Mysore J. Agric. Sci., 55 (2) : 98-105 (2021)

Effect of Nutrient Uptake on Yield and Economics of Hybrid Maize and its Response to Graded Levels of Concentrated Manures and Macronutrient Foliar Spray under Surahonne (*Calophyllum inophyllum* L.) Based Agro-Forestry System in Southern Transitional Zone of Karnataka

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ABSTRACT

A field experiment was conducted during *kharif* - 2017 at Biofuel park, Madenur, University of Agricultural Sciences, Bangalore on sandy loam soil with neutral in reaction (pH 6.8) and the electrical conductivity was normal (0.26 d Sm^{-1} at 25 ^{0}C). The available nitrogen present in the soil was medium (310.50 kg ha^{-1}) and the available phosphorus was high 34.6 kg ha^{-1} and potassium 243.9 kg ha^{-1}. The experiment comprised of seven treatments with three replications laid out in RCBD. The results revealed that combined application of recommended dose of NPK (100:50:25kg/ha) + FYM 5 t/ha recorded higher grain yield and stover yield (72.50 and 97.70 q ha^{-1}, respectively), net returns (Rs.70,472 ha^{-1} /ha), B:C ratio (2.90), nitrogen, phosphorus and potassium uptake (189.9 kg N ha^{-1}, 46.82 kg P_2O_5 ha^{-1} and 161.91 kg K_2O ha^{-1}). Significantly lower macro nutrient uptake was recorded with application of 75 per cent N equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (149.4 kg N ha^{-1}, 35.31 kg P_2O_5 ha^{-1} and 125.0 kg K_2O ha^{-1}).

Keywords: Nutrient, Uptake, Yield, Maize economics

In India, maize is placed in 3rd position among the cereals in terms of its importance, after rice and wheat. But from the last decade, the production peak of this crop is increasing very fast due to its demand as feed, better market price, wider adaptability and greater production potential of hybrids and versatile uses in domestic, livestock and industrial sectors. Both production and consumption have grown at a compound annual growth rate of 5.5 per cent and 4 per cent, respectively over the ten years from 2004-05 to 2013-14. Introduction of single cross hybrids have encouraged the farmers to keep the crop in the cropping system to maximize the profit. In the year of 2017-18 about 27.14 million metric tons production was recorded, contributing 9.7 per cent of the total foodgrain production of India; but the productivity (2.5 mt/ha) lags behind the global average (5.5 mt/ha) (Anonymous, 2015). One of main reasons of low productivity is the imbalance application of nutrients by the farmers. Indiscriminate and continuous application of macronutrients only through high analysis fertilizers causes micronutrients deficiencies, soil health deterioration and environmental pollutions Besides, in order to curtail down the environmental footprints and sharp rise of price associated with chemical fertilizers; organic sources of nutrients are now-a-days coming back as promising options which can be used in conjunction with inorganic fertilizer since they are balanced in nature. Integrated Nutrient Management (INM) with combination of organic manures and inorganic fertilizers may be beneficial to improve soil properties and higher productivity of crops. This could be achieved in sustainable manner without sacrificing soil health, environment safety and other natural resources. Besides that, INM practices also helps in reduction of the production cost and increases the returns of the farmers. Agroforestry is not a new concept, nor is it a new technology. For centuries, agroforestry has been practiced around the world and is most commonly associated with tropical and sub-tropical regions. Agroforestry is an intensive land-management system that optimizes the benefits

from the biological interactions created when trees and shrubs are deliberately combined with crops and livestock. It is an emerging concept and technology that bridges production agriculture and natural resource conservation with environmental enhancement and human needs. *Calophyllum inophyllum* is a slow-growing and low-branching tree and commonly called as tamanu mast wood it is native of tropical Asia locally called Surahonne, it usually reaches 8 to 20 m in height. Its wood is hard and strong and has been used in boat building. The fatty acid methyl esters derived from *C. inophyllum* seed oil meets the major biodiesel requirements in the United States and European Union. The average oil yield is 11.7 kg oil per tree or 4680 kg oil per hectare. Keeping these facts in mind, the present experiment was framed to study the Nutrient uptake, yield and economics of hybrid maize to graded levels of concentrated manures and macronutrient foliar spray under Surahonne (*Calophyllum inophyllum* L.) based agro-forestry system in Southern Transitional Zone of Karnataka during *kharif* season 2017.

Material and Methods

The experiment on 'Effect of nutrient uptake on yield and economics of hybrid maize and its response to graded levels of concentrated manures and macro nutrient foliar spray under Surahonne (*Calophyllum inophyllum* L.) based agro-forestry system in Southern Transitional Zone of Karnataka' was conducted during *kharif* 2017 at Biofuel park Madenur, College of Agriculture, Hassan, University of Agricultural Sciences, Bangalore. The experimental spot is geographically located in the Southern Transitional Zone (Zone-7) of Karnataka and located between 12^0 13' and 13^0 33' N Latitude and 75^0 33' and 76^0 38' E Longitude at an altitude of 827 m above Mean Sea Level (MSL). The soil was red sandy loam with neutral in reaction (pH 6.8) and the electrical conductivity was normal (0.26 dSm^{-1} at 25 ^{0}C). The available nitrogen present in the soil was Medium (310.50 kg ha^{-1}) and the available phosphorus was high 34.6 kg ha^{-1} and potassium 243.9 kg ha^{-1}.

Treatment Details are as follows :

The experiment comprised of seven treatments. The details of the treatments are as follows:

T_1 : Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1}

T_2 : 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_3 : 50 per cent N Equivalent through pongamia cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_4 : 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_5 : 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_6 : 50 per cent N Equivalent through neem cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_7 : 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

Experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Specification	
Hybrid	Hema (NAH 1137)
Season	*Kharif* - 2017
Spacing	60 cm x 30 cm
Recommended fertilizer dose	100:50:25 kg NPK ha^{-1}
Recommended seed rate used	15 kg ha^{-1}
Gross plot	6.0 m x 3.6 m = 21.6 m^2
Net plot size	4.8 m x 3.0 m = 14.4 m^2
Date of sowing	18th August 2017

All the four organic nutrient sources were analyzed for available N, P and K content and the required quantity of farm yard manure, neem cake and pongamia cake for each plot were calculated based on their nitrogen levels. Recommended dose of phosphorus and potassium were applied through

The Mysore Journal of Agricultural Sciences

chemical fertilizers. As per the treatments these organic sources were applied and incorporated into soil three weeks before sowing. The inorganic nutrient sources like N, P and K were supplied through Urea, SSP and MOP, respectively. The seeds were sown with the spacing of 60 cm x 30 cm. Irrigation was given as and when required depending upon soil moisture. The analysis of plant samples were done at harvest for nutrient uptake studies (Jackson, 1973) and B:C ratio was calculated by using the formula :

$$\text{B: C ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

RESULTS AND DISCUSSION

Nutrient Uptake by Crop at Harvest

The data on nutrient uptake like nitrogen, phosphorus and potassium uptake at harvest as influenced by graded levels of concentrated manures and macronutrient foliar spray under surahonne (*Calophyllum inophyllum* L.) based agro-forestry system are presented in Table 1.

At harvest, significantly higher macro nutrient uptake was recorded with application of Recommended package (100:50:25) N, P_2O_5, K_2Oha^{-1} + FYM @ 5 t ha^{-1} (189.9 kg N ha^{-1}, 46.82 kg P_2O_5 ha^{-1} and 161.91 kg K_2O ha^{-1}) and which was on par with application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (184.6 kg N ha^{-1}, 45.24 kg P_2O_5 ha^{-1} and 156.8 kg K_2O ha^{-1}) and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (180.7 kg N ha^{-1}, 44.27 kg P_2O_5 ha^{-1} and 154.0 kg K_2O ha^{-1}).

Significantly lower macro nutrient uptake was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (149.4 kg N ha^{-1}, 35.31 kg P_2O_5 ha^{-1} and 125.0 kg K_2O ha^{-1}).

Improved yield and growth attributes might be interpreted as the manifestation of higher nutrient uptake by the plants. It is known fact that hybrid maize is one of the highly exhaustive field crops and N responsive, producing higher biomass per unit of external application. Nitrogen being a structural component of proteins involved in various biological functions. Whereas, phosphorous involved in better

TABLE 1

Nutrient uptake of hybrid maize at harvest as influenced by graded levels of concentrated manures and macronutrient foliar spray under surahonne (*Calophyllum inophyllum* L.) based agro-forestry system

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	189.9	46.82	162.0
T_2	149.4	35.31	124.3
T_3	161.7	39.02	136.1
T_4	180.7	44.27	154.0
T_5	153.4	36.50	128.9
T_6	166.0	39.97	139.4
T_7	184.6	45.24	156.9
S.Em±	3.50	1.03	3.26
CD (p=0.05)	10.78	3.17	9.05

T_1: Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1}

T_2: 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF+ 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_3: 50 per cent N Equivalent through pongamia cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_4: 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_5: 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_6: 50 per cent N Equivalent through neem cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_7: 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

DAS: days after sowing NS: Non significant
RDF: Recommended dose of fertilizer

development of root systems and enhance the efficiency of nutrient and water uptake by roots. Potassium imparts resistance to major biotic and abiotic stress.

Application of Recommended package (100:50:25) N, P_2O_5, K_2Oha^{-1} + FYM @ 5 t ha^{-1} recorded significantly higher macronutrient uptake (Table 1) by hybrid maize and was on par with the application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS. This was mainly due to higher growth parameters, yield parameters and small extent increase in nutrient status of the kernel and stalk recorded with application of recommended dose of fertilizer and FYM.

The lower uptake of nitrogen, phosphorus and potassium in hybrid maize recorded with the application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS might be due to non-availability of adequate quantity of nutrients throughout the crop growth period as the slow release of nutrients from the concentrated organic manures become available only in the later growth stages and making the crop to suffer in the early growth period due to want of sufficient nutrients. Manimala Mahato *et al.* (2020). Tulsiram Nargave *et al.* (2018).

Soil Chemical Properties

Data on soil chemical properties after harvest as influenced by graded levels of concentrated manures and macronutrient foliar spray under Surahonne (*Calophyllum inophyllum* L.) based agro-forestry system are presented in Table 2.

TABLE 2

Nutrient status of soil after harvest of hybrid maize at harvest as influenced by graded levels of concentrated manures and macronutrient foliar spray under surahonne (*Calophyllum inophyllum* L.) based agro-forestry system

Treatments	pH	EC (ds m^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	6.73	0.27	220.3	32.23	107.0
T_2	6.30	0.29	271.1	28.00	148.4
T_3	6.57	0.28	259.5	31.33	136.3
T_4	6.68	0.26	242.4	32.10	116.7
T_5	6.35	0.28	267.2	25.83	142.1
T_6	6.63	0.28	257.4	29.11	131.5
T_7	6.72	0.27	237.5	31.10	112.6
S.Em±	0.036	0.004	3.76	0.98	3.24
CD (p=0.05)	0.11	0.01	11.58	3.03	9.99

T_1 : Recommended package (100:50:25) N, P_2O_5, K_2Oha^{-1} + FYM @ 5 t ha^{-1}

T_2 : 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_3 : 50 per cent N Equivalent through pongamia cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_4 : 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_5 : 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_6 : 50 per cent N Equivalent through neem cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_7 : 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

DAS : days after sowing NS: Non significant RDF: Recommended dose of fertilizer

The Mysore Journal of Agricultural Sciences

Soil pH

At harvest, significantly lower soil pH was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (6.30).

The reduction in soil pH might be attributed to the release of organic acids during the microbial decomposition of added organic manures and increased enzyme activity in soil.

Significantly higher soil pH was recorded with application of Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} (6.73).

Electrical Conductivity

At harvest, significantly higher electrical conductivity (dSm^{-1}) was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (0.29). Significantly lower electrical conductivity (dSm^{-1}) was recorded with application of Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} (0.27)

Available Nitrogen

Significantly higher available nitrogen content in soil after harvest of the crop was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (271.1 kg N ha^{-1}) and which was on par with application of 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (267.6 kg N ha^{-1}). This was mainly due to lower uptake of nutrients in kernel and straw.

Significantly lower available nitrogen content after harvest of the crop was recorded with application of recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} (220.9 kg N ha^{-1}). This might be due to higher uptake of nutrients by hybrid maize.

Available Phosphorus

Significantly higher available phosphorus content after harvest of the crop was recorded with application of Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} (32.23 kg P_2O_5 ha^{-1}) and which was on par with application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (31.10 kg P_2O_5 ha^{-1}) and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (32.10 kg P_2O_5 ha^{-1}). This might be due to high quantity of phosphorus applied through inorganic fertilizer and FYM.

Significantly lower available phosphorus content after harvest of the crop was recorded in 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (25.83 kg P_2O_5 ha^{-1}).

Available Potassium

Significantly higher available potassium content after harvest of the crop was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (148.4 kg K_2O ha^{-1}) and which was on par with application of 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS (142.1 kg K_2O ha^{-1}).

Significantly lower available potassium content after harvest of the crop was recorded with application of Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} (107.0 kg K_2O ha^{-1}).

The nutrient retained in the soil after harvest of the crop mainly depends on both supply of nutrients through various sources and uptake by the crop. In general, higher the uptake of nutrients by crop lower will be the residual available nutrients in the soil. Further, higher the nutrients quantity supplied higher is the residual soil nutrients. However, several factors influence the uptake as well as availability of nutrients.

Significantly lower available potassium and nitrogen content in soil after harvest of the crop was recorded with application of Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1}. It was mainly due to higher dry matter production, higher kernel and stover yield leads to higher uptake of nutrients resulted in reduction of available nutrients in the soil after the harvest of crop. Similar findings were reported by Shivakumar *et al.* (2011) and Pallavi *et al*. (2016).

Yield Parameters:

Kernel Yield (q ha^{-1})

The data on kernel yield (q ha^{-1}), Stover yield (q ha^{-1}) and harvest index are presented in Table 3.

Among the different treatments, application of Recommended package (T_1) (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} has recorded significantly higher kernel yield (72.50 q ha^{-1}) and which was on par with application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_7) at 45 and 60 DAS (69.63 q ha^{-1}) and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_4) at 45 and 60 DAS (67.80 q ha^{-1}).

Significantly lower kernel yield was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray (T_2) at 45 and 60 DAS (51.33 q ha^{-1}). The higher kernel yield was mainly due to combined addition of FYM and inorganic fertilizers increased the availability of the nutrients and thus higher uptake of these nutrients leading to higher kernel and stover yield of hybrid maize. Tulsiram Nargave *et al.* (2018).

Stover Yield (q ha^{-1})

Among the different treatments, application of Recommended package (T_1) (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} has recorded significantly higher stover yield (97.70 q ha^{-1}) and which was on par with application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_7) at 45 and 60 DAS (95.80 q ha^{-1}) and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_4) at 45 and 60 DAS (94.00 q ha^{-1}).

TABLE 3

Kernel yield, stover yield and harvest index of hybrid maize as influenced by graded levels of concentrated manures and macronutrient foliar spray under surahonne (*Calophyllum inophyllum* L.) based agro-forestry system

Treatments	Kernel yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index
T_1	72.50	97.70	0.43
T_2	51.33	82.20	0.38
T_3	58.43	85.50	0.41
T_4	67.80	94.00	0.42
T_5	53.33	83.83	0.39
T_6	60.33	87.60	0.41
T_7	69.63	95.80	0.42
S.Em±	1.97	2.94	0.01
CD (p=0.05)	6.07	9.05	NS

T_1: Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1}

T_2: 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF+ 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_3: 50 per cent N Equivalent through pongamia cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_4: 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_5: 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_6: 50 per cent N Equivalent through neem cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_7: 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

DAS: days after sowing NS: Non significant
RDF: Recommended dose of fertilizer

Significantly lower stover yield was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray (T_2) at 45 and 60 DAS (82.20 q ha^{-1}). Application of Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} produced significantly higher stover yield (Table 4.15 and Fig.4.11) and was on par with the application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS compared to other treatments. The main reason for this was higher leaf area which is responsible for the higher photosynthetic activity and promoted dry matter production resulting in higher kernel and stover yield (Singh *et al*., 2006). Tulsiram Nargave *et al.* (2018).

Harvest Index

Among the different treatments, harvest index did not vary significantly due to soil application of graded levels of concentrated manures and macronutrient foliar spray under Surahonne (*Calophyllum inophyllum* L.) based agro-forestry system. However, higher harvest index was recorded with application of Recommended package (T_1) (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} (0.43) followed by application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_7) at 45 and 60 DAS (0.42) and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_4) at 45 and 60 DAS (0.42).

Lower harvest index was recorded with application of 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray (T_2) at 45 and 60 DAS (0.38).

Economics

The data on economics of growth and yield of hybrid maize to graded levels of concentrated manures and macronutrient foliar spray under Surahonne (*Calophyllum inophyllum* L.) based agro-forestry system in Southern Transitional Zone of Karnataka are presented in Table 4.

Higher gross returns, net returns and B:C ratio were recorded in treatment with application of Recommended package (T_1) (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} (Rs.105280, Rs.70472 ha^{-1} and 2.9, respectively) followed by application of

TABLE 4

Economics of hybrid maize cultivation as influenced by graded levels of concentrated manures and macronutrient foliar spray under Surahonne (*Calophyllum inophyllum* L.) based agro-forestry system

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1	35808	105280	70472	2.9
T_2	66422	76493	10071	1.2
T_3	54404	85863	31459	1.6
T_4	42386	98850	56464	2.3
T_5	67521	79237	11716	1.2
T_6	55137	88553	33416	1.6
T_7	42752	101408	58656	2.4

T_1: Recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1}

T_2: 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF+ 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_3: 50 per cent N Equivalent through pongamia cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_4: 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_5: 75 per cent N Equivalent through neem cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_6: 50 per cent N Equivalent through neem cake + 50 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

T_7: 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS

DAS: days after sowing NS: Non significant
RDF: Recommended dose of fertilizer

25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_7) at 45 and 60 DAS (Rs.101408, Rs.58656 ha^{-1} and 2.4, respectively) and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray (T_4) at 45 and 60 DAS (Rs.98850, Rs.56464 ha^{-1} and 2.3 respectively).

Lower gross returns, net returns and B:C ratio were recorded in treatment with 75 per cent N Equivalent through pongamia cake + 25 per cent through RDF + 2 per cent macro nutrient foliar spray (T_2) at 45 and 60 DAS (Rs.76493, Rs.10071 ha^{-1} and 1.2, respectively).

Economic returns are the ultimate criteria for acceptance and wider adoption of any technology. Application of recommended package (100:50:25) N, P_2O_5, K_2O ha^{-1} + FYM @ 5 t ha^{-1} recorded significantly higher gross returns, net returns and B:C ratio fallowed by application of 25 per cent N Equivalent through neem cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS and 25 per cent N Equivalent through pongamia cake + 75 per cent through RDF + 2 per cent macro nutrient foliar spray at 45 and 60 DAS compared to other treatments (Table 4 and Fig. 4). The higher gross returns were due to higher kernel and stover yield. The higher net return was due to increased gross returns coupled with comparatively lower cost of cultivation. The higher benefit cost ratio (B:C) ratio was attributed to higher gross returns with lower cost of cultivation. Similar results were also reported by Shanwad *et al.* (2010) in hybrid maize crop.

From the field study it can be inferred that combined application of recommended dose of NPK (100:50:25 kg/ha) + FYM 5 t/ha recorded higher grain yield and stover yield (72.50 and 97.70 q ha^{-1}, respectively), net returns (Rs.70,472 ha^{-1} /ha), B:C ratio (2.90), nitrogen, phosphorus and potassium uptake (189.9 kg N ha^{-1}, 46.82 kg P_2O_5 ha^{-1} and 161.91 kg K_2O ha^{-1}) as compared to other treatments

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(*Received :* January 2021 *Accepted :* March 2021)