRD+ Fe 0.2% +Mn 0.3%, T7 GRD+ Mn 0.3%, T6 GRD+ Zn 0.5%,T5 GRD+ Fe 0.2%, T4 GRD+ 1% N andT3 GRD+ Tap water spray.

Table 1: Effect of nitrogen and micronutrients foliar spray on number of capitulum plant^{-1}, number of seeds capitulum^{-1} and test weight.

Treatments	Number of Capitulum Plant^{-1} (pooled)*	Number of seeds Capitulum^{-1} (pooled)	100 Seeds Test weight (gram) (Pooled)
T1-Absolutely control	11.17	10.33	4.42
T2-GRD (withoutspray)	15.33	16.50	4.44
T3-GRD with tap-water spray	17.33	17.33	4.43
T4-GRD+ 1% N foliar spray	17.17	18.50	4.43
T5-GRD+0.2% Fe foliar spray	18.17	18.17	4.44
T6-GRD+0.5% Zn foliar spray	18.33	18.33	4.44
T7-GRD+0.3% Mn) foliar spray	18.67	18.17	4.44
T8-GRD+Fe + Mn foliar spray	20.00	18.83	4.44
T9-GRD+Fe + Zn foliar spray	20.83	18.83	4.44
T10-GRD +Mn + Zn foliar spray	20.83	19.33	4.44
T11-GRD +Fe + Zn+Mn foliar spray	19.50	20.17	4.45
T12-GRD+Fe+Zn+Mn+Nfoliar spray	20.33	21.33	4.45
Mean	18.13	17.98	4.44
CD(5%)	6.72	4.10	NS
SEm	11.68	1.40	

Mean of two season

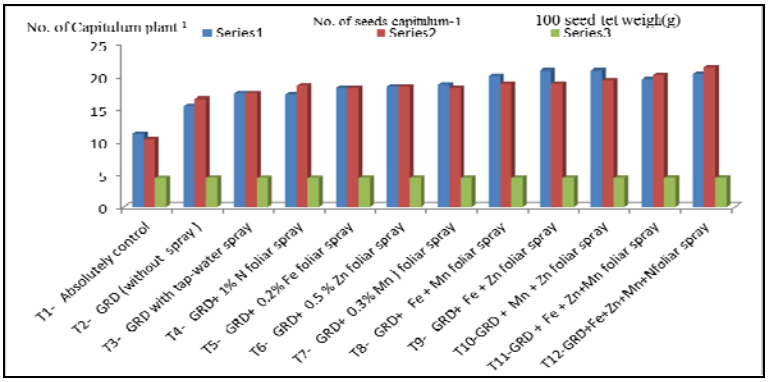

Fig 1: Effect of nitrogen and micronutrients foliar spray on number of capitulum Plant^{-1}, number of seeds capitulum^{-1} and test weight

Seed yield

Results on pooled seed yield as influenced by the treatments imposed are presented in table 2 and fig.2. Spraying the safflower plants by the combination of GRD + Fe 0.2% +Zn 0.5%+Mn 0.3%+ N1%, produced highest seed yield (15.71 q ha^{-1}),followed by T11 GRD+ Fe 0.2% +Zn 0.5%+Mn 0.3% (15.12 q ha^{-1}), T10 GRD + Mn 0.5%+Zn 0.3% (14.83 q ha^{-1}),T9 GRD +Fe 0.2% + Zn 0.5%(14.69 q ha^{-1}),T8 GRD+ Fe 0.2% +Mn 0.3%, (14.66 q ha^{-1}), T4 GRD+ 1% N (13.88 q ha^{-1}) T7 GRD+ Mn 0.3% (13.51 q ha^{-1}), T6 GRD+ Zn 0.5% (13.41 q ha^{-1}), T5 GRD+ Fe 0.2%, andthe minimum under T3 GRD+ tap water spray (12.78 q ha^{-1})with the increase in yield by 28.2, 23.4, 21.1, 19.9, 19.7, 13.3, 10.3, 9.5, 8.6 and 4.3%, respectively and the greatest value exceeds the control by more than 150%.

Increase in the yield due to application of micronutrients may be due to the fact that micronutrient elements play a critical role in plants that lead to increase of leaf area index, increased light absorption and thereby dry matter accumulation and economic yield. The increase of seed yield of safflower due to zinc foliar application has been reported by Movahhedi-Dehnavi *et al*. (2009) [24] Micronutrient application might have increased photosynthesis rate and improves leaf area duration thus seed yield (Ravi *et al.*, 2008) [11].

Table 2: Effect of nitrogen and micronutrients foliar spray on seed yield

Treatments	Seed yield (q ha^{-1})		Pooled Seed yield (q ha^{-1})	Yield increase(%)Over GRD
	2013-14	2014-15		
T1-Absolutely control	5.72	6.18	5.95	
T2-GRD (withoutspray)	11.70	12.80	12.25	
T3-GRD with tap-water spray	12.43	13.13	12.78	4.3
T4-GRD+ 1% N foliar spray	13.63	14.13	13.88	13.3
T5-GRD+0.2% Fe foliar spray	12.83	13.77	13.30	8.6
T6-GRD+0.5% Zn foliar spray	12.90	13.92	13.41	9.5
T7-GRD+0.3% Mn) foliar spray	13.11	13.90	13.51	10.3
T8-GRD+Fe + Mn foliar spray	14.77	14.55	14.66	19.7
T9-GRD+Fe + Zn foliar spray	14.85	14.52	14.69	19.9
T10-GRD +Mn + Zn foliar spray	14.75	14.90	14.83	21.1
T11-GRD +Fe + Zn+Mn foliar spray	15.42	14.82	15.12	23.4
T12-GRD+Fe+Zn+Mn+Nfoliar spray	15.64	15.77	15.71	28.2
Mean	13.38	13.43	13.25	
CD (5%)	3.92	2.95	3.12	
SEm	1.33	1.00	1.06	

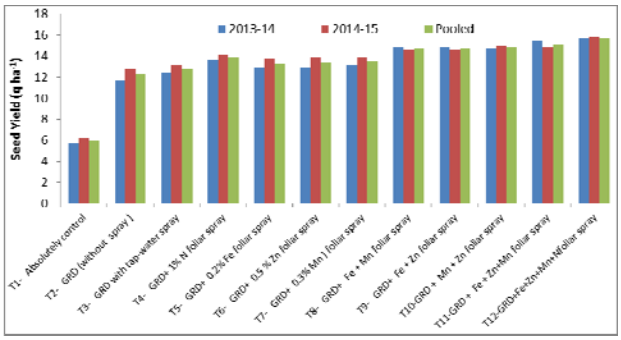

Fig 2: Effect of nitrogen and micronutrients foliar spray on seed yield flower

Stover yield

The results on stover yield as influenced by the foliar application of nitrogen and micronutrients are presented in table 4.3 and fig.4.3.Averaged stover yield was at par with each other but significantly superior over absolute control. The highest stover yield was observed due to foliar application of GRD + Fe 0.2% +Zn 0.5%+ Mn 0.3%+N 1% followed by combination of three and two micronutrient foliar spray with GRD, spray only Mn 0.3% with GRD, Fe 0.2% with GRD, and the lowest under GRD with tap water foliar spray application. The highest stover yield was achieved by the application of GRD + Fe 0.2% + Zn 0.5%+ Mn 0.3% + Urea 1% (42.40 q ha^{-1}), followed by, T11 GRD + Fe 0.2% +Zn 0.5%+ Mn 0.3%(41.57 q ha^{-1}), T10 GRD+ Zn 0.5%+ Mn0.3%(41.41 q ha^{-1}),T9 GRD + Fe 0.2% +Zn0.5% (40.63 q ha^{-1}), T8 GRD + Fe 0.2% +Mn 0.3% (40.02 q ha^{-1}),T7GRD+ Mn 0.3% (37.54 q ha^{-1})T6 GRD + Zn 0.5% (36.43 q ha^{-1}) and T4 GRD + 1% N foliar spray 36.44 q ha^{-1},T5 GRD +Fe 0.2%(35.96 q ha^{-1}) and lowest was recorded in T3GRD + tap water (35.36q ha^{-1}).

Shahrajabian *et al*., (2011) [12] observed more crop biomass with the foliar application of Zn+Fe+Mn. Suitable leaf area index (LAI) besides high plant height is so important when the economical aim is production of forage crops. Ravi *et al*. (2010) [29] concluded that combinations of Fe and Zn foliar spray in safflower recorded the highest yield, dry leaf and dry stem yield. The lowest dry leaf yield and dry stem yield was found in control treatment.

Table 3: Effect of nitrogen and micronutrients foliar spray on stover yield.

Treatments	Stover yield(q ha^{-1})		Pooled Stover yield (q ha^{-1})	Yield increase(%)Over GRD
	2013-14	2014-15		
T1-Absolutely control	15.28	15.61	15.44	
T2-GRD (withoutspray)	34.43	34.89	34.66	
T3-GRD with tap-water spray	34.88	35.83	35.36	2.0
T4-GRD+ 1% N foliar spray	37.21	37.67	36.44	5.1
T5-GRD+0.2% Fe foliar spray	34.06	37.87	35.96	3.8
T6-GRD+0.5% Zn foliar spray	37.17	37.92	36.43	5.1
T7-GRD+0.3% Mn) foliar spray	35.07	37.79	37.54	8.3
T8-GRD+Fe + Mn foliar spray	37.82	42.21	40.02	15.5
T9-GRD+Fe + Zn foliar spray	40.57	42.26	40.63	17.2
T10-GRD +Mn + Zn foliar spray	38.57	42.70	41.41	19.5
T11-GRD +Fe + Zn+Mn foliar spray	40.45	42.69	41.57	19.5
T12-GRD+Fe+Zn+Mn+Nfoliar spray	42.12	42.68	42.40	22.3
Mean	35.63	37.54	37.43	
CD $_{(5\%)}$	11.99	10.87	10.70	
SEm	4.09	3.70	3.64	

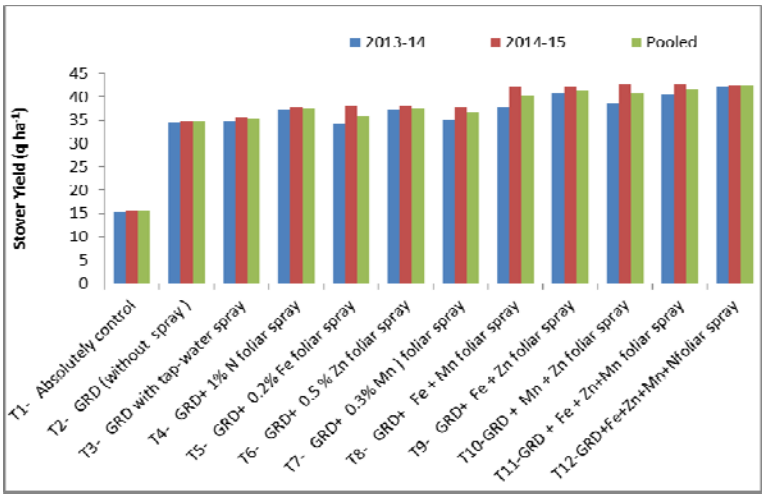

Fig. 3: Effect of nitrogen and micronutrients foliar spray on stover yield

Nutrient uptake

Macronutrient uptake

Nitrogen uptake in seed and stover

The highest (63.58 kg ha^{-1}) total nitrogen uptake showed in (table 4 and fig4) was found in GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) foliar spray treatment combination, which was significantly superior over all the treatments. The lowest (21.78 kg ha^{-1}) total nitrogen uptake was observed in control (N0:P0:K0) treatment due to the crop nutrient requirement

was support by the contribution from soil which finally decreased the yield and uptake of nitrogen also.

The highest nitrogen use efficiency was recorded 73.16%and showed in (table 4 fig 4) in GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) foliar spray treatment combination, which was significantly superior over all the treatments. The lowest Nitrogen use efficiency was observed in GRD alone (N55:P25:K20) treatment (42.16%).

Based on the increase in both yield and nitrogen fertilizer use efficiency, it was found that use of micronutrient-enriched fertilizers results in significant economic benefit to farmers. Fertilizer use efficiency (FUE) for different crops increased by the application of micronutrients. It is recommended by Mohammad Jafar and Malakouti, (2008) [30] that in order to maximize FUE in crop production, practice of balanced fertilization in crop production are beneficial. Balanced fertilization (NPK + micronutrients), in contrast to the control (NPK), was the best (Malakouti, 2000; Malakouti and Tehrani, 2005). [31, 32] Mean wheat grain yields and mean agronomic efficiency was maximum due to balanced fertilization. The highest grain yield, nitrogen use efficiency (NUE) and nitrogen apparent recovery fraction (NARF) was obtained with balanced fertilization and thereby maximum recovery rates were obtained with balanced fertilization. In addition to increases in yield of 12%, increased NUE to 15 kg of grain kg^{-1} N and 36% NARF increased.

The utilization of nitrogen by safflower increased significantly with the application of treatments compared to control. The increase in nitrogen uptake by safflower may be as described to increase in seed and stover yield and high nitrogen content in treatment GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) resulted high nitrogen uptake. It may be due to the fact that better utilization of nitrogen by the healthy and vigorous plants at various vegetative and reproductive growths which increase nitrogen content in plant. The higher N content resulted in higher yield and finally the nitrogen uptake by safflower.

Eman Abdel-Latif, Haggan (2014) [33] found that the Zn foliar application increased plant height at harvest by (5.02%), number of branches plant^{-1} (27.48%), number of pods plant^{-1} (13.48%), 100-seed weight (11.88%) seed yield plant^{-1} (10.74%) and seed yield ha^{-1} (22.82%), compared with control treatment. Foliar application of Mn also increased plant height at harvest by (5.02%), number of branches plant^{-1} (13.06%), number of pods plant^{-1} (16.69%), 100-seed weight (17.82%) seed yield plant^{-1} (16.12%) and seed yield ha^{-1} (30.97%) compared with control treatment. Boron foliar application also showed increase in plant height at harvest by (5.02%), number of branches plant^{-1} (8.56%), number of pods plant^{-1} (12.40%), 100-seed weight (7.43%) seed yield plant^{-1} (13.54%) and seed yield ha^{-1} (33.02%) compared with control treatment. These results obtained are also comparable with findings of Berglund (2002); Malakoti and Keshavarz, (2003); Noor *et al*., 2004); Bakhshi and Karimian (2004); Ghasemian *et al*. 2010). [34-37]

Table 4: Effect of nitrogen and micronutrients foliar spray on total nitrogen uptake of safflower

Treatments	Total Nitrogen uptake safflower(Kg ha^{-1})			NUE (%)
	2013-14	2014-15	Pooled Mean	
T1-Absolutely control	21.21	22.36	21.78	
T2-GRD (Withoutspray)	43.69	46.25	44.97	42.16
T3-GRD with tap-water spray	46.7	48.5	47.6	46.95
T4-GRD+ 1% Urea foliar spray	49.86	50.46	50.16	44.34
T5-GRD+ 0.2% Fe Foliar spray	47.17	51.06	49.11	49.69
T6-GRD+ 0.5% Zn Foliar spray	52.4	55.31	53.85	58.31
bT7-GRD+ 0.3% Mn) Foliar spray	51.32	53.42	52.37	55.62
T8-GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$) Foliar spray	54.96	58.05	56.51	63.15
T9-GRD+ (Fe $_{0.2\%}$+ Zn$_{0.5\%}$) Foliar spray	61.14	60.52	60.83	71.00
T10- GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) Foliar spray	58.85	61.78	60.31	70.05
T11- GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) Foliar spray	62.45	61.59	62.02	73.16
T12- GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) +1%UreaFoliar spray	62.84	64.33	63.58	65.31
CD (5%)	7.71	7.33	6.04	
SEm$_{\pm}$	2.63	2.50	2.06	

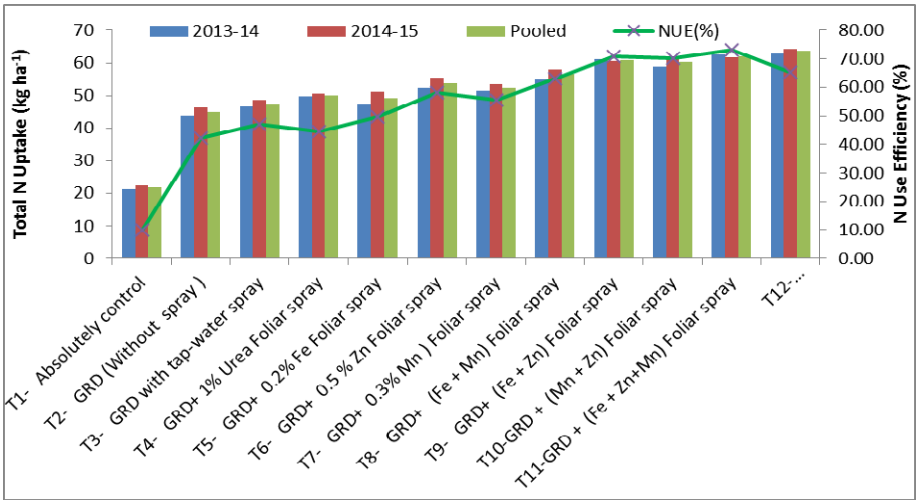

Fig 4: Effect of nitrogen and micronutrients foliar spray on total nitrogen uptakeand NUE in seed of safflower

Total Phosphorus uptake in safflower

The different treatments combinations of nitrogen and micronutrients foliar spray with GRD significantly influenced total phosphorus uptake in safflower (Table, 5 and Fig 5). The total phosphorus uptake by safflower was significantly superior with GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn $_{0.5\%}$) +1% urea foliar spray treatment (19 kg ha^{-1}), over GRD alone, which fallowed by GRD(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$)(17.5 kg ha^{-1}), GRD (Mn$_{0.3\%}$ +Zn $_{0.5\%}$)16.8 kg ha^{-1}), GRD (Fe $_{0.2\%}$ +Zn$_{0.5\%}$) (16.4 kg ha^{-1}), andGRD(Fe$_{0.2\%}$+ Mn$_{0.3\%}$ Foliar spray (15.7 kg ha^{-1})respectively.

Further it was also observed (table 5 fig.5) highest total phosphorus uptake increases by 48.44% in the treatments GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) +1% urea foliar spray over alone GRD treatment, followed by GRD(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) (36.72%), GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) foliar spray (31.25%),-GRD+ (Fe $_{0.2\%}$+ Zn$_{0.5\%}$) foliar spray (28.13%), GRD+ 0.3% Mnfoliar spray (22.13%), -GRD+ 1% Urea foliar spray (10.16%), GRD with tap-water spray andGRD+ 0.2% Fe Foliar spray (5.47%) and minimum with GRD+ 0.3% Mnfoliar spray (4.69%).

Mohd Abbas *et al*. (1995), Dineshkar and Babulkar (1998) [38, 39] in safflower also reported that the application of micronutrients i.e zinc and iron Mn and boron with major element increased the uptake of nitrogen, phosphorus, potassium, sulphur, zinc and iron significantly. As a consequence increased nutrient uptake resulted in higher dry matter. Uptake of nutrients directly related to concentration and yield, Zinc, Fe and Mn activate so many mechanism like nutrient absorption, photosynthesis etc.

Generally, Zinc and iron applied as single or in combination have been proven effective in increasing the productivity, yield of *Cymbopogon citratus* grown in newly reclaimed land. These increases may be due to the beneficial vital role of Zn in plant growth and development. Zinc which is closely involved in the metabolism of RNA and ribosomal content in plant cells which lead to stimulation of carbohydrates, proteins and the DNA formation.

Table 5: Effect of nitrogen and micronutrients foliar spray on total phosphorous uptakeof safflower

Treatments	TotalPuptake(Kg ha^{-1})		
	2013-14	2014-15	Pooled Mean
T1-Absolutely control	5.33	6.29	5.81
T2-GRD (Withoutspray)	12.3	13.4	12.8
T3-GRD with tap-water spray	13.3	13.8	13.5
T4-GRD+ 1% Urea foliar spray	12.9	15.2	14.1
T5-GRD+ 0.2% Fe Foliar spray	11.9	15	13.5
T6-GRD+ 0.5% Zn Foliar spray	14.2	15.3	14.8
T7-GRD+ 0.3% Mn) Foliar spray	12.6	14.3	13.4
T8-GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$) Foliar spray	15.1	16.3	15.7
T9-GRD+ (Fe $_{0.2\%}$+ Zn$_{0.5\%}$) Foliar spray	16.9	15.9	16.4
T10- GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) Foliar spray	15.8	17.7	16.8
T11- GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$)Foliar spray	16	18.9	17.5
T12- GRD(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) + 1%Urea Foliar spray	18	20	19
CD (5%)	3.44	3.34	2.36
SEm$_{\pm}$	1.17	1.14	0.80

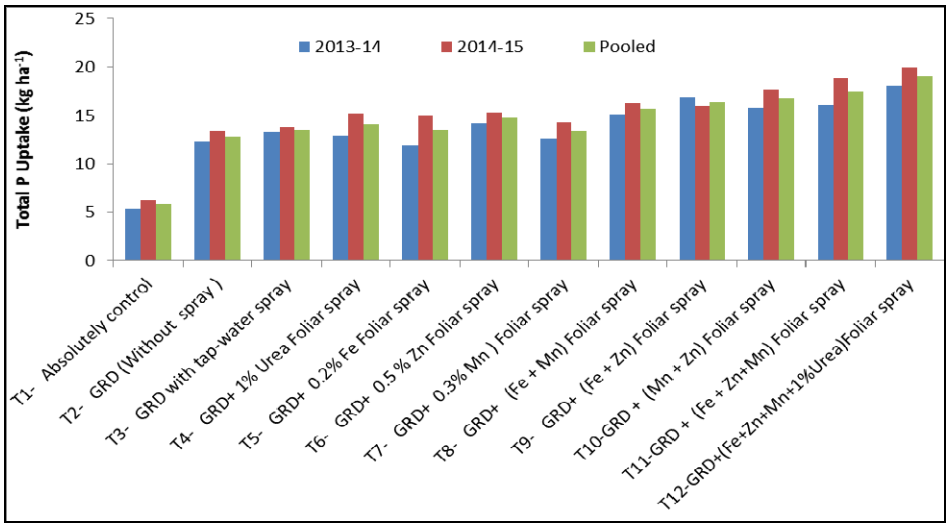

Fig 5: Effect of nitrogen and micronutrients foliar spray on total phosphorous uptakeof safflower

Potash uptake in safflower

Thedifferent treatments combinations of nitrogen and micronutrients foliar spray with GRD inboth *Rabi* season was the significantly higher total potash uptake bysafflower with GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) +1% urea foliar spray treatment.(107.76 kg ha^{-1}), followed by GRD+ (Fe $_{0.2\%}$+ Zn$_{0.5\%}$) foliar spray (104.56 kg ha^{-1}),which was at par with GRD(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$)(104.31 kg ha^{-1}),GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) foliar spray (101.16 kg ha^{-1}), GRD+ 0.3% Mn + Fe.2%foliar spray (99.13 kg ha^{-1}), GRD+ 0.3% Mn) foliar spray (98.6 kg ha^{-1})and lowest the incontrol (36.03 kg ha^{-1}).

Similar results observed indicates that application ofmicronutrients i.e zinc and iron Mnand boron with major

element increased the uptake of nitrogen, phosphorus, potassium, sulphur, zinc and iron significantly. Reverse is the consequence increased nutrient uptake will results in higher dry matter. Uptake of nutrients directely related to concentration and yield, Zinc, Fe and Mn activate so many mechanism like that nutrient absorption,photosynthesis etc.These results are in conformity with the findings of Mohd Abbas *et al*. (1995) in safflower, Dineshkar and Babulkar (1998) [38, 39] in safflower.

Table 6: Effect of nitrogen and micronutrients foliar spray on total Potash uptake in of safflower

Treatments	Total Potash uptake(Kg ha^{-1})		
	2013-14	2014-15	Pooled Mean
T1-Absolutely control	35.25	36.82	36.03
T2-GRD (Withoutspray)	82.36	82.38	82.37
T3-GRD with tap-water spray	85.49	93.97	89.73
T4-GRD+ 1% Urea foliar spray	92.03	92.03	92.03
T5-GRD+ 0.2% Fe Foliar spray	79.21	90.56	84.88
T6-GRD+ 0.5% Zn Foliar spray	89.8	81.54	85.67
T7-GRD+ 0.3% Mn) Foliar spray	90.97	106.24	98.6
T8-GRD+(Fe + Mn) Foliar spray	93.64	104.61	99.13
T9-GRD+ (Fe + Zn) Foliar spray	101.74	107.37	104.56
T10- GRD+(Mn + Zn) Foliar spray	93.52	108.81	101.16
T11- GRD+(Fe+ Mn+ Zn) Foliar spray	103.09	105.52	104.31
T12- GRD(Fe+ Mn+ Zn + Urea)Foliar spray	107.33	108.19	107.76
CD (5%)	31.77	23.29	19.49
SEm±	10.83	7.94	6.64

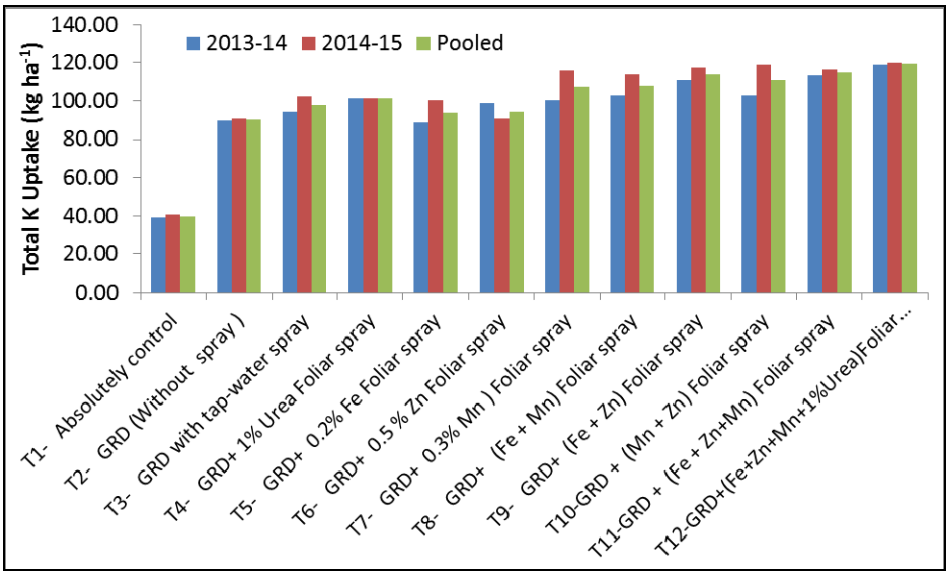

Fig 6: Effect of nitrogen and micronutrients foliar spray on total Potash uptake in of safflower

Micronutrients uptake

Zinc uptake in Seed and Stover

The results on uptakepooled mean of total zinc of safflowerregardingboth *rabi* season 2013-14 and 2014-15 to presented in (table 7 and Fig 7) showed was observed ranged from 75.97 to 218.14 gm ha^{-1}. The highest total uptake of zinc (218.14 g ha$^{-1)}$ by safflower was also observed in treatment GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) + 1%Urea Foliar spray treatment, which was significantly superior, when compared with GRD alone, but at par GRD with tap-water spray (179.30 g ha^{-1}). The increase in zinc uptake was 27.95% and 5.17% in the treatment GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$ +1% urea) foliar spray (27.95%) and GRD with tap-water spray when compared with GRD alone.

Similar finding sudgested Zehra *et al* 2014 in both years, the Zn concentration in the seed was increased by Zn application. In the first and second year, the mean Zn concentration in the seeds was 36 mg kg-1 and 38 mg kg-1, respectively, without Zn application, whereas the mean Zn concentration was 41 mg kg-1 and 43 mg kg-1, respectively, with Zn application. Movahhedy- Dehnavy *et al*. (2009) [8] found that Zn application changed the Zn concentration of safflower seeds, and finally uptake is the product of concentration of nutrient multiply with seed yield.

Sakal *et al*. (1996) [40] reported that the amount of Zn absorbed varies with the oilseed-based cropping systems and ranges from 242 to 504 g ha^{-1} yr^{-1} The use efficiency of applied Zn was found to be low in general. In oilseed crops, the utilization of applied Zn by the crops was found to be <0.5% (Prasad 2006). [41] The results are closely related to the findings reported by Biswas *et al*. (2008) [42].

Taha *et al* (2013) [43] observed that application of Zn and Fe significantly increased the nutrient uptake, receiving Fe: Zn at 0.3:0.6% foliar spray recorded the highest uptake (12.77 and 8.18 mg/100 g D.W) followed by the application of Zn alone at 0.6%. The increase 101.26 and 166.81% for Fe and Zn, respectively. These findings were in agreement with Pasricha and Aulakh, (1991) [44] who reported that that the combination of sulphur and micronutrients had marked influence on Zn and Fe uptake.

Table 7: Effect of nitrogen and micronutrients foliar spray on total zinc uptake in Stover of safflower

Treatments	Totalzinc uptake(g ha^{-1})		
	2013-14	2014-15	Pooled Mean
T1-Absolutely control	75.18	76.76	75.97
T2-GRD (Withoutspray)	166.75	174.22	170.49
T3-GRD with tap-water spray	176.45	182.15	179.30
T4-GRD+ 1% Urea foliar spray	188.48	191.13	189.80
T5-GRD+ 0.2% Fe Foliar spray	173.51	192.43	182.97
T6-GRD+ 0.5% Zn Foliar spray	184.72	190.44	187.58
T7-GRD+ 0.3% Mn) Foliar spray	181.50	193.44	187.47
T8-GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$) Foliar spray	195.18	207.90	201.54
T9-GRD+ (Fe $_{0.2\%}$ + Zn$_{0.5\%}$) Foliar spray	209.08	210.87	209.97
T10- GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) Foliar spray	198.70	211.40	205.05
T11- GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) Foliar spray	214.02	218.15	216.09
T12- GRD(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) + 1%Urea Foliar spray	217.24	219.03	218.14
CD (5%)	54.89	35.82	32.20
SEm$_{\pm}$	18.71	12.21	10.97

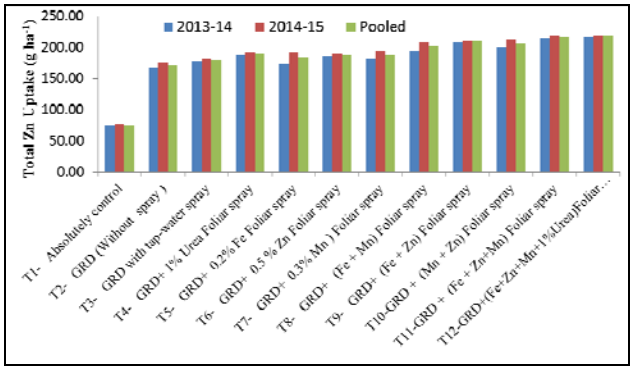

Fig 7: Effect of nitrogen and micronutrients foliar spray on total zinc uptake of safflower

Total Iron uptake in safflower

The results regarding pooled mean of two *rabi* season on total uptake of iron by safflower presented in (Table 8 and Fig 8). The treatments combinations of nitrogen and micronutrients foliar spray with GRD was observed ranged from 601.55 to 1781.99 gm ha^{-1}. The highest total uptake of Iron 1781.99 g ha^{-1} by safflower was also observed in GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) + 1%Urea Foliar spray treatment, which was significantly superior GRD alone, (1781. 99 gm ha^{-1}) followed by treatment GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) (1760.59 gm ha^{-1}), GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) Foliar spray (1718.32 gm ha^{-1}) Foliar sprayGRD+ (Fe $_{0.2\%}$ + Zn$_{0.5\%}$) Foliar spray (1742.39 gm ha^{-1}), GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$) Foliar spray (1666.61 gm ha^{-1}), GRD+ 0.3% Mn) Foliar spray (1657.88 gm ha^{-1}), GRD+ 0.5% Zn Foliar spray (1547.95 gm ha^{-1}), andGRD+ 0.2% Fe Foliar spray (1612.28 gm ha^{-1}), but at par GRD with tap-water spray (1509.60 g ha^{-1})and GRD with 1% urea(1558.81 gm ha^{-1}).

On other hand the highest total iron uptake percent increased over GRD alone was obtained with GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$ +1% urea) foliar spray (24.91%) and lowest GRD with tap-water spray (5.81%). Intensive cropping systems deplete soil Zn more due to higher production. Taha *et al* (2013) [43] observed that application of Zn and Fe significantly increased the nutrient uptake, receiving Fe: Zn at 0.3:0.6% foliar spray recorded the highest uptake (12.77 and 8.18 mg/100 g D.W) followed by the application of Zn alone at 0.6%. The increase 101.26 and 166.81% for Fe and Zn, respectively. (Sakal *et al*. 1996) [40] Reported that the amount of Zn absorbed varies with the oilseed-based cropping systems and ranges from 242 to 504 g ha^{-1} yr^{-1} The use efficiency of applied Zn was found to be low in general. In oilseed crops, the utilization of applied Zn by the crops was found to be <0.5% (Prasad 2006). [41] The results are closely related to the findings reported by Biswas *et al.* (2008). [42]

Table 8: Effect of nitrogen and micronutrients foliar spray on total Iron uptake of safflower

Treatments	Total Iron uptake in safflower(g ha^{-1})		
	2013-14	2014-15	Pooled Mean
T1-Absolutely control	558.69	644.41	601.55
T2-GRD (Withoutspray)	1378.63	1340.95	1386.29
T3-GRD with tap-water spray	1498.99	1483.26	1509.60
T4-GRD+ 1% Urea foliar spray	1453.1	1593.87	1558.81
T5-GRD+ 0.2% Fe Foliar spray	1482.46	1548.14	1612.28
T6-GRD+ 0.5% Zn Foliar spray	1513.34	1530.17	1547.95
T7-GRD+ 0.3% Mn) Foliar spray	1645.45	1503.96	1657.88
T8-GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$) Foliar spray	1572.2	1625.8	1666.61
T9-GRD+ (Fe $_{0.2\%}$+ Zn$_{0.5\%}$) Foliar spray	1688.06	1639.40	1742.39
T10- GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) Foliar spray	1645.96	1659.71	1718.32
T11- GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) Foliar spray	1711.63	1801.26	1760.59
T12- GRD(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) + 1%UreaFoliar spray	1706.92	1845.57	1781.99
CD (5%)	248.59	135.06	187.97
SEm$_{\pm}$	84.76	46.05	64.09

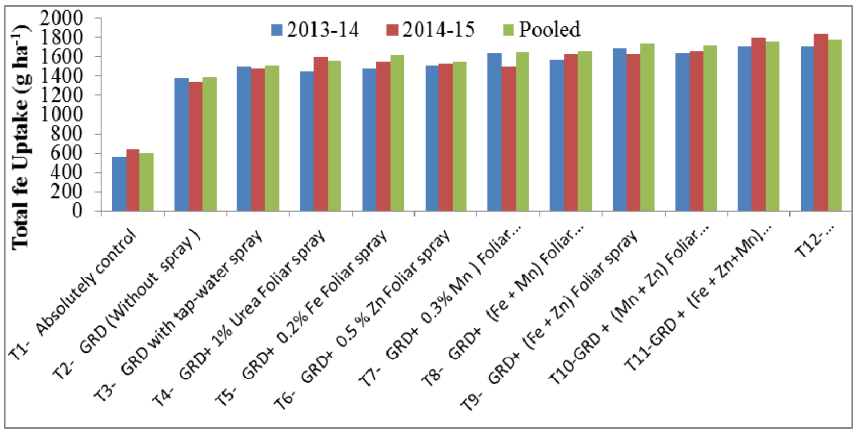

Fig 8: Effect of nitrogen and micronutrients foliar spray on total Iron uptake in safflower.

Manganese uptake in safflower

The results regarding pooled mean of two *rabi* season on uptake of manganese by seed of safflower presented are in Table 9 and Fig 9 thetreatments combinations of nitrogen and micronutrients foliar spray the total uptake of manganese by safflower ranged from 42.30 to 83.94 gm ha^{-1}. The highest total uptake of manganese by safflower was also observed in GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) + 1%Urea Foliar spray treatment, which was significantly superior GRD alone (83.94 g ha^{-1}),followed by treatment GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) Foliar spray (83.49 gm ha^{-1}), GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) Foliar spray (83.06 gm ha^{-1}) and GRD+ (Fe $_{0.2\%}$+ Zn$_{0.5\%}$) Foliar spray (81.88 gm ha^{-1}), GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$) Foliar spray (80.74 gm ha^{-1}), GRD+ 0.5% Zn Foliar spray (78.60 gm ha^{-1}),GRD+ 0.3% Mn) Foliar spray (78.18 gm ha^{-1}), andGRD+ 0.2% Fe Foliar spray (75.81 gm ha^{-1}).but at par (and GRD with 1% ureaGRD 70.99 g ha^{-1}) with tap-water spray (69.54 gm ha^{-1})

On other hand the highest total manganese uptake percent increased over GRD alone was obtained with GRD (Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$ +1% urea) foliar spray (28.42%). and lowest GRD with tap-water spray (6.39%). Intensive cropping systems deplete soil Zn more due to higher production.

Taha *et al* (2013) [43] observed that application of Zn and Fe significantly increased the nutrient uptake, receiving Fe: Zn at 0.3:0.6% foliar spray recorded the highest uptake (12.77 and 8.18 mg/100 g D.W) followed by the application of Zn alone at 0.6%. The increase101.26 and 166.81% for Fe and Zn, respectively. These findings were in agreement with Pasricha and Aulakh, (1991) [44] who reported that that the combination of sulphur and micronutrients had marked influence on Zn and Fe uptake.

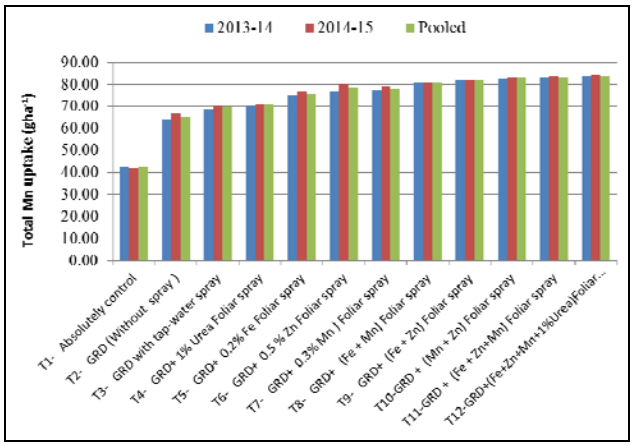

Fig. 9: Effect of nitrogen and micronutrients foliar spray on total manganese uptake of safflower.

Table 9: Effect of nitrogen and micronutrients foliar spray on total manganese uptake of safflower

Treatments	Total manganese uptake in seed(g ha^{-1})		
	2013-14	2014-15	Pooled Mean
T1-Absolutely control	42.59	42.02	42.30
T2-GRD (Withoutspray)	63.88	66.83	65.36
T3-GRD with tap-water spray	68.34	70.74	69.54
T4-GRD+ 1% Urea foliar spray	70.64	71.33	70.99
T5-GRD+ 0.2% Fe Foliar spray	74.81	76.82	75.81
T6-GRD+ 0.5% Zn Foliar spray	77.04	80.16	78.60
T7-GRD+ 0.3% Mn) Foliar spray	77.35	79.01	78.18
T8-GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$) Foliar spray	80.90	80.58	80.74
T9-GRD+ (Fe $_{0.2\%}$+ Zn$_{0.5\%}$) Foliar spray	81.85	81.92	81.88
T10- GRD+(Mn$_{0.3\%}$ + Zn $_{0.5\%}$) Foliar spray	82.67	83.46	83.06
T11- GRD+(Fe $_{0.2\%}$ + Mn$_{0.3\%}$+ Zn $_{0.5\%}$) Foliar spray	83.40	83.58	83.49
T12- GRD(Fe $_{0.2\%}$ + Mn$_{0.3\%}$ + Zn$_{0.5\%}$) +1%Urea Foliar spray	83.65	84.23	83.94
CD (5%)	10.58	9.87	9.44
SEm$_{\pm}$	3.60	3.36	3.22

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