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Effect of Foliar Fertilization of Market Available Soluble Fertilizers on Nutrient Dynamics of Maize Crop (*Zea mays* L.) and Soil

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Abstract The goal of this study was to evaluate the effect of foliar fertilization of market available soluble fertilizers on nutrient dynamics of maize crop (*Zea mays* L.) and soil. To reach the goal, seven market available soluble fertilizers which are sprayed in two concentrations at 30 and 50 DAS. Only water spray was kept as control. Foliar applications were made in addition to RDF application. All these soluble fertilizers are available in the market. Present study was conducted during *kharif* 2015 the experiment was laid out in randomized complete block design with 3 replications and 12 treatments. The soil of the experimental site is medium deep black soil with pH of 7.2, 322.0 kg ha^{-1} available N, 39.8 kg ha^{-1} available P_2O_5 and 452.19 kg ha^{-1} available K_2O. Soil was high in NPK content. The results revealed that application of potassium nitrate with 1.0% foliar spray recorded significantly higher grain yield and fodder yield (9371 kg ha^{-1} and 135.7 q ha^{-1}, respectively) over control (only water spray) (6430 kg ha^{-1} and 82.4 q ha^{-1}, respectively) . The magnitude of per cent increase of grain yield and fodder yield with potassium nitrate with 1.0% foliar spray over control (only water spray) was 44.4 and 64.7%, respectively. Potassium nitrate with 1% foliar spray also recorded significantly higher NPK uptake in grain and straw over control. But significantly higher soil available nutrients status (279.8, 29.3 and 323.2 kg ha^{-1} NPK) after harvest of maize recorded in control due to less growth and yield of maize and less uptake of nutrients. Lowest soil available nutrients status (193.8, 20.3 and 273.8 kg ha^{-1} NPK) recorded in potassium nitrate with 1.0% foliar spray.

Keywords Foliar fertilization, Soil fertilization, Nutrient uptake, Soil available nutrient status.

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Introduction

Maize is an exhaustive crop and is known to deplete soil fertility when grown as a sole crop. It needs heavy manuring for expressing its genetic yield potential . It is one of the single most cereal crop which produce yield up to 250 q ha$^{-1.}$ Which is achieved by

only proper nutrition of crop. Foliar nutrition is only way by which, we can achieve highest yield. After knowing the nutrient availability status, application of recommended nutrient levels and further enhancement of the productivity of maize crop is challenging aspect. In the present study investigation is conducted on foliar fertilization with different concentrations and stages of application with market available soluble fertilizers. Taking in to account the uptake pattern and nutrient balance in soil and plant after application of foliar fertilization with varius soluble fertilizers and analysis of results will be made with greater benefit to the production practices. Study also investigates the foliar feeding of maize and its behavior pattern with reference to yielding ability.

The intensive crop rotation and imbalance fetilizer use have resulted in a wide range of nutrient deficiencies in field. Further , about 50% of applied N and 70% of applied phosphorus to the soil remain unavailable to a crop due to a combination of leaching, fixation and volatilization. N-losses in summer crops are very high and efficiency of N-fertilizers used is very low. Thus, foliar feeding as a supplement or a partial substitution to soil fertilizer application was studied , in this connection, efficient and positive response of some field crops due to foliar feeding combined with N-fertilizers soil application were recorded by authors [1]. In addition, the beneficial effect of foliar nutrition of N, P and K in mineral form compounds or humic acid containing N, P and K as a supplemental or a partial substitution to soil application [2, 3]. There are many research studies were conducted on foliar fertilization but no any research study conducted on foliar fertilization of market available soluble fertilizers. Keeping this in view, field experiments were carried out on effect of foliar fertilization of market available soluble fertilizers on nutrient dynamics of maize crop and soil. These foliar applications were made in addition to RDF at 30 and 50 DAS.

Materials and Methods

A field experiment was conducted during *kharif* 2015 at Agricultural Resaerch Station Arabhavi, University of Agricultural Sciences, Dharwad. ARS, Arbhavi is located in the Northern Dry Zone (Zone 3) Region-II of Karnataka. Geographically, it lies at 16° 12′ N latitude 74° 57′ E longitude with an altitude of 640 m above mean sea level (MSL). The average rainfall of the Agricultural Research Station, Arabhavi is 468 mm. Crop was raised under irrigatied situation. Source of irrigation water is from Ghataprabha Left Bank Canal (GLBC) . The soil of the experimental site is medium deep black with pH of 7.2. Fertility record indicates , 322.0 kg ha^{-1} N, 39.8 kg ha^{-1} P_2O_5 and 452.19 kg ha^{-1} K_2O of available nutrients. The experiment was laid out in randomized complete block design with 3 replications and 12 treatments. The crop was sown on 25th June 2015. At each spot one seed was dibbled up to 4 to 5 cm deep in the seed line with a row spacing of 60 cm and plant spacing of 20 cm. The treatments consist of seven market available soluble fertilizers which are sprayed in different concentrations at 30 and 50 DAS. Treatments consist of : F_1-19 : 19 : 19-1.0% foliar spray (FS) F_2-19 : 19 : 1-2.0% FS, F_3-Mono ammonium phosphate (MAP) -0.5% FS, F_4-MAP - 1.0% FS, F_5-Potassium Nitrate -0.5% FS, F_6-Potassium Nitrate-1.0% FS, F_7-Mono potassium phosphate (MPP) -0.25% FS, F_8- MPP-0.5% FS, F_9-Muriate of potash (MOP)-2% FS, F_{10}-Urea-2% FS, F_{11}-Sulfate of potash (SOP)-2% FS and control (only water spray). Total RDF applied as -150 : 65 : 65 kg /ha NPK + 25 kg/ha $ZnSO_4$ + 25 kg/ha $FeSO_4$ + 10 t/ ha FYM. Of the total 150 kg nitrogen, 50 kg N applied as basal dose and remaining N applied in two equal splits at 30 and 45 DAS. Total P, K, Zn and Fe applied as basal before sowing of maize crop. Foliar applications were made in addition to RDF and all these soluble fertilizers are available in the market. Only water spray was kept as control.

At maturity, samples of maize grain and fodder were collected and oven dried at 70° C to constant weight and ground to pass through a 0.5 mm sieve for chemical analysis. Nitrogen content in plant samples was determined by micro-Kjeldahl method [4]. The samples were digested in tri-acid mixture (HNO_3 : H_2SO_4 : $HClO_4$,10 : 1 : 4 by volume) and in the digest, P was measured by vanadomolyb date yellow color method [4] and K by flame photometer [5]. Uptake of N, P and K by crop was estimated by

multiplying the dry matter yields (after drying at 70° C to constant weight) of maize crop by plant nutrient concentrations.

Composite soil samples were collected before sowing and at harvest of the crop for chemical analysis of soil. The soil samples collected from 0-30 cm depth were dried under shade and finally crushed with wooden pestle and mortar to pass through 2 mm sieve and the soil samples were analyzed . Available nitrogen in soil was estimated by alkaline potassium permanganate oxidation method as out lined by authors [6]. It was expressed in kg ha[1]. Available phosphorus was estimated by adopting Olsen's method as outlined by authors [4], using 0.5 M $NaHCO_3$ as an extractant. Phosphorus in the extract was determined by chlorostannus reduced molybdophosphoric blue color method. The intensity of blue color was recorded at 660 nm using spectrophotometer. It was expressed in kg ha^{-1}. Available potassium content in soil was extracted with neutral ammonium acetate (pH 7.0) . The potassium content in the extract was determined by flame photometer (Model : Systronics FPM-125) as described by authors [4]. It was expressed in kg ha^{-1}.

The crop was harvested from the net plots. Grain and fodder yield was expressed at 15% moisture level.

Results and Discussion

Yield

Among the different treatments potassium nitrate with 1.0% foliar spray (F_6) recorded significantly higher grain yield (9371 kg ha^{-1}) over control (F_{12}) (6430 kg ha^{-1}). The grain yield increase was up to 44.4% in F_6 over F_{12}. It was on par with F_2 and F_8 . So the above mentioned results reveals that higher grain yields of maize can be achieved with increased yield components by application of different soluble fertilizers with different levels as compared to only water spray. Increase in concentration of soluble fertilizers also increased the grain yield of maize. Higher grain weight has been reported by increasing nitrogen fertilizer in study of maize [7] . Authors [8] stated that grain weight can be increased by some factors determining the length of grain filling after flowering stage with nitrogen fertilization.

Among the different treatments potassium nitrate with 1.0% foliar spray (F_6) recorded significantly higher fodder yield (135.7 q/ha^{-1}) over control (F_{12}) (82.4 q ha^{-1}). It was on par with rest of treatments except F_3 and F_9 . Increase was up to 64.7% in F_6 over F_{12} . Higher growth parameters such as plant height, number of leaves, leaf area and leaf area index leads in higher total dry matter production per plant attributed to higher fodder yield over other treatments. The results of present findings are in line with authors [9] who noticed that higher fodder yield of maize by foliar fertilization of multi-nutrient solutions over RDF alone. Authors [10] also reported the higher fodder yield of maize to foliar fertilization of multi-nutrient solutions over RDF alone.

Nutrient uptake

Nutrient uptake (kg ha^{-1}) differed significantly due to different type of market available soluble fertilizers and their levels (Table 1). Nutrient uptake was increased with the higher concentration of foliar nutrients compared to lower concentration and control.

The higher total nitrogen uptake in grain and fodder (122.1, 177.6 kg ha^{-1}) of maize was noticed with potassium nitrate with 1.0% foliar spray (F_6) over control. (F_{12}) (84.6, 107.9 kg ha^{-1}, respectively). The higher uptake of nitrogen was due to favorable influence of nitrogen on higher degree of root proliferation, anchoring and deep penetration which in turn absorb higher amount of nutrients from the rhizosphere and supply to the crop resulting in higher dry matter production. Similar findings were also observed by authors [10] noticed the higher uptake of nitrogen by maize to the foliar fertilization of multi-nutrients over RDF alone.

Among different treatments significantly higher phosphorus uptake (38.0, 42.1 kg ha^{-1}) in grain and fodder of maize was recorded with potassium nitrate with 1.0% foliar spray (F_6) over control (F_{12}) (20.8, 23.1 kg ha^{-1}), respectively). The better performance

Table 1. Total quantity of nutrients applied in soil and foliar fertilization to maize.

Treatments	RDF (N + P +K) (kg ha^{-1})	Quantity of foliar fertilizer applied (kg ha^{-1})	Nutrient content in foliar fertilizers (kg ha^{-1}) N	P_2O_5	K_2O	Total nutrient content in foliar fertilizers (kg ha^{-1})	Total nutrient applied (RDF+ foliar) (kg ha^{-1})
F_1 = 19 : 19 : 19 — 1.0% FS*	280	12.5	2.375	2.375	2.375	7.125	287.1
F_2 = 19 : 19 : 19 –2.0% FS	280	25	4.75	4.75	4.75	14.25	294.3
F_3 = 12 : 61 : 0 (Mono ammonium phosphate)– 0.5% FS	280	6.25	0.75	3.8125	0	4.5625	284.6
F_4 = 12 : 61 : 0 (Mono ammonium phosphate) – 1.0% FS	280	12.5	1.5	7.625	0	9.125	289.1
F_5 = 13 : 0 : 45 (Potassium nitrate) – 0.5% FS	280	6.25	0.81	0	2.81	3.62	283.6
F_6 = 13 : 0 : 45 (Potassium nitrate) – 1.0% FS	280	12.5	1.625	0	5.625	7.25	287.3
F_7 = 0 : 52 : 34 (Mono potassium phosphate) - 0.25% FS	280	3.125	0	1.625	1.06	2.685	282.7
F_8 = 0 : 52 : 34 (Mono potassium phosphate) – 0.5% FS	280	6.25	0	3.25	2.125	5.375	285.4
F_9 = 0 : 0 : 60 (Muriate of potash) – 2% FS	280	25	0	0	15	15	295
F_{10} = 46 : 0 : 0 (Urea) – 2% FS	280	25	11.5	0	0	11.5	291.5
F_{11} = 0 : 0 : 50 (Potassium sulfate) – 2% FS	280	25	0	0	12.5	12.5	292.5
F_{12} = Control (only water spray)	280	0	0	0	0	0	280

of phosphorus uptake was due to synergistic effect of nitrogen and potassium with phosphorus, which can promote root growth, enhanced the utilization of soil nutrients and water by plants increased the more uptake of phosphorus. The results are also in line with authors [11].

Potassium uptake significantly higher (76.9,

Table 2. Grain yield, fodder yield, total nutrient uptake and soil available nutrient status after harvest of maize as influenced by different types of foliar applied soluble fertilizers and their levels. *FS – Foliars spray, ** Values followed by same alphabets are not significantly superior.

Treatments	Grain yield (kg ha^{-1})	Stover yield (q ha^{-1})	Total uptake of nutrients (kg ha^{-1}) N Grain	Straw	Total	P_2O_5 Grain	Straw	Total	K_2O Grain	Straw	Total
F_1 = 19:19:19 – 1.0% FS*	7789 b**	114.8 ab	101.9a	150.3ab	252.2	28.3 cde	31.7 bc	60.01	63.1b	93.3bc	156.4
F_2 = 19:19:19–2.0% FS	8357 ab	121.3ab	109.4ab	158.5ab	268.2	33.2 b	35.1 b	68.33	68.7ab	102.9ab	171.5
F_3 = 12:61: 0 (Mono ammonium phosphate)–0.5% FS	7635bc	111.1b	100.0b	145.4b	245.4	27.7cde	30.7bc	58.35	61.9b	90.3bc	152.2
F_4 = 12: 61 : 0 (Mono ammonium phosphate)–1.0% FS	7910b	118.6ab	103.5b	155.3ab	258.8	30.1bcd	32.7bc	62.82	64.0b	96.4bc	160.4
F_5 = 13: 0 45 (Potassium nitrate) –0.5% FS	8053 b	121.3ab	105.5b	158.8ab	264.3	31.1bc	33.5 bc	64.55	65.3b	99.2b	164.5
F_6 = 13 : 0: 45 (Potassium nitrate) –1.0% Fs	9371 a	135.7a	122.1a	177.6 a	299.7	38.0a	42.1 a	80.15	76.9a	114.8a	191.6
F_7 = 0:52:34 (Mono potassium Phosphate)–0.25% FS	7561 bc	118.5 ab	99.0 b	155.1ab	254.1	26.4 de	30.7 bc	57.11	61.3b	96.3bc	157.6
F_8 = 0:52:34 (Mono potassium phosphat)–0.5% FS	8247 ab	119.0 ab	108.0 b	155.7ab	263.7	32.1b	33.8 b	65.97	66.8b	98.3 b	165.1
F_9=0:0:60 (Muriate of potash) 2% FS	7302 bc	100.0bc	95.9 bc	130.9 bc	226.8	25.7 e	27.6 cd	53.34	59.3bc	81.3c	140.7
F_{10} = 46 : 0 : (Urea) –2% FS	7613 bc	120.5 ab	99.6b	157.7 ab	257.3	27.2de	33.2 bc	60.41	61.6 b	97.9bc	159.5
F_{11} = 0 : 0 : 50 (Potassium sulfate) –2% Fs	7771 b	115.7ab	101.8b	151.5ab	253.3	27.4cde	31.9bc	59.37	63.0b	94.1bc	157.0
F_{12} = Control (only water spray)	6430 c	82.4 c	84.6 c	107.9 c	192.4	20.8 f	23.1 d	43.87	52.3c	66.3d	118.6
SEm±	384.2	7.2	4.67	9.41	11.69	1.15	1.82	2.28	2.87	4.98	6.38
CD at 5%	1126.8	21.1	13.71	27.60	34.3	3.37	5.32	6.68	8.41	14.59	18.72

Table 2. Continued.

Treatments	Soil available nutrients status after harvest of maize (kg ha^{-1}) N	P_2O_5	K_2O
F_1 = 19 : 19 ; 19 – 1.0% FS*	233.2 b	24.8 b	286.3 bc
F_2 = 19 : 19 : 19 – 2.0% FS	219.7 bc	23.0 bc	282.3 bc
F_3 = 12 : 61 : 0 (Mono ammonium phosphate) – 0.5% FS	237.2 b	25.3 b	287.2 bc
F_4 = 12 : 61 : 0 (Mono ammonium phosphate) – 1.0% FS	228.2 b	24.0 b	283.0 bc
F_5 = 13 : 0 : 45 (Potassium nitrate) – 0.5% FS	229.1 b	23.9 b	285.9 bc
F_6 = 13 : 0 : 45 (Potassium nitrate) – 1.0% FS	193.8 c	20.3 c	273.8 c
F_7 = 0 : 52 : 34 (Mono potassium phosphate) – 0.25% FS	241.9 b	24.5 b	291.0 bc
F_8 = 0 : 52 : 34 (Mono potassium phosphate)–0.5 % FS	226.9 b	23.7 b	284.0 bc
F_9 = 0 : 0 : 60 (Muriate of potash) – 2% FS	250.7 ab	26.2 ab	306.0 ab
F_{10} = 46 : 0 : 0 (Urea) – 2 % FS	247.4 ab	25.9 ab	287.5 bc
F_{11} = 0 : 0 : 50 (Potassium sulfate) – 2% FS	233.6 b	24.4 b	287.1 bc
F_{12} = Control (only water spray)	279.8 a	29.3 a	323.2 a
SE m±	10.71	1.12	8.44
CD at 5%	31.42	3.29	24.76

114.8 kg ha^{-1}) in grain and fodder of maize was recorded with potassium nitrate with 1.0%foliar spray (F_6) over the control (F_{12}) (52.3, 66.3 kg ha^{-1}, respectively). Increased potassium potassium uptake might be due to higher proportion of potassium in foliar fertilizers, which met the crop demand at important growth phases like tassel emergence and seed filling stage. Authors [10] also reported similar findings that significantly higher potassium uptake by the maize crop to foliar fertilization of multi-nutrients as compared to the control.

Soil available nutrients status after harvest of maize (kg ha^{-1})

Available soil nutrients status (kg ha^{-1}) differed significantly due to different type of market available soluble fertilizers and their levels (Table 2).

Among different treatment control (F_{12}) recoded significantly higher nitrogen, phosphorus and potassium availability (279.8, 29.3 and 323.2 kg ha^{-1}, respectively) in soil over rest of treatments after harvest of crop. Significantly lower nitrogen, phosphorus and potassium availability (193.8, 20.3 and 273.8 kg ha^{-1}), respectively) in soil was recorded with potassium nitrate (13 : 0 : 45) with 1.0% foliar spray (F_6). More availability of available soil nutrients in control due to less growth of plants and less uptake of soil nutrients. The investigations led by authors [13], also reported similar results for B C ratio that support the findings of the present research work. Findings of authors [12] were in support with the findings of the present research work.

Conclusion

Initial status of soil was showing higher in nitrogen , phosphorous and potassium content. Foliar fertilization of soluble fertilizers has significant effect on nutrient dynamics of crop and soil. Application of potassium nitrate (13 : 0 : 45) with 1.0 % foliar spray at 30 and 50 DAS increased in grain yield, fodder yield, nutrient uptake in both grain and fodder. It was also observed on par with 19 : 19 : 19 with 2% foliar spray and mono potassium phosphate (0 : 52 : 34) with 0.5% foliar spray. Control (only water spray) recorded significantly higher soil available nutrients status after harvest of maize.

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