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Research Article

STUDIES ON THE EFFECT OF SOIL AND FOLIAR APPLICATION OF NIROGEN, PHOSPHORUS AND POTASSIUM FERTILIZERS ON THE PERFORMANCE OF HYBRID MAIZE (*Zea mays* L.)

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Abstract

Field experiment was conducted in the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalainagar, Tamil Nadu during Summer season (February – May, 2016) to study the effect of soil and foliar application of N, P and K fertilizers on the performance of Hybrid maize (*Zea mays* L.). The experiment consisted of ten treatments *viz.,* T_1–Without soil and foliar application of nutrients – (As Control), T_2– Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} alone, T_3 – Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS, T_4–Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS, T_5–50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} alone, T_6 –50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS, T_7–50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS, T_8–100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} alone, T_9–100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS, T_{10}–100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS. The experiments were laid out in Randomized Block Design with three replications. Among the treatments tried, T_9–100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS recorded higher values for growth attributes *viz.,* plant height, leaf area index and dry matter production and yield attributes *viz.,* cob length, cob diameter, number of grains cob^{-1} and test weight which in turn accelerated the higher grain and stover yield, respectively. This was on par with T_{10}–100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS. The same treatments (T_9 and T_{10}) recorded higher value of nutrient uptake and post harvest soil available nutrients. In respect of economics to hybrid maize, higher net return of Rs. 1,26,017 and Rs. 1,21,045 and return rupee^{-1} invested of 3.61 and 3.51 were recorded through T_9 and T_{10} treatments, respectively.

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1. Introduction

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice with respect to area and productivity. Since the crop has very high genetic yield potential, it is also called as "Queen of cereals". Besides being a potential source of food for human being and used for feeding cattle, poultry and industries for the production of starch, syrup, alcohol, acetic acid, lactic acid etc. It is an

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efficient converter of solar energy into dry matter. Maize has high potential especially under irrigated condition when compared to any other cereal crop. The productivity of maize is largely dependent on its nutrient management. Chemical fertilizers are the potential sources of high amounts of nutrient that are available in easy form. It is well known that maize is more responsive to chemical fertilizers. Nutrient supply is key to ensuring higher productivity of maize.

N is the most important element required for plant growth and development. N is a component of protein, nucleic acids and other compounds essential for plant growth process which mediates the utilization of P, K and other elements in plants (Onasanya *et al*., 2009).

The early phonological development in maize with P application probably may be due to increased root development and thus helped the plants to obtain more P to complete its life cycle quickly (Amanullah *et al*., 2010). The beneficial physiological function of K in mitigation the adverse effect of drought sensitive by increased nitrate assimilation and osmotic regulation in maize crop (Lixin Zhang *et al*., 2014).

The foliar nutrients application not only provides the nutrients to the hungry plants, it could also provide water to the thirsty maize plants under drought condition (Amanullah *et al*., 2014). Keeping these points in view, the present investigation was required out to develop specific management practices such as soil and foliar application of N, P and K fertilizers in Hybrid maize (*Zea mays* L.), with the following objectives.

- To study the effect of varied levels of soil applied N, P and K fertilizers along with foliar spray on the growth and yield of Hybrid maize.
- To study the effect of soil and foliar application of N, P and K fertilizers on crop nutrient uptakement and post harvest soil available nutrient status.
- To workout the economics of adaptation of soil and foliar application of N, P and K fertilizers for yield maximization and income generation of Hybrid maize.

2. Materials and methods

Field experiment was conducted in the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalainagar, Tamil Nadu during Summer season (February – May, 2016) to study the effect of soil and foliar application of N, P and K fertilizers on the performance of hybrid maize (*Zea mays* L.). The experimental site is situated at 11^o 24' N latitude and 79^o44' E Longitude at a altitude of 5.79 m above mean sea level. The weather at Annamalai nagar is moderately warm with hot summer months. The maximum temperature ranges from 20.6^o C to 37.8^o C with a mean of 33.8^o C and the minimum temperature ranges from 20.8^o C to 27.3^o C with a mean of 23.8^o C . The relative humidity ranges from 88 to 72 per cent with a mean of 82 per cent. The mean hour of bright sunshine is 9.5. The mean annual rainfall received is 1500 mm. the soil of the experimental farm is classified as udic chromustert (clay) according to FAO/UNESCO (1974). The soil is deeply clay, low in available nitrogen, medium in available phosphorous and high in available potassium. The experiment was laid out in randomized block design (RBD) and replicated thrice with different treatment schedule *viz.*, T_1 – without soil and foliar application of nutrients –(As Control), T_2 – Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} alone, T_3 – Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS, T_4 – Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS, T_5 – 50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} alone, T_6 – 50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS, T_7 – 50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS, T_8 – 100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} alone, T_9 – 100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS, T_{10}

– 100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS.

Five plants in each plot were selected at random and tagged. These plants were used for recording all biometric observation at different stages of crop growth. Observations on growth components of maize *viz.*, Plant height, LAI and DMP yield components like cob length, cob diameter, grain number per cob, Test weight, no of grains cob^{-1}, grain weight cob^{-1} were recorded. Yield parameters of grain and stover yield from each net plot was recorded and expressed in Kg ha^{-1}.

The expenditure incurred from sowing to harvest was worked out as cost of cultivation and expressed as Rs. ha^{-1}. Total income obtained from grain stover yield was calculated for individual treatments. Gross and net returns were worked out and presented.

The observations collected during the experiments in respect of crop and weeds statistically analysed using the procedure outlined by Panse and Sukhantme(1978). WCI values were transformed by angular transformation and that of the weeds counts by the formula $\sqrt{x+0.5}$ before statistical analysis for significant results, the critical difference was worked out at 5 per cent probability level to draw statistical conclusions.

3. Results and Discussion

Growth Attributes

The result of the field study on hybrid maize crop revealed that the maize plant growth attributes *viz.*, Plant height, LAI, DMP and CGR was significantly influenced by the application of NPK fertilizers through both soil and foliar application. Among the different treatments, T_9 – (100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS), recorded the maximum value of plant height. This was on par with T_{10} – (100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS). The least plant height was noticed under the treatment T_1 (Control).

Maximum plant growth attributes were performed due to the increased level of NPK fertilizers in soil which was responsible for all round enhancement of plant growth, root growth, increased metabolic activities, assimilation rate cell division and elongation within the plant. The results are in accordance with the reports of Amandeep Kaur *et al*., (2012). The foliar application of NPK could be considered as the best way to reduce the salt accumulation and maintain necessary fertility levels in plant root zone and consequently improved plant height, plant metabolism and enhanced plant meristematic activity. These are similar findings of Mohamed *et al*., (2010).

Yield Attributes

The results of the field study on hybrid maize crop revealed that the cob length and diameter were significantly influenced by the application of NPK fertilizers through both soil and foliar application. An increased supply of NPK fertilizers to plant from soil during growth period by more assimilation rate and its integral part of protein, the building blocks of plant which resulted in slower leaf senescence which might be the reason for increased cob length and diameter in the treatment T_9 – (100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS. This was on par with T_{10} – (100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS). The least cob length and diameter value was noticed under the treatment T_1 (Control).

Yield parameters like cob length and diameter were increased due to application of increased doses of NPK fertilizers which enhanced nutrients uptake by the crop, by better translocation of photosynthates from source to sink in hybrid maize. These results are in accordance with those of Abd El-Rheem *et al*. (2015).

Cob length and diameter increased due to sufficient supply of foliar NPK to the crop. Because, NPK being an essential constituent o plant tissue is involved in cell division, cell elongation. Application of foliar NPK facilitates production of more photosynthates leading to increased cob length and diameter in maize.

These are similar with findings of Rasheed *et al*. (2003).

Yield

The results of the field study on hybrid maize crop revealed that the grain yield was significantly influenced by the application of NPK fertilizers through both soil and foliar application. Among the different treatments, application of 100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS (T_9), significantly influenced the higher grain yield. This was on par with T_{10} – (100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS). The lowest grain yield was noticed under the treatment T_1 (Control).

Increased grain yield was probably due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by the crop. The three major nutrients *viz.*, N, P and K are known to promote the growth and yield attributes by produced more dry matter and photosynthetic surface, well developed root system, study stem and more number of kernels cob^{-1} and heavier individual cobs due to ample cell turgidity and effective translocation of photosynthates from sources to sink as a consequence of liberal absorption of N, P and K respectively. The yield potential of hybrid maize is mainly governed by the growth and yield components. The positive and significant improvement in LAI and DMP noticed at different stages, increased yield attributes and nutrient uptake would have resulted in enhanced cob length, cob diameter, number of grains cob^{-1} and thus more grain yield. The findings are in line with the findings of Sunitha and Reddy (2012).

Foliar application of NPK fertilizers was found most beneficial in terms of better growth, increased yield and yield components like cob length, cob diameter and number of grains cob^{-1} of hybrid maize than control (no soil and foliar application). NPK absorbed by plant is responsible for fixation of carbon skeleton to amino acid synthesis which results in several proteins that have specific functions in plant metabolisms. In addition to this, during grain filling period these carbon compounds previously fixed are broken down, transported and stored in form of proteins and amino acids. These are similar with findings of Grzebisz *et al*. (2003) and Amanullah *et al*. (2016).

Economics

Among the treatments, application of 100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS (T_9) registered the higher net return of Rs. 1,26,017 ha^{-1} and BCR of Rs. 3.61. This was on par withT_{10} – (100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS). This could be significantly enhanced the maximum productivity and profitability of hybrid maize through both soil and foliar application of NPK fertilizers. The least net return and BCR value recorded under the treatment control (T_1).

The total cost of production, economic return, net farm income and benefit cost ration of maize was influenced by NPK fertilizers rate. The value increased with increase in fertilizers rate up to maximum quantity applied. Similar effect of NPK application on economics of corn has been reported by Sankaran *et al*. (2005).

The foliar application is a convenient and efficient operate and provides a low-cost approach for correcting NPK deficiency by allowing low rates frequent applications thus avoiding excess use and build up of salts while maintaining maximum nutrient availability to the crop its entire life span. Hence, foliar nutrient fertication through water dissolve NPK is a cost effective agronomic nutrient management practices thus enhanced the more economic returns. These are similar with findings of Rolston *et al*. (1979). The application of increased quantity of NPK fertilizers through soil applied and foliar application of NPK, registered the maximum values for most of the parameters like growth, yield attribute, green cob and stover yield of maize. In the light of the above facts, it might be concluded that application of 100% Increased quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS (T_9) and T_{10} – (100% Increased

quantity of RDF @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS) is a fitting and cost effective practice for augmenting higher hybrid maize yield. Also, this practice was found to be agronomically sound and economically viable and can be recommended to the hybrid maize growers of Tamil Nadu for realizing better yield and returns.

Table - 1: Effect of soil and foliar application of NPK ferilizers on LAI, DMP and CGR at 60 DAS

Treatments	LAI	DMP (kg ha^{-1})	CGR (g m^{-2} day^{-1})
T_1 – Without soil and foliar application of nutrients – (As Control)	2.91	2096	3.74
T_2 – Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} alone	4.05	4534	10.85
T_3 – Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS	4.96	5237	12.63
T_4 – Recommended dose of fertilizer @ 250:75:75 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS	4.84	5183	12.46
T_5 – 50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} alone	5.09	5482	13.11
T_6 – 50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS	5.99	6258	14.98
T_7 – 50% Increased quantity of recommended dose of fertilizer @ 375:112.5:112.5 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS	5.86	6167	14.84
T_8 – 100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} alone	6.12	6469	15.47
T_9 – 100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NPK (19:19:19) @ 2.5 kg ha^{-1} at 30 DAS	7.37	7565	18.11
T_{10} – 100% Increased quantity of recommended dose of fertilizer @ 500:150:150 kg of NPK ha^{-1} + Foliar application of NOP (13:0:45) @ 2.5 kg ha^{-1} at 30 DAS.	7.11	7325	17.53
$S.E_d$	0.13	196.92	0.33
CD (P=0.05)	0.27	393.87	0.68

Table-2: Effect of soil and foliar application of NPK ferilizers on cob length, cob diameter, number of grains cob^{-1}, grain yield and stover yield

Treatments	Cob length (cm)	Cob diameter (cm)	No. of grains cob^{-1}	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	8.96	6.89	51	1098	2547
T_2	13.94	9.88	167	3676	6781
T_3	16.11	11.61	231	5108	7457
T_4	15.93	11.47	225	4957	7323
T_5	16.77	11.94	244	5410	7692
T_6	19.45	13.73	345	7749	8958
T_7	19.26	13.62	336	7597	8776
T_8	20.07	14.07	357	8056	9169
T_9	23.17	16.42	496	11257	10645
T_{10}	22.29	15.96	482	10933	10421
$S.E_d$	0.42	0.23	10.64	237.14	189.93
CD (P=0.05)	0.90	0.48	21.30	474.26	398.87

Table-3: Effect of soil and foliar application of NPK fertilizers on Economics of Hybrid Maize

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	Return rupee^{-1} invested
T_1	29389	17743	-11645	0.60
T_2	39500	58530	17903	1.48
T_3	39950	80348	40398	2.01
T_4	39950	78016	38066	1.95
T_5	43703	84996	41293	1.94
T_6	44153	120714	76561	2.74
T_7	44153	118343	74190	2.68
T_8	47910	125424	77514	2.61
T_9	48360	174177	125817	3.60
T_{10}	48360	169205	120845	3.50

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