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Influence of water soluble fertilizers on growth and yield parameters of hybrid maize (*Zea mays* L.) under rainfed situation of southern transitional zone of Karnataka

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Abstract
A field experiment was conducted during Kharif 2014 at Agricultural and Horticultural Research Station, Bhavikere, UAHS, Shivamogga, on red clay loam soil which was low in available nitrogen, medium in available phosphorus and potassium. There were 11 treatment combination consisting of two different water soluble fertilizers along with Package of practice (*viz.,* only RDF, 0.5 % 18:18:18, 1.0 % 18:18:18, 1.5 % 18:18:18, 0.5 % Multi-K, 1.0 % Multi-K, 1.5 % Multi-K, 1.0 % 18:18:18 + 0.5 % Multi-K, 1.0 % 18:18:18 + 1.0 % Multi-K and 1.0 % 18:18:18 + 1.5 % Multi-K). All water soluble fertilizer were given as foliar spray at two stages (30 DAS and 60 DAS) of crop growth and all the treatments received RDF as per the requirements.. The experiment was laid out in RCBD with three replications. The Package of Practice + 18:18:18 @ 1.0 % + Multi-K @1.5 % recorded significantly higher plant height (218.7 cm), leaf area (62.8 cm2 plant-1), total dry weight (335 g plant-1), cob length (18.5 cm), thousand grain weight (236 g), shelling percentage (82.9 %), number of grain per cob (435), grain rows per cob (12.9), grain weight per plant (179 g), Grain yield (83.99 q ha^{-1}), stover yield (183.38 q ha^{-1}) and harvest index (0.46) compared to other of treatments.

Keywords: water soluble, yield parameters, hybrid maize, *Zea mays* L

Introduction
Maize is cultivated in an area of of 9.4 million ha with a production of 23 million tons with productivity of 2500 kg ha^{-1}in India. In Karnataka, maize is grown on an area of 1.3 million ha with a production of 4.4 million tons and a productivity of 3500 kg ha^{-1} (Anon., 2014) [1]. By 2020, the equipment of maize for various sectors will be around 100 million tones. In Karnataka, maize yield is low due to imbalanced application of fertilizers. The recommendation of fertilizer dose is a challenge to the scientists as it should meet both nutrient demand of the crop as well as sustain the production system (Shankar and Umesh, 2008) [9].

During the last decades, foliar fertilization or application of water soluble fertilizers has become an established procedure to increase yield and improve the quality of crop product. On the other hand, foliar feeding of a nutrient, may actually promote root absorption of same nutrient. Through water soluble fertilizers, it is easy to supply the precise amount of nutrients required by the plants. The use of water soluble fertilizers in different crops is meager in India, while it is very high in developed countries. Water soluble fertilizers consumption in USA about 17% of the total fertilizers used in all the crops in 2009. In India, these are mainly applied as foliar sprays or applied through drip fertigation system. So far, the most important use of foliar application has been in micro nutrients. The greater difficulty in supplying N, P and K through foliar spray lies in its application in adequate amounts without severely affecting the crop such as burning of the leaves. Hence, use of water soluble fertilizers is mainly through fertigation. But, in some places only water soluble fertilizers are used for direct application to soil similar to that of the normal fertilizers application.

Foliar feeding with plant nutrients gives quick benefits and economizes nutrient element as compared to soil application (Verma, 1973) [11]. Foliar feeding is often effective when roots are unable to absorb sufficient nutrients from the soil due to high degree of fixation, losses from leaching, low soil temperature and lack of soil moisture. Foliar application of nutrients for increasing and exploiting genetic potential of the crop is considered as an efficient and economic method of supplementing the nutrient requirement.

Application of inorganic spray will also enhance the nutrient availability and in turn increase the productivity. Nutrients play a pivotal role in increasing yield. Foliar application of major and minor nutrients like NPK shall be more effective than soil application and also avoiding the depletion of these nutrients in leaves, thereby resulting in an increased photosynthetic rate, better translocation of these nutrients from the leaves to the developing grains. (Manomani and Srimathi, 2009) [6] Keeping these points in view, the present experiment entitled "Effect of liquid fertilizers on rainfed hybrid maize (*Zea mays* L.) in Southern Transition Zone of Karnataka.'' was conducted at Agriculture and Horticultural Research Station, Bavikere (Chickmagaluru District, Karnataka).

Materials and Methods

A field experiment in randomized block design, consisting of 11 treatments with three replication, was conducted at the Agricultural and Horticultural Research Station, Bavikere ($13^o42'$ N and $75^o51'$ E with average annual rainfall of 990mm) during raining season of 2014. The soil was red clay loam, slight acidic pH (5.6), medium in organic carbon (%), low in available nitrogen, medium in both available phosphorus and potassium. The experiment consisting of eleven treatment combination T_1: RDF, T_2: RDF+FYM @ 7.5 t ha^{-1} +$ZnSO_4$@10 kg ha^{-1}(POP), T_3: POP + 18:18:18 @ 0.5 %, T_4: POP + 18:18:18 @ 1.0 %, T_5: POP + 18:18:18 @ 1.5 %, T_6: POP + MULTI-K @ 0.5 %, T_7: POP + MULTI-K @ 1.0 %, T_8: POP + MULTI-K @ 1.5 %, T_9: POP + 18:18:18 @ 1.0 % +MULTI-K @ 0.5 %, T_{10}:POP + 18:18:18 @ 1.0 % +MULTI-K @ 1.0 % and T_{11}:POP + 18:18:18 @ 1.0 % +MULTI-K @ 1.5 %. The treatments were replicated three times in a Randomized Block Design (RBD). The crop was sown at 60 × 30 cm spacing in $24.3m^2$ plot (5.4m × 4.5m) in third week of August and harvested in fourth week of December. The cultivation practices were followed as per the guidelines of Crop Production Guide of University Agricultural sciences, Bengaluru (Anon, 2014). The fertilizer sources used were urea for N (46 per cent N), Di Ammonium Phosphate for P (18:46:0 per cent water soluble N and P_2O_5), muriate of potash for K (60 per cent of K_2O) and zinc sulphate for Zn (22 per cent Zn). Growth and yield attributes were recorded as per standard procedures. The cost of cultivation, net returns and benefit: cost ratio were calculated on the basis of prevailing market price of different inputs and outputs. The nutrient use (kg grain/ kg nutrient) was calculated by dividing the grain yield with total nutrients. The nutrient content and uptake by maize were analyzed through prescribed laboratory procedures. The post harvest soil samples were collected from 0-20 cm depth for analyzing available nutrient status.

Results and Discussion

The growth attributing characters such as plant height, leaf area and total dry matter production were significantly influenced by various treatments (Table 1). Significantly taller plants of maize were noticed by POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 %(218.7 cm), significantly increased plant height of maize and which was on par with the plant height of POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (216.60 cm), POP +18:18:18 @ 1.0 % + Multi-K @ 0.5 % (214.70 cm), POP + Multi-K @ 1.5 % (212.1 cm), POP + Multi-K @ 1.0 % (202.0 cm), POP +18:18:18 @ 1.5 % (207.7 cm) however compared lower plant height was recorded in RDF (184.9cm) compared to other treatments. Higher plant height might be attributed to foliar application of nutrients for proper nourishment of crop and optimum growth and also increased the activity of meristamatic cell and cell elongation with application of nutrients as they are known to have favorable effects on metabolic process and better vegetative growth. These results are in conformity with the findings of Gururaj Kombali (2014) [2]. Mamathashree (2014) [5] and Parasuraman *et al*. (2008) [7]. Leaf area per plant at harvest differed significantly due to liquid fertilizers. POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % recorded significantly higher leaf (62.8 dm^2 $plant^{-1}$) over rest of the treatments, where as POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (61.7 dm^2 $plant^{-1}$) and POP +18:18:18 @1.0% + Multi-K @ 0.5 % (59.00 dm^2 $plant^{-1}$) and POP + Multi-K @ 1.5 % (57.9) were significantly on par with each other. POP (48.0 dm^2 $plant^{-1}$) recorded significantly lower number of leaves per plant when compared to other treatments. This might be due to development of efficient photosynthetic systems, which enabled the plant to intercept higher amount of radiant energy which is linked to higher dry matter accumulation per plant. There were significant differences in total dry matter production of rainfed hybrid maize at harvest stage due to different level of liquid fertilizers. POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % (335 g $plant^{-1}$) recorded significantly increased total dry matter production and which was on par with the total dry matter production of POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (321 g $plant^{-1}$), POP +18:18:18 @ 1.0 % + Multi-K @ 0.5 % (335 g $plant^{-1}$) and POP + Multi-K @ 1.5 % (306 g $plant^{-1}$). While the RDF (281) alone recorded significantly lower total dry matter accumulation.

The yield attributes such as cob length, number of grains per cob, number of grain rows per cob, thousand grain weight, grain weight per plant, grain yield, stover yield and harvest index were significantly influenced by various treatments (Table 1).

Table 1: Effect of liquid fertilizers on growth and yield parameters of rainfed hybrid maize (Zea mays L.) in Southern Transition Zone of karnataka

	Leaf area (dm^2 $plant^{-1}$)	Plant height (cm)	Total dry matter production (g $plant^{-1}$)	Cob length (cm)	Test weight (g)	Number of grains per cob	Grain rows per cob	grain weight per plant (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index
T_1: RDF	48.7	184.90	281	15.9	201	355	12.0	108	68.00	161.14	0.42
T_2: RDF+FYM @ 7.5 t ha^{-1} +$ZnSO_4$@10 kg ha^{-1}(POP)	48.0	188.30	284	16.2	203	361	12.1	113	70.80	162.39	0.44
T_3: POP + 18:18:18 @ 0.5 %	55.4	197.70	294	17.4	213	386	12.1	131	73.90	163.13	0.45
T_4: POP + 18:18:18 @ 1.0 %	52.7	202.10	303	17.9	217	399	12.3	143	76.10	167.99	0.45
T_5: POP + 18:18:18 @ 1.5 %	55.7	207.70	304	18.0	221	404	12.5	151	78.50	173.67	0.45
T_6: POP + MULTI-K @ 0.5 %	52.4	196.20	290	17.1	209	378	12.4	125	73.70	162.16	0.45
T_7: POP + MULTI-K @ 1.0 %	51.4	202.00	298	17.7	214	395	12.5	136	75.00	166.30	0.45
T_8: POP + MULTI-K @ 1.5 %	57.9	212.10	306	18.2	226	409	12.6	158	77.50	174.16	0.45

T_9: POP + 18:18:18 @ 1.0 % +MULTI-K @ 0.5 %	59.0	214.70	335	18.2	228	411	12.6	164	80.29	178.03	0.45
T_{10}:POP + 18:18:18 @ 1.0 % +MULTI-K @ 1.0 %	61.7	216.60	321	18.4	235	422	12.8	173	82.75	182.67	0.45
T_{11}:POP + 18:18:18 @ 1.0 % +MULTI-K @ 1.5 %	62.8	218.70	335	18.5	236	435	12.9	179	83.99	183.38	0.46
S. Em. ±	2.31	6.55	10.30	0.53	6.46	11.87	0.45	4.55	1.03	0.52	2.8
C.D. at 5%	6.82	19.32	30.98	1.57	19.06	35.02	NS	13.43	2.99	1.53	NS

Significantly higher cob length per plant was recorded in POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % (18.5cm) over rest of the treatments, which was on par with the number of leaves of POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (18.4 cm), POP +18:18:18 @ 1.0 % + Multi-K @ 0.5 % (18.2 cm), POP + Multi-K @ 1.5 % (18.2 cm), POP + Multi-K @ 1.0 % (17.7 cm), POP + Multi-K @ 0.5 % (17.1 cm), POP +18:18:18 @ 1.5 % (18.0 cm), POP +18:18:18 @ 1.0 % (17.9 cm) and POP +18:18:18 @ 0.5 % (17.4 cm). However RDF recorded significantly lower cob length (15.2 cm). Factors associated with leaf area contributed towards significant improvement in growth and yield attributes and ultimately resulted in higher cob length and cob girth. The similar interpretation was also denoted by Parasuraman *et al*. (2008) [7].

Significantly higher 1000 grain weight were recorded in POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % (236 g) over rest of the treatments, which was on par with the number of leaves of POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (235 g), POP +18:18:18 @ 1.0 % + Multi-K @ 0.5 % (228 g), POP + Multi-K @ 1.5 % (226 g), POP +18:18:18 @ 1.5 % (221 g) and POP +18:18:18 @ 1.0 % (217 g). Whereas significantly lower 1000 grain weight was recorded in RDF (201 g). Higher test weight was mainly attributed to higher leaf area and dry matter accumulation in leaves which might have supplied required photosynthates to the reproductive parts, more precisely to the seed. Thus, due to availability of photosynthates, the seed might have developed fully and resulted in bolder seeds hence recorded higher test weight. These results are in accordance with the results obtained by Jagathjyothi *et al*. (2012) [3].

POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % recorded significantly higher number of grains per cob (435). Which was on par with POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (422), POP +18:18:18 @ 1.0 % + Multi-K @ 0.5 % (411), POP +Multi-K @ 1.5 % (409) and POP +18:18:18 @ 1.5 % (435). Whereas significantly lower number of grains per cob (355) was recorded in RDF compared rest of treatments.

Conspicuously there was no significant difference occurred among the treatments with the application of liquid fertilizers. However application of POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % (14.1) recorded numerically more grain rows per cob. The lowest grain rows per cob (13.0) were recorded in RDF over the treatments.

Application of POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % recorded significantly higher grain weight per plant (179 g) and it was on par with POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (173 g). While significantly lower grain weight per plant was recorded in RDF (108 g) compared to other treatments. This may be due to less uptake of nutrients and less seeds per cob. These results are in corraborate with findings of Jayaprakash *et al.* (2006) [4] and Jagathjyothi *et al.* (2012) [3].

The grain yield (q ha^{-1}) significantly influenced by liquid fertilizers. Significantly higher grain yield (83.99 q ha^{-1}) was recorded in POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % which was on par with POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (82.75 q ha^{-1}), where as significantly lower grain yield (68.00) was recorded in RDF compared to rest of treatments.

The stover yield (q ha^{-1}) significantly influenced by liquid fertilizers. Significantly higher Stover yield (183.38 q ha^{-1}) was recorded in POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % which was on par with POP +18:18:18 @ 1.0 % + Multi-K @ 1.0 % (182.97 q ha^{-1}), while significantly lower Stover yield (161.14 q ha^{-1}) was recorded in RDF.

The harvest index did not differ significantly due to foliar fertilizer application. However numerically higher harvest index was recorded in POP +18:18:18 @ 1.0 % + Multi-K @ 1.5 % (0.45) and numerically lower harvest index was recorded in RDF (0.42) compared to other treatments.

The higher grain and stover yield of rainfed maize was mainly due to better translocation of photosynthates from source to sink and higher growth attributing characters like higher number of green leaves, leaf area and dry matter production and its accumulation into different parts of plant and yield attributing characters like grain weight per cob, number of seeds per cob, number of rows per cob, test weight, cob length and cob girth. These results are in accordance with those obtained by Veeresh (2010) [10]. Ravikumar (2008) [8].

Conclusion

It is concluded that to get maximum productivity from rainfed hybrid maize in Southern Transition Zone of Karnataka the crop should be fertilized with RDF +FYM @ 7.5 t ha^{-1} + $ZnSO_4$ @10 kg ha^{-1}. (POP) +18:18:18 @ 1.0 % + Multi-K @ 1.5 %. Rainfed maize will produce more grain and stover yield mainly because of better translocation of photosynthates from source to sink and more number of green leaves, leaf area and dry matter production, grain weight per cob, number of seeds per cob, number of rows per cob, test weight, cob length and cob girth due to sufficient amount of required amount of nutrients made available through water soluble fertilizers at required period.

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