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Effect of integrated nutrient management practices for maximizing the Productivity and profitability of fodder Maize

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Abstract

Field experiments were conducted during the Summer 2021 and 2022 to find out the effect of integrated nutrient management practices in fodder maize + cowpea intercropping at Vjayapur and Bagalkot District Cooperative Milk Union Ltd., Vijayapur Farm, which is situated between 13^{0}17'24''N latitude and 77º47'60'' E longitude at an altitude of 650 m above mean sea level and which come under the Northern Dry Zone (ZONE-III) of Karnataka. The field experiments were laid out in split plot design with three replications. In the main plot, different methods and type of biofertilizer application viz., BF_1 - control (no biofertilizer), BF_2 - seed treatment with *Azospirillum*, BF_3 - soil application of Phosphobacteria and BF_4 - seed treatment with *Azospirillum* and soil application of Phosphobacteria were imposed. Whereas in the sub plot, four INM component such as application of graded levels of recommended dose of nitrogen (75, 100 and 125 % RDN) with vermicompost at equivalent basis of 25, 50 and 75 % of RDN was undertaken along with one absolute control treatment. The impact of treatment imposition were studied on the yield and economics of fodder maize cultivation under fodder maize + cowpea intercropping.The results of the experimental study apparently confirmed that seed treatment with *Azospirillum* and soil application of Phosphobacteria significantly registered higher green forage yield and gross returns. Among the different N combinations, application 75% recommended dose of N + recommended dose of P and K+ 25% N on equivalent basis of vermicompost proved superior. Interaction effect between types and methods of biofertilizer application and nitrogen management practices was significant. However, seed treatment of *Azospirillum* and soil

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application of Phosphobacteria along with application 75% recommended dose of N + recommended dose of P and K+ 25% N on equivalent basis of vermicompost excelled all other treatments and resulted in higher values on green fodder yield and economic returns.

Key words : Fodder maize, INM, RDN, *Azospirillum,* Biofertilizers and Vermicompost.

Maize (*Zeamays* L.) is one of the most significant cereal fodder crops used for livestock and poultry food and feed. The fodder maize is essential for raising the livestock's productivity and increasing the profitability of this enterprise[3]. The crop has an advantage over cultivated fodder crops due to its versatility, better fodder quality, and ease of silage administration. Cattle love fodder maize because it is rich in protein, carbohydrates, minerals, and vitaminswith a high dry matter yield. However, cattle require protein for health and milk production. Even while maize offers ample fodder, its quality be enhanced by mixing it with suitable fodder legumes without diminishing its forage production. It has been found that the addition of legumes will improve forage quality since legumes are high in protein[33]. Ghanbari *et al*.[11] found that planting grains and legumes together makes forage better and also increases soil fertility by fixing nitrogen from the air.

Fodders as a group of crops differ from food and commercial crops as they are primarily grown for the fresh green vegetative biomass. Cereal forages such as maize, sorghum, oat, barley and millets give higher forage yield but are deficient in protein contents. Forage legumes such as soybean, cowpea, cluster bean etc. are rich sources of protein but their forage yield only half in comparison with cereal forages[16]. Maize when grown as fodder, the crop gives huge quantities of green herbage in a short time. 59 per cent of total maize grain produced in the country is utilized in manufacture of concentrate feed for livestock[32]. Although maize provides high yield in terms of dry matter, it produces forage with low protein content. Protein is also needed by rumen bacteria which digests much of the feed for ruminant animals[10] which becomes necessary to provide livestock with protein supplements when forage quality is low. Cowpea an annual legume with high level of protein can be mixed with maize to improve forage protein content in diets and thus cost of high quality forage production can be lowered[9]. In India it occupies 0.3 million hectare out of 0.65 million hectare area under different pulse and vegetable cowpea[32]. The concept of intercropping is to get increased total productivity per unit area and time besides equitable and judicious utilization of land resources and farming inputs[27]. Intercropping legumes contribute to increased productivity of other crops when incorporated into cropping systems as intercrops[13]. Maize-legume intercropping is currently receiving global attention because of its prime importance in world agriculture. According to Iqbal *et al*.[15] plant nutrition has a significant effect on forage maize yield; particularly nitrogen supplied either through inorganic or organic means. The requirement of fodder crops for nutrients particularly nitrogen is comparatively higher.

This is due to the fact that fodder crops are grown to produce luxuriant and succulent vegetative growth in a short period[2].

Field experiments were conducted to find out the effect of integrated nutrient management practices in fodder maize under fodder maize + cowpea intercropping at Vijayapur and Bagalkot district Cooperative Milk Union Ltd., Vijayapur. Dairy farm, Bhutanal village, Vijayapur District, Karnataka. The soil at the experimental site is medium black and the texture of the soil is a clayey loam, belonging to the order *vertisols*. The analysis of pre - soil samples report showed with low in available nitrogen (179.4 kgha^{-1}), medium in available phosphorus (28.4 kgha^{-1}) and high in available potassium (428.3 kgha^{-1}). The soil pH and E.C. report were showed 7.98 and 0.28 dsm^{-1}, respectively. The fodder variety selected for this study was maize African tall. The experiment was laid out in split plot design with three replications. In the main plots, the specifics of the treatments are described as BF_1– Control(no biofertilizer), BF_2 - Seed treatment with *Azospirillum*, BF_3 - Soil application of Phosphobacteria and BF_4 - Seed treatment with *Azospirillum* + Soil application of Phosphobacteria. Where as in the subplots, the specifics of the treatments are described as N_1 - Absolute control, N_2 - 100% of Recommended Dose of Nitrogen (RDN), N_3 - 75% RDN + 25% as vermicompost, N_4 - 50% RDN + 50% N as vermicompost and N_5 - 25% RDN + 75% N as vermicompost. Recommended dose of 200:50:40 kg of NPK ha^{-1} was adopted and the recommended dose of P and K were applied uniformly to all the subplots except absolute control.

Green forage yield :

The data concerning the influence of green forage yield under fodder maize + cowpea intercropping system through integrated nutrient management have been displayed in Table-1.

Effect of types and methods of biofertilizer application :

The data revealed that there was a significant difference was found amongst the treatments with the influence of types and methods of biofertilizer applicationin fodder maize during 2021 and 2022. Significantly higher fodder maize forage yield of 352.20 q ha^{-1} and 371.64 q ha^{-1} in the year 2021 and 2022, respectively were found with seed treatment with *Azospirillum* + soil application of Phosphobacteria. This was significantly followed by the soil application of Phosphobacteria (305.95 q ha^{-1} and 321.50 q ha^{-1}) and seed treatment with *Azospirillum* (304.31 q ha^{-1} and 320.06 q ha^{-1}) during the year 2021 and 2022, respectively. Later, a significantly lower (272.21 q ha^{-1} and 284.04 q ha^{-1}) forage yield was found with absolute control. This was probably the result of N fixation by *Azospirillum* and increased phosphorus solubilization by Phosphobacteria. Furthermore, combined inoculation of *Azosprillum* and Phosphobacteria had a pronounceable impact on the bacterial population in the rhizosphere. This might result in a greater release of root exudates in the form of soluble carbohydrates and sugars into the rhizosphere and lead to an increase in the multiplication of bacteria supplied via inoculations and offered congenial soil environment to the plant. It corroborated

with Dadarwal *et al.,*[7], Mahapatra *et al*.,[24]. The favourable effect of integrated nutrient supply in improving the biomass yield components of fodder maize was resulted in enhancement of green forage yield. Increase in yield and its attributes observed with integrated application of inorganic, organic and biofertilizer is ascribed to better translocation, utilization of applied nutrients which increased sink capacity and partitioning of photosynthesis.

Integrated N approach :

Data presented in Table-1 rendered that there was a pronounced difference perceived among the treatments in fodder maize as influenced by different integrated nitrogen management approach. When the treatments were collated with absolute control, it revealed significantly higher maize forage yield of 432.04 q ha^{-1} and 456.77 q ha^{-1} with 75% Recommended Dose of Nitrogen (RDN) + Recommended dose of P and K + 25% N on equivalent basis of vermicompost during the year 2021 and 2022, respectively. This was followed by application of 100 per cent recommended dose of NPK and registered the of green forage yield of 348.39 q ha^{-1} and 367.20 q ha^{-1}, respectively. However, significantly lower maize forage yield of 145.45 q ha^{-1} and 150.44 q ha^{-1} were found in absolute control. This could be attributed to the increase in green fodder yield brought on by the improvement in plant growth and development overall by the application of sufficient nutrition from both organic N and vermicompost source of N. This fostered healthy growth and development by allowing the plant to extract more nutrients from the soil. Nitrogen is primarily a part of the chlorophyll molecule, which enables the plant to capture sunlight energy by photosynthesis, driving plant growth and fodder yield and it also plays a critical role within the plant to ensure energy is available and where the plants needs it to optimize yield. The increase in green forage yield is mainly due to higher plant height and leaf stem ratio and quick release of nutrient from bio-compost resulted better growth of plant which led to greener biomass. This is in conformity with the findings of Karforma *et al*.[22], Hussain *et al*.[14], Meena *et al*.[29], Jat *et al*.[19], Kalhapure *et al*.,[21], Deva[8], and Verma *et al*.,[35]. Shekar *et al.,*[34] and Naveena *et al*.,[31].

Interaction effects :

The interaction effect between the type and method of biofertilizer application and integrated nitrogen management strategies on green fodder yield of maize was significant in both the years. The treatment combinations of seed treatment with *Azospirillum* and soil application of Phosphobacteria along with application of 75% Recommended Dose of Nitrogen (RDN) + recommended dose of P and K + 25% N on equivalent basis of vermicompost excelled over all other treatments by recording the highest green fodder yield of 489.40 and 519.57 q ha^{-1} in the year 2021 and 2022, respectively. This might be due to superiority of combined treatment of inorganic, organic sources and use of Azotobacter as seed inoculation resulted in better growth and PSB containing phosphate solubilising ability due to secretion of phosphate enzyme to dissolve P present in the organic matter applied in the form of vermicompost for increasing forage yield of fodder maize by simultaneous exudation of organic acids. The

Table-1. The effect of INM on the green forage yield of fodder Maize

Treatment	Green forage yield (q per ha)	
	2021	2022
Bio fertilizers (BF)		
BF1	272.21	284.04
BF2	304.31	320.06
BF3	305.95	321.50
BF4	352.20	371.64
SEd	1.57	1.64
CD (p=0.05)	3.84	4.03
Levels of N and INM		
N1	145.45	150.44
N2	348.39	367.20
N3	432.04	456.77
N4	310.46	325.52
N5	306.98	321.62
SEd	2.42	2.55
CD (p=0.05)	4.94	5.20
Interactions		
BF1N1	120.50	121.55
BF1N2	298.77	312.38
BF1N3	401.33	421.49
BF1N4	269.00	281.24
BF1N5	271.43	283.55
BF2N1	150.69	156.67
BF2N2	345.17	364.01
BF2N3	419.00	443.39
BF2N4	310.80	326.14
BF2N5	295.88	310.07
BF3N1	154.28	160.57
BF3N2	346.98	364.96
BF3N3	418.44	442.61
BF3N4	314.19	329.28
BF3N5	295.88	310.07
BF4N1	156.31	162.97
BF4N2	402.65	427.45
BF4N3	489.40	519.57
BF4N4	347.85	365.42
BF4N5	364.75	382.79
BF x N		
SEd	4.61	4.85
CD (p=0.05)	9.61	10.12
N x BF		
SEd	4.85	5.11
CD (p=0.05)	9.88	10.40

Table -2. The effect of INM on the economics of fodder Maize

Treatment	Gross return	
	2021	2022
Bio fertilizers (BF)		
BF1	68051.74	71010.63
BF2	76076.56	80014.24
BF3	76488.60	80374.64
BF4	88048.79	92910.15
SEd	**392.07**	**411.20**
CD (p=0.05)	**959.40**	**1006.22**
Levels of N and INM		
N1	36361.56	37610.20
N2	87098.23	91800.22
N3	108010.92	114191.85
N4	77615.28	81380.11
N5	76746.11	80404.70
SEd	**606.05**	**638.35**
CD (p=0.05)	**1234.51**	**1300.31**
Interactions		
BF1N1	30124.18	30388.21
BF1N2	74692.65	78095.52
BF1N3	100332.50	105373.21
BF1N4	67250.98	70309.22
BF1N5	67858.38	70886.99
BF2N1	37673.32	39167.13
BF2N2	86291.83	91003.34
BF2N3	104750.00	110847.87
BF2N4	77698.88	81535.35
BF2N5	73968.76	77517.54
BF3N1	38570.66	40142.77
BF3N2	86745.43	91239.55
BF3N3	104610.00	110652.94
BF3N4	78548.14	82320.39
BF3N5	73968.76	77517.54
BF4N1	39078.06	40742.67
BF4N2	100663.00	106862.47
BF4N3	122351.19	129893.39
BF4N4	86963.12	91355.49
BF4N5	91188.56	95696.74
BF x N		
SEd	**1152.85**	**1213.69**
CD (p=0.05)	**2403.02**	**2529.40**
N x BF		
SEd	**1212.10**	**1276.70**
CD (p=0.05)	**2469.03**	**2600.62**

results are supported by the findings of Karforma *et al*.[22], Husain *et al*.[14], Meena *et al*.[29], Jat *et al*.[19], Kalhapure *et al*.[21], Deva[8], Verma *et al*.[35], Jadhav *et al.,*[17], Shekar *et al*.,[34].

Economics :

Table-2 depicted the gross return, net return and B:C ratio of fodder maize cultivation.

Effect of types and methods of biofertilizer application :

Among the treatments projected on table-2 claims that there was marked breach was found in the practice of seed treatment with *Azospirillum* and soil application of Phosphobacteria by registering the maximum gross return of Rs. 88048.79 and Rs.92910.15 ha^{-1}, net return of Rs.39859.25 and Rs. 44720.62 ha^{-1} and B:C ratio of 1.84 and 1.94 in the year 2021 and 2022, respectively. However, the control plot registered minimum gross return of Rs. 68051.74 and Rs.71010.63 ha^{-1}, net return of Rs.20932.20 and Rs.23891.10 ha^{-1} and B:C ratio of 1.46 and 1.52 in the year 2021 and 2022, respectively. This might be due to the synergistic and cumulative effect of seed treatment with Azospirillum and soil application of Phosphobacteria, the largest forage yield was attained in the above treatment combination, And yield obtained through improvement in soil health by judicious integrated nutrient management approach using 75% inorganic NPK with organic manure (vermicompost) and mixed bio fertilizers. Similar findings with Asoka *et al.,*[4], Meena *et al.,*[29], and Shekar *et al.,*[34] which resulted in greater economic returns.

Integrated N approach :

The maximum gross return of Rs.108010.92 and Rs.114191.85 ha^{-1}, net return of Rs. 60376.16 and Rs. 66557.09 ha^{-1} and B: C ratio of 2.27 and 2.40 in the first and second year experimentation, respectively were observed with the integrated nitrogen management treatments such as 75% recommended dose of N + recommended dose of P and K +25% N on equivalent basis of vermicompost. Whereas, the minimum gross return of Rs. 36361.56 and Rs. 37610.20 ha^{-1}, net returns of Rs.3779.56 and Rs.5028.20 ha^{-1} and B:C ratio of 1.12 and 1.15 in the first and second year experimentation, respectively were observed with the absolute control. This could be attributed to the prolonged and increased availability of both native and applied nutrients until crop harvest, which strengthened a better source-sink connection, hence contributing to higher yield and resulted in maximum economic benefits. This was happens due to higher green forage yield biomass contributed higher gross returns and lower cost of vermicompost with higher nitrogen content. This is in accordance with the findings of Kumar *et al.,*[23], Shekar *et al.,*[34] and Naveena *et al.,*[31].

Interaction effects :

In general, the combination of biofertilizers and vermicompost with inorganic fertilizers treatment had proved it economical superiority by realizing higher net return, return $rupee^{-1}$ invested. However, the combinations

Table -3. The effect of INM on the economics of fodder Maize

Treatment	Net return	
	2021	2022
Bio fertilizers (BF)		
BF1	20932.20	23891.10
BF2	28527.03	32464.71
BF3	28771.07	32657.11
BF4	39859.25	44720.62
SEd	**186.12**	**200.16**
CD (p=0.05)	**455.44**	**489.79**
Levels of N and INM		
N1	3779.56	5028.20
N2	47043.31	51745.30
N3	60376.16	66557.09
N4	22404.69	26169.52
N5	14008.22	17666.81
SEd	**307.34**	**338.36**
CD (p=0.05)	**626.05**	**689.24**
Interactions		
BF1N1	-1922.82	-1658.79
BF1N2	35172.73	38575.60
BF1N3	53232.74	58273.45
BF1N4	12575.39	15633.63
BF1N5	5602.99	8631.60
BF2N1	5196.32	6690.13
BF2N2	46341.91	51053.42
BF2N3	57220.24	63318.11
BF2N4	22593.29	26429.76
BF2N5	11283.37	14832.15
BF3N1	5883.66	7455.77
BF3N2	46585.51	51079.63
BF3N3	56870.24	62913.18
BF3N4	23232.55	27004.80
BF3N5	11283.37	14832.15
BF4N1	5961.06	7625.67
BF4N2	60073.08	66272.55
BF4N3	74181.43	81723.63
BF4N4	31217.53	35609.90
BF4N5	27863.17	32371.35
BF x N		
SEd	**580.44**	**637.51**
CD (p=0.05)	**1206.82**	**1324.38**
N x BF		
SEd	**614.69**	**676.72**
CD (p=0.05)	**1252.11**	**1378.47**

Table -4. The effect of INM on the economics of fodder Maize

Treatment	B:C	
	2021	2022
Bio fertilizers (BF)		
BF1	1.46	1.52
BF2	1.62	1.71
BF3	1.63	1.71
BF4	1.84	1.94
SEd	**0.01**	**0.01**
CD (p=0.05)	**0.02**	**0.02**
Levels of N and INM		
N1	1.12	1.15
N2	2.17	2.29
N3	2.27	2.40
N4	1.41	1.47
N5	1.22	1.28
SEd	**0.01**	**0.01**
CD (p=0.05)	**0.02**	**0.03**
Interactions		
BF1N1	0.94	0.95
BF1N2	1.89	1.98
BF1N3	2.13	2.24
BF1N4	1.23	1.29
BF1N5	1.09	1.14
BF2N1	1.16	1.21
BF2N2	2.16	2.28
BF2N3	2.20	2.33
BF2N4	1.41	1.48
BF2N5	1.18	1.24
BF3N1	1.18	1.23
BF3N2	2.16	2.27
BF3N3	2.19	2.32
BF3N4	1.42	1.49
BF3N5	1.18	1.24
BF4N1	1.18	1.23
BF4N2	2.48	2.63
BF4N3	2.54	2.70
BF4N4	1.56	1.64
BF4N5	1.44	1.51
BF x N		
SEd	**0.02**	**0.03**
CD (p=0.05)	**0.05**	**0.05**
N x BF		
SEd	**0.02**	**0.03**
CD (p=0.05)	**0.05**	**0.05**

of seed treatment with *Azospirillum* and soil application of Phosphobacteria along with the 75% recommended dose of N + recommended dose of P and K + 25% N on equivalent basis of vermicompost recorded the maximum gross return of Rs.122351.19 and Rs.129893.39 ha^{-1}, net return of Rs.74181.43 and Rs.81723.63 ha^{-1} and B:C ratio of 2.54 and 2.70 in the year 2021 and 2022, respectively. The lowest gross return of Rs. 30124.18 and Rs.30388.21 ha^{-1} and negative net return of Rs.-1922.82 and Rs.-1658.79 ha^{-1} and B: C ratio of 0.94 and 0.95 in the year 2021 and 2022, respectively were realized in the absolute control (no biofertlizers, vermicompost and inorganics). The optimal neutron-physiological conditions provided by integrated nutrition management resulted to the highest economic yields and increased profitability in this treatment combination. These findings are in conformity with the study of Meena *et al.,*[28], Sharma and Behera[33], Ghanbari *et al.,*[12] and Binoy and Sinha[6], Naveena *et. al.*,[31] by integrated nutrient management.

In the light of the above facts, it can be concluded that seed treatment with *Azospirillum* and soil application of Phosphobacteria along with application of 75% recommended dose of N + recommended dose of P and K (150 :50:40 kg ha^{-1}) +25% N on equivalent basis of vermicompost (2057 kg ha^{-1}) holds promise as an agronomically efficient, ecologically viable and economically feasible technology for augmenting the green fodder yield and economic returns of fodder maize in maize + cowpea intercropping situation.

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