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Research Article

COST ECONOMICS OF *RABI* MAIZE (*Zea mays* L.) AS INFLUENCED BY DRIP FERTIGATION OF NITROGEN, POTASSIUM AND MICROBIAL CONSORTIUM

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Abstract- The field experiment was conducted with two fertigation levels (100 and 75% RD N&K) and four levels of Microbial Consortium biofertigation (MC, *Azotobacter*, P solubulizing bacteria, K releasing bacteria and Zn solubulizing bacteria) at Water Technology Centre, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during *rabi* 2018-19 on maize (*Zea mays* L.). Randomized Block Desing (RBD) with 3 replications was used for this experiment. The maximum grain yield (7254 and 7304 kg ha^{-1}) was obtained with fertigation of 100% RD N&K and biofertigation of MC five times. Also, the interaction effect was not significant. Between fertigation levels maximum cost of cultivation was observed in 100% RD N&K (₹75,488 ha^{-1}) followed by 75% RD N&K (₹70,917 ha^{-1}) and in second factor, soil application of MC recorded higher cost of cultivation (₹75,973 ha^{-1}) and the minimum was observed in treatment where MC was not applied (₹71,573 ha^{-1}). Fertigation of 100% RD N&K recorded significantly higher gross and net returns (₹1,32,797 and ₹57,309 ha^{-1}, respectively), whereas fertigation with 75% RD N&K recorded on par net returns (₹56,151 ha^{-1}) with 100% RD N&K and higher B:C ratio (1.91) than 100% RD N&K. Biofertigation of MC five times recorded significantly higher gross returns (₹1,33,665 ha^{-1}) over treatment where MC was not applied (₹1,23,645 ha^{-1}) and was on par with biofertigation of MC three times (₹1,32,301 ha^{-1}) and soil application of MC (₹1,30,118 ha^{-1}). Significantly, higher net returns were observed with five times and three times biofertigation of MC (₹60,892 and ₹59,808 ha^{-1}) compared to soil application of MC (₹54,146 ha^{-1}) and treatment without MC application (₹52,072 ha^{-1}) which recorded lower net returns. Higher B:C ratio was observed with five times MC biofertigation (1.84) and three times MC biofertigation (1.83). Significantly Lower B:C ratio was observed in soil application of MC (1.71) and treatment without application of MC (1.73).

Keywords- *Fertigation, Biofertigations, Microbial Consortium, Gross and net returns*

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Introduction

Maize has the high productivity potential among the cereals crop of family Graminacea and can be cultivated in different seasons and agro-climatic conditions. After rice and wheat, maize is the third most important food crop in the world. Maize covers an area of 1.19 M ha in country with an average production and productivity of 5.90 M t and 4978 kg ha^{-1} respectively [1]. It can be grown in both Kharif and Rabi, as well as in Summer provided good irrigation facilities. Maize is highly efficient in terms of water usage for unit dry matter production. Water and fertilizers are important production factors for improving maize production. Fertigation is used to supply water and fertilizer simultaneously. Drip fertigation has proved its superiority over conventional fertilizer application by providing judicious amounts of water and nutrients. The price of chemical fertilizers has nearly doubled during past 5-6 years. This has necessitated search for cheaper source of fertilizers to meet the needs of the crops. Farmers use chemical fertilizers to increase the production to meet their needs, but the excessive use of fertilizers leads to contamination of soil and groundwater and reduce soil fertility. On the other hand, for marginal farmers in India, the purchase of chemical fertilizers is difficult and expensive. So, biofertilizers can partially replace chemical fertilizers and they are ecofriendly, non-hazardous and Non-Toxic. Nitrogen fixing, phosphate solubilizing and plant growth promoting microorganisms are main biofertilizers used for most of the crops. Among so many Biofertilizers, *Azotobacter, Azolla, Azospirillum*, Blue Green Algae (BGA), P-solubulizing microorganisms, mycorrhizae and sinorhizobium are have great potential for crop production. Under low soil moisture conditions, due to rainfed farming, poor and low efficiency traditional irrigation methods, the survival rate of soil microbes is difficult and there by their nutrient fixing ability. The biofertigation, that is application of liquid biofertilizers or microbial consortium along with drip irrigation can precisely deliver the bioinoculants in the root zone. Nowadays in Telangana state Drip irrigation technology is spreading fast within the farming community and covering more area, because of its many benefits and ease in application of water and nutrients which lead to increased efficiency in application of critical inputs and better crop performance.

Keeping in view of the above, the present study was planned to evaluate the performance of biofertigation under field condition along with fertigation of inorganic fertilizers on rabi maize.

Materials and Methods

A field experiment was conducted at Water Technology Centre, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during rabi 2018-19 in rabi maize (*Zea mays* L.)". For this experiment, maize variety DHM-117 was selected and experiment was carried out in Randomized Block Design (RBD) with 3 replications. The treatments, comprising of two fertility levels *viz*., 75% and 100% recommended dose (RD) of nitrogen and potassium (N&K) as first factor and biofertigtion of Microbial consortium (MC) *viz*., soil application of MC (SMC), biofertigation of MC three times (MC3), biofertigation of MC five times (MC5) and without application of MC (MC0) as second factor. The recommended dose of (RD) nutrients were 240:80:80 kg N:P_2O_5:K_2O ha^{-1}. The spacing adopted for sowing was 80 cm × 15 cm, experimental soil was loamy in texture, slightly alkaline in reaction, non-saline, low in available nitrogen, medium in available phosphorous and high in available potassium, medium in organic carbon content.

Fertigation of N&K

N & K was applied in different doses (75% & 100% RDF) through fertigation at an interval of 3 days in the form of urea and SOP (white) and drip irrigation was scheduled at 1.2 Epan during the entire crop growth period. The entire dose of phosphorus was applied to soil as basal whereas nitrogen and potassium were applied through fertigation by dissolving the required quantity of fertilizer as per the crop need plot-1 and applied through venturi system.

Liquid Microbial consortium

The liquid Microbial consortium consisted of *Azotobacter chrococcum* (Non symbiotic heterotrophic N_2 fixing bacterium), P solubulizing bacteria (*Pseudomonas flourescens*), K releasing bacteria (*Bacillus mucilaginaceous*) and Zn solubulizing bacteria (*Bacillus edapicus*).

Soil application of MC

Soil application of microbial consortium was done at 10 DAS @ 1.5 L (with microbial count 1012 cell ml^{-1}) mixed with 150 kg of vermicmpost for one hectare and applied along the plant rows.

Biofertigation of MC

Applied through drip irrigation system @ 1.5 L (with microbial count of 1012 cell ml^{-1}) diluted in 500 L of water for one hectare (except for soil application). Biofertigation was started from 10 days after sowing (DAS) at 10 days interval (20, 30 and 40 DAS for 3 times and 20, 30, 40, 50 and 60 DAS for 5 times application). Factorial RBD concept was utilized in analyzing the collected data, due to observance of Non-significant variation among treatments.

Results and Discussion

Grain and stover yield (kg ha^{-1})

Grain yield observed in treatment Fertigation with 100% RD of N&K (7254 kg ha^{-1}) has shown significant difference and higher when compared to observed grain yield with fertigation with 100% RD of N&K (6951 kg ha^{-1}). Microbial Consortium (MC) when biofertigated 5 times recorded maximum Grain yield (7304 kg ha^{-1}) among biofertigation treatments and was on par with the biofertigation of MC three times (7230 kg ha^{-1}), soil application of MC (7118 kg ha^{-1}) and was significantly superior over the treatment without application of MC (6758 kg ha^{-1}).

Significantly higher stover yield (9471 kg ha^{-1}) was recorded with 100% RD N&K over 75% RD N&K (8907 kg ha^{-1}). Stover yield recorded with biofertigation of MC five times (9496 kg ha^{-1}) and three times (9397 kg ha^{-1}) was significantly higher than that recorded without application of MC (8752 kg ha^{-1}) and was on par with soil application of MC (9111 kg ha^{-1}). The lower stover yield was recorded with treatment without application of MC and was on par with soil application of MC [Table-1]. The increase in grain and stover yield might be due to combined effect of biofertilizer microbial consortium with conventional N&K fertilizers which increases the availability of nutrients and transport major nutrients like N, P and K, besides secreting plant growth promoting substances which resulted in increase the plant height, number of leaves and leaf area which in turn lead to higher production and translocation of photosynthates and yield attributes like cob length (cm), cob girth (cm), number of rows cob-1, cob weight (g), grain weight (g) and more dry matter production plant-1. Observed findings are in similar trend, that is application of microbes through drip irrigation resulted in increasing grain and stover yield by Abdelhamid *et al*. (2011) through biofertigation, through seed inoculation in maize by Obid *et al*. (2016) [2] in maize, Bharathi *et al*. (2017) [3] in bhendi and Shravani (2018) [4] in greengram, Baral and Adhikari (2013) and Meena *et al*. (2013).

Table-1 *Grain and stover yield (kg ha-1) of rabi maize as influenced by nitrogen, potassium and microbial consortium drip fertigation*

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
RD N&K		
100% RD N&K	7254	9471
75% RD N&K	6951	8907
SE.m ±	73	119
CD (P=0.05)	222	362
Biofertigation		
MC_0	6758	8752
SMC	7118	9111
MC_3	7230	9397
MC_5	7304	9496
SE.m ±	103	169
CD (P=0.05)	314	511
Interaction between RD N&K and biofertigation		
SE.m ±	146	238
CD (P=0.05)	NS	NS

RD N&K: 100% RD (240:80 kg N:K_2O ha^{-1}) ; 75%RD (180:60 kg N:K_2O ha^{-1}).
Biofertigation: MC0-Without Microbial Consortium (MC); SMC-Soil application of MC; MC3-Biofertigation of MC three times; MC5-Biofertigation of MC five times.

Cost Economics

Cost of cultivation

Cost of cultivation varied from ₹70,917 to ₹75,488 ha^{-1} in fertigation of RD N&K and among biofertigation of MC it was ranged from ₹71,573 to ₹75,973 ha^{-1} of rabi maize [Table-2]. Main variation in cost of cultivation was due to biofertigation; cost of fertilizers and man power required for biofertigation.

Table-2 *Cost of cultivation, Gross, Net returns (₹ha-1) and B:C ratio of rabi maize as influenced by nitrogen, potassium and microbial consortium drip fertigation*

Treatment	Gross returns (₹ha^{-1})	Cost of cultivation (₹ha^{-1})	Net returns (₹ha^{-1})	B:C ratio
RD N&K				
100% RD N&K	132797	75488	57309	1.76
75% RD N&K	127068	70917	56151	1.79
SE.m ±	1279	-	1279	0.02
CD (P=0.05)	3881	-	3881	0.05
Biofertigation				
MC_0	123645	71573	52072	1.73
SMC	130118	75973	54146	1.71
MC_3	132301	72493	59808	1.83
MC_5	133665	72773	60892	1.84
SE.m ±	1809	-	1809	0.02
CD (P=0.05)	5488	-	5488	0.07
Interaction between RD N&K and biofertigation				
SE.m ±	2559	-	2559	0.03
CD (P=0.05)	NS	-	NS	NS

Note: Sale price of maize grains -1700.0 q^{-1}; maize straw - 1.0 kg^{-1}
RD N&K: 100% RD (240:80 kg N:K_2O ha^{-1}) ; 75%RD (180:60 kg N:K_2O ha^{-1}).
Biofertigation: MC0-Without Microbial consortium (MC); SMC-Soil application of MC; MC3-Biofertigation of MC three times; MC5-Biofertigation of MC five times

Gross returns (₹ha^{-1})

Significantly higher gross returns (₹1,32,797 ha^{-1}) were recorded with fertigation of 100% RD N&K compared to 75% RD N&K (₹1,27,068 ha^{-1}). There was no significant difference in gross returns among biofertigation of MC five times (₹1,33,665 ha^{-1}) and three times (₹1,32,301 ha^{-1}) and were significantly superior

than soil application of MC (₹1,30,118 ha^{-1}) and without application of MC (₹1,23,645 ha^{-1}). The higher gross returns were recorded due to higher yield with biofertigation of MC than soil application.

Fig-1 Drip System

Fig-2 Maize Experimental plot

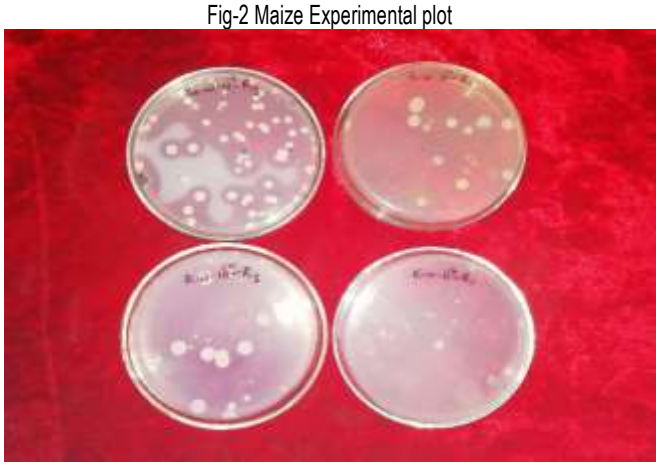

Fig-3 Microbial Plates

Net returns (₹ha^{-1})

Net returns recorded with fertigation of 75% and 100% RD N&K (₹56,151 and ₹57,309 ha^{-1}, respectively) were not significantly different, even though higher yield was recorded with fertigation with 100% RD N&K but the cost of input fertilizers is more in 100% RD N&K compared to 75% RD N&K which recorded lower yield than 100% RD N&K. Among biofertigation of MC, significantly higher net returns were observed in biofertigation of MC five times (₹60,892 ha^{-1}) compared to soil application of MC (₹54,146 ha^{-1}), without application of MC (₹52,072 ha^{-1}) and was on par with biofertigation of MC three times (₹59,808ha^{-1}). The net returns observed in soil application of MC was on par with the treatment where MC was not applied. The results are in confirmity with the results reported by Ahmed *et al.* (2000) in cotton.

B:C ratio

75% RD N&K recorded higher B:C ratio (1.79) and was on par with 100% RD N&K (1.76) in fertigation levels. This may be due to lower fertilizer cost in 75% RD N&K compared to 100% RD N&K. Among biofertigation of MC, there was no significant difference in B:C ratio was observed between biofertigation of MC five times (1.84) and three times (1.83) and were significantly superior over soil application of MC (1.71) and with treatment without application of MC (1.73). This may be due to relative increase in yield with biofertigation of MC proportional to increased cost of inputs.

Conclusion

Application of 75% RD N&K with biofertigation of MC either three times or five times can be recommended over 100% RD N&K and soil application of biofertilizers for realizing optimum and economical yields with reduced use of chemical fertilizers for sustaining soil health.

Application of research: Farmers can improve soil health and maintain soil sustainability without compromising crop yield and net returns with the use of liquid biofertilizers. Use of drip irrigation system for these liquid biofertilzers application ensures proper survival rate of these microorganisms, which increases nutrient fixation and availability to the crops there by reduces the farmers dependency on use chemical fertilizers partially.

Research Category: Integrated Nutrient Management (INM), Biofertigation and Soil Health and Sustainability

Abbreviations: RD-Recommended Dose, RDF-Recommended Dose of Fertilizer, MC-Microbial Consortium, RBD-Randomizes Block Design, B:C-Benefit Cost Ratio, M t-Million Ton, M ha^{-1} Million Hectare, SMC-Soil Application of Microbial Consortium, SOP-Sulphate of Potash, DAS-Days After Sowing, ha^{-1}-Per hectare, CD-Critical Difference, SE.m ± - Standard error of the Mean

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Study area / Sample Collection: College Farm, PJTSAU, Rajendranagar, Hyderabad, 500030

Cultivar / Variety / Breed name: Deccan Hybrid Maize (DHM) - 117

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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