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Moisture Conservation and Nutrient Management Practices on Growth and Yield of Maize (*Zea mays* L.)

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Abstract

Plant nutrients and soil moisture are considered some of the most important factors affecting physiological characters and grain yield of maize. Therefore, a field experiment was conducted at UBKV, Cooch Behar, West Bengal during 2013 and 2014 to study the effects of moisture conservation and nutrient management practices on growth and yield of maize (*Zea mays* L.). The experiment was laid out in a split –plot design with three replications. Four levels of moisture conservation practices M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @5.0 t ha^{-1} M_3: FYM mulch @ 5.0 t ha^{-1} were assigned to main plots and four levels of nutrient management N_1: 100% RDF 80:40:40 kg ha^{-1} of $N:P_2O_5$: K_2O N_2:100% RDF + phosphate solubilising bacteria (PSB) + *Azotobacter* N_3:75% RDF+ PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1} and N_4:50% RDF + PSB + *Azotobacter* + 50% vermicompost @ 2.5t ha^{-1} for sub plot. Among the moisture conservation practices, application of irrigation recorded the highest growth, yield attributes, yield and harvest index followed by FYM mulch and dry weed bio-mass mulch. Similarly, N, P and K uptake of maize was recorded highest under irrigation followed by FYM mulch; dry weed bio mass mulch and lowest N, P and K uptake were recorded under without irrigation and mulch. Among the nutrient management practices the highest growth, yield attributes, yield, harvest index and N, P & K uptake were recorded under 75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t ha^{-1} followed by 100% RDF + PSB+ *Azotobacter* & 100% RDF and lowest were recorded under 50% RDF + PSB + *Azotobacter* + 50% vermicompost 2.5 t ha^{-1}. Likewise, maximum benefits were recorded under 75% RDF + PSB+ *Azotobacter* + vermicompost @ 5.0 t ha^{-1} and lowest net return and return per rupee invested were recorded under 50% RDF + PSB + *Azotobacter* + 50% vermicompost 2.5 t ha^{-1}. From this study, maize grown with irrigation and supplied with 75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t ha^{-1} is found the best for obtaining overall gain on a sustainable basis.

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Introduction

Maize (*Zea mays* L.) is an annual C4 plant belonging to the grassy family *Poaceae.* After rice and wheat, maize is the third most important food crops of India and it is currently cultivated in an area 8.49 m ha^{-1} with a production of 21.28 mt and productivity of 2507 kg ha^{-1}.[1] However, in West Bengal, maize productivity was only 39.4 q ha^{-1} with the total production of 0.39 mt from the total area of 0.10 mha.[2]

Maize, in general, is an exhaustive feeder of nutrients; require much more nutrients compared to the other crops and in order to meet those nutritional requirements the farmers are applying large quantities of inorganic fertilizers without understanding its negative impact in the soil fertility status as well as the concerned environment. Organic source of fertilizers hold the key to the solution of current problems of fertilizers scarcity and expensiveness and continuous use of organics helps to build up soil humus and beneficial microbes besides, improving the soil physical properties and provides regulated supply of nutrients by releasing them slowly and thereby increases nutrient availability and use efficiency.[3] Therefore, use of organic fertilizers alone does not result in spectacular increase in crop yields, due to their low nutrient status whereas judicious combination of organic and inorganic fertilizers helps to maintain soil health and improve crop productivity.[4] However, combined application of organic and inorganic fertilizers as an integrated manner is a better solution for conjunctive use of inorganic and organic sources of plant nutrients for crop productivity as well as sustaining soil health.

In Indian condition, maize is cultivated both as *kharif* and *rabi* crop though the former is followed more but still there is potential for the latter. Maize cultivation in winter is gaining more popularity due to minimum losses caused by biotic factors and greater response to applied plant nutrients. However, raising a *rabi* crop is a challenge due to lack of rainfall which is the major source of irrigation to maize crops which is sufficient during *Kharif* season in rainfed conditions. Lack of adequate moisture in seed zone during seeding is the major constrains for establishment of crop.[5] Apart from this, the productivity of maize is also limited due to moisture stress[6] and this could be achieved by soil and nutrient management practices as these are of paramount concern to conserve soil moisture, improve the productivity and fertility.[7]

To overcome of this problem, mulching is an important practice for soil moisture conservation in rainfed condition and it could be greatly increased by imposition of mulches on soil surface.[8] Mulch particularly restricts the transport of water vapour from soil surface to microclimate, which diminish the direct evaporation loss of water[9,10] and increases the availability of soil water to the crops[11] regulates of soil temperature.[12] Considering the above mentioned reason, this study was carried out to find out the effects of moisture conservation and nutrient management practices on growth, yield attributes, yield and nutrient uptake of maize.

Materials and Methods

A field experiment was carried out to with the objective of studying the growth, yield attributes, yields and nutrients uptake of maize as influenced by moisture conservation and nutrient management practices. The experiment was laid out in a split –plot design with three replications. The plot size is 7.5 (breadth) X 4.5 (length) sq. m and 20 kg ha^{-1} seed rate. Date of sowing was done in 16.01.2013 and 17.01.2014. Sowing was done in the lines with the help of tyne by opening a shallow furrow at uniform depth (3-5 cm). 45 cm row-to-row spacing in the North-South direction. Before sowing seeds were treated with Carbendazim @ 3g kg^{-1} of seed and spraying Carbaryl 50 WP @ 2 kg in 1000 lt ha^{-1} was done with the help of Knapsack sprayer to control the stem borer during both the years. Two irrigation applied at knee high and silking stage. Removal of weeds by hand with the help of *khurpi* and to cover the base of the plant by soil and earthing up was done after completion of second weeding (35 DAS). The date of harvesting of maize was 06.05.2013 and 07.05.2014. The maize plants were harvested from net plot earmarked for harvesting leaving the boarder rows. Husks were removed from the cobs and were dried under the sun for 7-8 days. Thereafter, grains were removed with the help of maize shellers. Four levels of moisture conservation practices M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @5.0 t ha^{-1} M_3: FYM mulch @ 5.0 t ha^{-1} were assigned to main plots and four levels of nutrient management N_1: 100% RDF 80:40:40 kg ha^{-1} of $N:P_2O_5:K_2O$ N_2:100% RDF + phosphate solubilising bacteria (PSB) + *Azotobacter* N_3:75% RDF+ PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1} and N4:50% RDF + PSB + *Azotobacter* + 50% vermicompost @ 2.5t ha^{-1} for sub plot.

The results were analyzed taking consideration of physiological parameters *viz.* plant height, dry matter accumulation (DMA), leaf area index (LAI) calculated according to the formula given by Watson.[13]

Leaf area index (LAI) =

$$\text{LAI} = \frac{\text{Area of total number of leaves surface}}{\text{Ground area from which leaf sample were collected}}$$

Then the mean LAI (L) was calculated as per the formula given below.

$$\text{Mean LAI } (\bar{L}) = \frac{L_2 - L_1}{\text{Log}_e L_2 - \text{Log}_e L_1}$$

Where, L_1 and L_2 are the leaf area indices at two successive occasions on time t_1 and t_2 respectively. Crop Growth Rate (CGR) expresses the gain in dry matter production of the crop per unit land area per unit time and is expressed as gram per meter square per day (g m^{-2} day^{-1}). It is calculated according to the formula given by Watson.[14]

$$\textbf{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_1 and W_2 was the dry weight of the aerial plants per unit area gained at time t_1 and t_2, respectively. Post harvest parameters were number of cobs $plant^{-1}$, number of grains cob^{-1}, 1000-grain weight (g), cob length (cm), cob girth (cm), grain yield (q ha^{-1}), stover yield (q ha^{-1}), harvest index (%) and nitrogen, phosphorus and potassium uptake. Economic analyses such as gross return (Rs.), net return (Rs.) and return per rupee investment.

Returns per rupee invested

This is obtained from the formula:

Return per rupee invested =

$$\frac{\text{Gross returns}}{\text{Total (variable) cost of cultivation}}$$

This index provides an estimate of the benefit a farmer derives for the expenditure he incurred in adopting particular cropping systems. Anything above the value of 2.00 (means that the farmer gets Rs. 2.00 in return for every one rupee he has invested) can be considered safe, making allowance for the marketing costs, fixed costs and minor fluctuations in prices of produces.

In the same manner, return per rupee invested on a particular input can be computed. For example, return on labour can be calculated as follows:

Return per rupee invested =

$$\frac{\text{Gross returns-(cost of cultivation except that incurred on labour)}}{\text{Cost of labour}}$$

Return per rupee spent on chemicals and power can also be calculated likewise.

Data were analyzed by using INDO-STAT- software for analysis of variance following split- plot design and treatment means were separated by applying CD Test (critical difference) at 5% level of significance.

Result and Discussions

Physiological Parameters

Plant height of maize gradually increased with the advancement of crop age upto harvest. Higher plant height was noted under irrigated plot (M_1) during both the years of experimentation. This might be due to the easily available soil moisture which helps to develop suitable environment for root growth and improve micro environment for their growth (Table 1). The application of irrigation at critical stages increases the moisture content in soil which ultimately enhances the plant height of maize.[15] The dry matter accumulation, leaf area index and crop growth rate also recorded highest in irrigated plot (M1) (Table 1, 2, 3 & 4) followed by FYM mulch (M_3) and dry weed bio mass mulch (M_2) and lowest DMA, LAI and CGR recorded under without irrigation and without mulch (M_0).The different water supply conditions at different crop growth stages significantly increases the plant height, dry matter accumulation, leaf area and crop growth.[16] From the data it was revealed that FYM and dry weed biomass mulch also significantly influenced the growth of crop at different stages of crop growth (Table 1, 2, 3 & 4). Plant height, DMA, LAI and CGR were recorded maximum when FYM and dry weed bio mass mulch were applied as compared to without irrigation and without mulch (M_0). This was due to the applied mulch materials improve soil physical properties, enhances the available soil moisture and nutrient content in soil. Spreading of farm yard manure as mulching materials increased the soil moisture which enhanced the crop growth and development.[8] Mulch materials restrict the transportation of water vapour from soil surface to microclimate which ultimately reduces the evaporation loss[17] and availability of soil water to crop which enhances the growth and development of crops.[11,18 and 19] The growth parameters such as dry matter accumulation, LAI and CGR were higher on irrigated plots compared to the other plots. This finding is also in conformity with the findings of De and Bandyopadhyay[20] and Yi *et al.,*[21].

Table 1: Effect of nutrient management and moisture conservation practices on plant height of maize

Treatments	**Plant height (cm)**											
	Days after sowing (DAS)											
	30			**60**			**75**			**At harvest**		
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	20.6	22.5	21.6	66.9	69.7	68.3	123.6	126	124.8	191.8	192.9	192.4
M1	29.9	32.2	31	77	81.1	79.1	141.1	144.5	142.8	215.7	219.6	217.7
M2	22.8	25	23.9	70.5	73	71.8	132.7	135.3	134	204.5	206.7	205.6
M3	26.9	28.6	27.8	73	76.5	74.8	135.7	138.6	137.2	209.8	212.9	211.4
S. Em (±)	**0.79**	**0.47**	**0.43**	**1.57**	**1.91**	**1.38**	**1.84**	**1.42**	**1.05**	**2.21**	**1.64**	**1.31**
C.D. (0.05)	**2.75**	**1.63**	**1.49**	**4.58**	**5.58**	**4.03**	**5.36**	**4.15**	**3.62**	**7.65**	**5.68**	**4.51**
Nutrient Management (N)												
N1	23.6	25.1	24.3	70.2	73.3	71.8	132	134.4	133.2	202.9	204.9	203.9
N2	26.5	28.7	27.6	73.2	76.6	74.9	135.6	138.2	136.9	208.5	210.7	209.6
N3	29.1	31.4	30.2	76.9	79.5	78.2	140.4	143.5	142	215.5	218.1	216.8
N4	21	23.1	22.1	67.3	70.9	69.1	125.2	128.3	126.7	194	198.4	196.6
S. Em(±)	**0.87**	**1.23**	**0.71**	**0.94**	**1.09**	**0.65**	**1.21**	**1.01**	**1.01**	**1.57**	**1.63**	**1.29**
C.D. (0.05)	**NS**	**NS**	**NS**	**3.26**	**3.79**	**2.23**	**4.17**	**3.5**	**NS**	**4.57**	**4.76**	**3.77**
Interaction												
M0NI	19.6	21.6	20.6	65.38	68.2	66.8	121.5	123.7	122.6	189.2	190.6	189.94
M0N2	21	23	22	67.52	70.8	69.1	124.6	126.4	125.5	195.2	196.5	195.9
M0N3	23	24.7	23.8	71.85	73.9	72.8	130.2	133	131.6	201.1	202.2	201.6
M0N4	18.7	20.8	19.8	63.2	65.8	64.5	118.2	121	119.6	181.6	182.5	182.1
M1N1	27.8	29.2	28.5	75.42	79	77.2	139.7	142.7	141.2	212.9	215.3	214.1
MIN2	32	34.5	33.3	78.5	83.2	80.8	143.4	146.1	144.7	218.8	223	220.9
M1N3	35.5	38.6	37.1	82.33	86.2	84.2	149.2	153.3	151.3	228.1	233	230.6
M1N4	24.2	26.3	25.2	71.94	76.3	74.1	132	136.1	134.1	203	207.2	205.1
M2N1	21.6	23.2	22.4	68.82	71.3	70	132.1	134.4	133.2	202.9	203.5	203.2
M2N2	24.1	25.8	25	72.38	74.6	73.5	135.1	138.3	136.7	208.1	209.1	208.6

M2N3	26.6	29.2	27.9	75.6	77.2	76.4	139.1	141.4	140.3	212.6	214.6	213.6
M2N4	19	21.8	20.4	65.34	69	67.1	124.5	127.1	125.8	194.5	199.5	197
M3N1	25.3	26.4	25.9	71.37	74.8	73	134.4	136.8	135.6	206.7	210.2	208.4
M3N2	29	31.3	30.2	74.42	77.8	76.1	139.3	142.1	140.7	212.1	214.3	213.2
M3N3	31.2	33	32.1	77.81	80.8	79.3	143.1	146.4	144.7	220.3	222.6	221.4
M3N4	22.2	23.7	22.9	68.75	72.7	70.7	126.1	129	127.6	200.2	204.5	202.3
M x N S. Em (±)	**1.75**	**2.25**	**1.42**	**3.14**	**3.82**	**2.76**	**3.67**	**2.85**	**2.02**	**3.13**	**3.26**	**2.58**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**11.16**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**1.71**	**2**	**1.31**	**2.88**	**3.49**	**2.47**	**3.4**	**2.66**	**2.04**	**3.5**	**3.26**	**2.59**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1}:

N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + Azotobacter, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Table 2: Effect of nutrient management and moisture conservation practices on leaf area index of maize

Treatments	Leaf area index											
	Days after sowing (DAS)											
	30			60			75			At harvest		
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	1.26	1.29	1.28	3.35	3.38	3.37	3.91	3.93	3.92	1.12	1.14	1.13
M1	1.57	1.62	1.60	3.88	3.92	3.90	4.39	4.42	4.41	1.34	1.36	1.35
M2	1.39	1.42	1.41	3.61	3.66	3.64	4.09	4.11	4.10	1.19	1.21	1.20
M3	1.44	1.49	1.48	3.72	3.75	3.74	4.19	4.22	4.21	1.24	1.26	1.26
S. Em (±)	**0.01**	**0.02**	**0.01**	**0.04**	**0.03**	**0.03**	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**
C.D. (0.05)	**0.04**	**0.07**	**0.04**	**0.12**	**0.09**	**0.09**	**0.07**	**0.07**	**0.05**	**0.03**	**0.03**	**0.03**
Nutrient Management (N)												
N1	1.39	1.43	1.42	3.59	3.63	3.61	4.12	4.14	4.13	1.21	1.23	1.22
N2	1.43	1.47	1.46	3.67	3.72	3.69	4.18	4.21	4.19	1.24	1.26	1.25
N3	1.48	1.53	1.51	3.79	3.83	3.82	4.25	4.27	4.26	1.28	1.31	1.29
N4	1.34	1.39	1.37	3.49	3.54	3.52	4.04	4.07	4.06	1.16	1.18	1.17
S. Em(±)	**0.01**	**0.02**	**0.01**	**0.03**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**
C.D. (0.05)	**0.04**	**NS**	**0.03**	**0.09**	**0.09**	**0.07**	**0.06**	**0.05**	**0.04**	**0.03**	**0.02**	**0.02**
Interaction												
M0NI	1.25	1.27	1.26	3.33	3.36	3.35	3.88	3.89	3.89	1.10	1.12	1.1
M0N2	1.27	1.30	1.29	3.38	3.42	3.40	3.94	3.96	3.95	1.14	1.15	1.14
M0N3	1.30	1.34	1.32	3.45	3.48	3.46	4.01	4.03	4.02	1.17	1.19	1.19
M0N4	1.21	1.26	1.24	3.24	3.27	3.26	3.81	3.82	3.82	1.07	1.08	1.07
M1N1	1.55	1.59	1.57	3.81	3.86	3.84	4.34	4.37	4.36	1.32	1.34	1.33

MIN2	1.61	1.65	1.63	3.91	3.96	3.94	4.42	4.45	4.44	1.36	1.38	1.37
M1N3	1.67	1.72	1.70	4.05	4.09	4.07	4.52	4.55	4.54	1.40	1.42	1.42
M1N4	1.45	1.52	1.48	3.73	3.78	3.76	4.28	4.32	4.30	1.28	1.30	1.29
M2N1	1.37	1.41	1.39	3.58	3.62	3.60	4.08	4.09	4.09	1.18	1.20	1.19
M2N2	1.41	1.43	1.42	3.65	3.70	3.67	4.12	4.14	4.13	1.21	1.22	1.21
M2N3	1.44	1.46	1.45	3.74	3.80	3.77	4.19	4.21	4.20	1.25	1.27	1.25
M2N4	1.33	1.39	1.36	3.48	3.52	3.50	3.97	3.98	3.98	1.12	1.15	1.13
M3N1	1.41	1.46	1.44	3.63	3.67	3.65	4.16	4.19	4.18	1.23	1.25	1.24
M3N2	1.46	1.50	1.48	3.75	3.79	3.77	4.23	4.26	4.25	1.26	1.28	1.27
M3N3	1.51	1.59	1.55	3.95	3.96	3.96	4.28	4.31	4.29	1.29	1.31	1.30
M3N4	1.36	1.42	1.39	3.53	3.59	3.56	4.10	4.13	4.12	1.19	1.21	1.20
M x N S. Em (±)	**0.02**	**0.03**	**0.02**	**0.07**	**0.05**	**0.04**	**0.04**	**0.03**	**0.03**	**0.02**	**0.02**	**0.01**
C.D. (0.05)	**NS**	**0.09**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**0.02**	**0.03**	**0.02**	**0.06**	**0.06**	**0.05**	**0.04**	**0.04**	**0.03**	**0.02**	**0.02**	**0.01**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1}:
N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Table 3: Effect of nutrient management and moisture conservation practices on dry matter accumulation of maize

Treatments	Dry matter accumulation (g m^{-2})											
	Days after sowing (DAS)											
	30			60			75			At harvest		
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	313.2	315.4	314.3	483.7	489.3	486.5	711.5	716.1	713.8	948.2	957.1	952.6
M1	392.7	396.4	394.6	611.7	618.8	615.2	905.7	911.4	908.6	1198.1	1207.6	1202.8
M2	370.0	373.2	371.6	566.1	571.7	568.9	820.4	823.8	822.1	1078.2	1086.7	1082.4
M3	381.1	384.7	382.9	584.6	593.4	589.0	858.5	862.7	860.6	1127.5	1135.8	1131.7
S. Em (±)	**3.38**	**3.36**	**3.28**	**2.75**	**2.65**	**2.22**	**4.60**	**3.62**	**4.05**	**5.32**	**5.12**	**5.20**
C.D. (0.05)	**11.69**	**11.62**	**11.36**	**9.47**	**9.15**	**7.65**	**15.87**	**12.52**	**13.98**	**18.37**	**17.66**	**17.96**
Nutrient Management (N)												
N1	360.7	364.0	362.3	554.9	561.4	558.1	807.0	811.7	809.4	1065.3	1073.2	1069.2
N2	370.9	374.5	372.7	571.2	577.6	574.4	840.1	844.4	842.2	1108.2	1115.7	1111.9
N3	387.4	390.8	389.1	594.5	601.1	597.8	881.7	885.4	883.5	1162.2	1171.3	1166.7
N4	338.1	340.4	339.2	525.5	533.2	529.4	767.4	772.5	769.9	1016.4	1027.1	1021.8
S. Em(±)	**1.79**	**2.16**	**1.83**	**1.80**	**2.24**	**1.82**	**2.20**	**2.09**	**2.14**	**2.40**	**2.51**	**2.42**

C.D. (0.05)	**NS**	**6.32**	**NS**	**5.26**	**6.55**	**5.33**	**6.43**	**6.12**	**6.24**	**7.03**	**7.32**	**7.07**
Interaction												
M0NI	313.3	315.5	314.4	479.9	484.8	482.4	700.6	704.6	706.6	932.0	938.7	939.1
M0N2	317.2	321.3	319.3	490.2	498.0	494.1	721.6	726.4	727.2	961.8	968.3	967.1
M0N3	322.1	326.1	324.1	504.1	509.3	506.7	750.6	754.9	755.6	1001.7	1011.5	1006.8
M0N4	300.1	298.6	299.3	460.4	465.0	462.7	673.5	678.4	679.5	897.5	909.8	906.7
M1N1	383.6	385.5	384.6	601.0	604.3	602.7	884.1	890.1	896.2	1169.6	1178.9	1185.6
MIN2	396.5	400.8	398.6	618.7	624.1	621.4	918.9	924.9	927.1	1215.5	1223.4	1227.1
M1N3	420.9	425.3	423.1	648.2	657.5	652.9	970.5	974.1	976.7	1283.7	1293.4	1294.5
M1N4	369.9	374.1	372.0	578.9	589.1	584.0	849.0	856.5	862.7	1123.5	1134.6	1141.1
M2N1	367.2	371.1	369.1	561.6	567.0	564.3	802.2	806.6	812.6	1055.8	1063.1	1067.1
M2N2	381.3	384.6	383.0	580.2	585.0	582.6	844.2	846.9	851.9	1105.6	1114.6	1116.3
M2N3	399.5	402.1	400.8	603.8	609.1	606.4	883.9	886.2	888.2	1155.8	1164.7	1161.7
M2N4	331.9	335.1	333.5	519.0	525.8	522.4	751.3	755.6	758.3	995.4	1004.4	1004.5
M3N1	381.1	383.8	381.2	577.3	589.3	583.3	840.6	845.6	852.5	1103.9	1111.7	1118.2
M3N2	388.5	391.4	390.0	595.6	603.2	599.4	875.7	879.5	885.6	1149.6	1156.3	1160.7
M3N3	407.1	409.7	408.4	621.8	628.5	625.1	922.0	926.3	925.9	1207.4	1215.4	1213.1
M3N4	350.4	353.7	352.1	543.8	552.8	548.3	795.9	799.6	804.7	1049.3	1059.9	1061.7
M x N S. Em (±)	**3.58**	**4.33**	**3.66**	**5.49**	**5.30**	**4.44**	**9.20**	**7.25**	**8.10**	**10.64**	**10.23**	**10.40**
C.D. (0.05)	**NS**	**NS**	**NS**	**11.36**	**13.85**	**11.30**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**4.59**	**5.03**	**4.56**	**4.16**	**4.70**	**3.86**	**5.97**	**5.13**	**5.48**	**6.76**	**6.71**	**6.68**
C.D. (0.05)	**NS**	**NS**	**NS**	**13.10**	**14.52**	**11.95**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha_{-1}:

N_1: 100% RDF 80:40:40 kg ha_{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Application of 75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1} (N_3) produced maximum plant height, leaf area index, dry matter accumulation and crop growth rate (Table 1, 2, 3 and 4) followed by 100% RDF + PSB+ *Azotobacter* (N_2) and lowest values of growth parameters were recorded under 50% RDF + PSB + *Azotobacte*r + 50% vermicompost 2.5 t ha^{-1} (N_4). This might be due to the availability of higher amount of macro and micro nutrients. Adoption of nutrient management in an integrated manner helps to maintain soil fertility which leads to increase the plant height, LAI, dry matter accumulation and other secondary growth. This is due to the utilization of applied nutrients by crops. These results are also in conformity with the findings of Rajeshwari *et al.,*[22], Zhao and Zhou[23], Sujatha *et al.,*[8] and Kumar and Dhar.[24] The 100% recommended dose of fertilizer and vermicompost application which remained at par with 75% recommended dose of fertilizer and vermicompost and 100% recommended dose of fertilizer alone recorded highest growth of crop.[25] However, application of 50 % RDF + PSB + *Azotobacter* + 50% vermicompost 2.5 t ha^{-1} resulted in significantly lower growth compared to the 100% recommended dose of fertilizer. Plant height of maize was improved when combined application of organic and inorganic fertilizer can compare statistically with the blanket application of inorganic fertilizer.[26] The application of recommended dose of fertilizers with Azotobacter and phosphate solubilizing bacteria significantly increases growth of maize[27] but also make available added phosphorus thereby increasing phosphorus availability and improving the growth of maize.[28]

Table 4: Effect of nutrient management and moisture conservation practices in crop growth rate of maize

Treatments	Dry matter accumulation (g m^{-2})														
	Days after sowing (DAS)														
	30			60			75			At harvest					
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	2.93	3.07	3.01	8.44	8.51	8.48	15.19	15.56	15.37	12.28	12.47	12.29	3.51	3.59	3.55
M1	4.01	4.13	4.07	10.62	10.69	10.66	19.60	20.74	20.17	14.57	14.79	14.52	4.91	4.95	4.93
M2	3.59	3.68	3.64	9.49	9.55	9.52	16.95	17.45	17.19	13.28	13.56	13.28	3.91	3.95	3.93
M3	3.69	3.90	3.80	9.88	10.01	9.95	18.26	18.88	18.57	13.79	14.04	13.73	4.14	4.16	4.14
S. Em (±)	**0.05**	**0.05**	**0.04**	**0.11**	**0.09**	**0.07**	**0.30**	**0.36**	**0.33**	**0.18**	**0.24**	**0.18**	**0.15**	**0.17**	**0.16**
C.D. (0.05)	**0.05**	**0.05**	**0.04**	**0.11**	**0.09**	**0.07**	**0.30**	**0.36**	**0.33**	**0.18**	**0.24**	**0.18**	**0.15**	**0.17**	**0.16**
Nutrient Management (N)															
N1	3.47	3.62	3.54	9.49	9.54	9.52	16.80	17.45	17.13	13.21	13.42	13.16	4.01	4.01	4.01
N2	3.65	3.77	3.71	9.73	9.76	9.75	17.93	18.54	18.23	13.66	13.86	13.65	4.21	4.23	4.21
N3	3.82	3.92	3.87	9.99	10.12	10.05	19.15	19.85	19.49	14.27	14.49	14.31	4.43	4.56	4.49
N4	3.28	3.48	3.38	9.21	9.36	9.29	16.12	16.78	16.45	12.77	13.10	12.72	3.83	3.87	3.85
S. Em(±)	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.02**	**0.11**	**0.12**	**0.11**	**0.06**	**0.07**	**0.04**	**0.03**	**0.02**	**0.02**
C.D. (0.05)	**0.06**	**0.06**	**NS**	**0.10**	**0.08**	**0.07**	**0.35**	**0.37**	**0.33**	**0.20**	**0.22**	**0.14**	**0.09**	**0.07**	**0.07**
Interaction															
M0NI	2.85	2.95	2.90	8.26	8.33	8.30	14.71	15.16	14.92	12.03	12.22	12.05	3.39	3.38	3.43
M0N2	3.01	3.14	3.07	8.53	8.63	8.58	15.41	15.63	15.46	12.43	12.51	12.42	3.60	3.62	3.67
M0N3	3.19	3.29	3.24	8.95	8.93	8.94	16.43	16.68	16.54	12.92	13.05	12.90	3.81	4.06	3.99
M0N4	2.66	2.89	2.77	8.03	8.14	8.09	14.19	14.79	14.46	11.73	12.11	11.80	3.21	3.31	3.29
M1N1	3.92	4.06	3.99	10.57	10.53	10.55	18.87	20.19	19.97	14.21	14.44	14.09	4.82	4.81	4.78
MIN2	4.13	4.20	4.17	10.77	10.69	10.73	20.02	21.16	20.73	14.79	14.88	14.74	4.98	5.02	4.97
M1N3	4.26	4.33	4.29	10.94	11.15	11.05	21.51	22.54	22.23	15.68	15.89	15.80	5.17	5.40	5.29
M1N4	3.74	3.94	3.84	10.20	10.39	10.29	18.01	19.08	19.05	13.59	13.96	13.48	4.70	4.58	4.59

M2N1	3.55	3.68	3.61	9.41	9.39	9.40	16.09	16.52	16.44	13.08	13.28	13.06	3.78	3.82	3.68
M2N2	3.66	3.72	3.69	9.60	9.63	9.62	17.60	18.09	17.90	13.45	13.81	13.45	3.98	4.03	3.89
M2N3	3.81	3.88	3.84	9.81	9.92	9.87	18.63	19.23	19.17	13.90	14.27	14.00	4.27	4.29	4.12
M2N4	3.35	3.45	3.40	9.12	9.26	9.19	15.48	15.94	15.92	12.67	12.89	12.62	3.61	3.69	3.51
M3N1	3.57	3.79	3.68	9.73	9.90	9.82	17.55	17.95	18.18	13.51	13.74	13.43	4.04	4.00	3.92
M3N2	3.79	4.03	3.91	10.01	10.09	10.05	18.68	19.29	19.38	14.01	14.23	13.98	4.25	4.22	4.07
M3N3	4.04	4.17	4.10	10.28	10.43	10.35	20.01	20.97	20.60	14.57	14.76	14.54	4.45	4.51	4.29
M3N4	350.4	353.7	352.1	543.8	552.8	548.3	795.9	799.6	804.7	1049.3	1059.9	1061.7			
M x N S. Em (±)	**0.04**	**0.04**	**0.04**	**0.22**	**0.18**	**0.14**	**0.61**	**0.71**	**0.65**	**0.35**	**0.49**	**0.36**	**0.32**	**0.35**	**0.33**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**0.06**	**0.06**	**0.05**	**0.12**	**0.10**	**0.08**	**0.37**	**0.42**	**0.38**	**0.21**	**0.27**	**0.20**	**0.17**	**0.18**	**0.17**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1};

N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Yield Attributes and Yield

Yield attributing characters such as number of rows cob^{-1}, grains row^{-1}, 100-grain weight, number of grains cob^{-1}, cob length, cob girth are presented in Table 5a & 5b, grain, stover yield and harvest index are presented in Table 6. The moisture conservation practices significantly influenced the yield attributes and yield of maize. However, the highest number of rows cob^{-1} of maize, grain row^{-1}, 100- grains weight, number of grains cob^{-1}, length of cob, cob girth (Table 5a & 5b) and grain, stover yield and harvest index (Table 6) were recorded under irrigation (M1). The application of irrigation at critical stages might have improved soil moisture, availability of water and absorption of moisture by crops which enhanced the crop growth, yield attributing characters and ultimately yield. The application of irrigation both at silking and grain development stage increases the yield parameters like cob girth, cob length and grain yield per plant.[29,30] Moisture conservation practices by FYM and dry weed biomass mulch also increased yield attributing characters such as number of rows cob^{-1}, 100-grain weight, number of grains cob^{-1}, cob length, cob girth, grain yield and stover yield (Table 5a, 5b and 6). This was due to the applied mulch materials conserve soil moisture which improves the microclimate of soil as well as plant. This result is in conformity with findings of Khan and Parvej.[31]

The highest yield attributing characters (Tables 5a & 5b and) and grain yield (Table 6) were recorded with treatment receiving 75% RDF in combination with PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1} (N_3). Increased in grain and stover yield with integration of organic and inorganic fertilizers along with vermicompost, *Azotobacter* and phosphate solubilizing bacteria might be due to improvement in the yield components (number of grains rows cob^{-1}, grain row^{-1}, 100-grain weight, number of grains cob^{-1}, cob length and cob girth). 100% RDF + PSB + *Azotobacter* (N_2), 100% RDF (N_1) significantly influenced the yield attributes and yield, which was due to the more availability and absorption of nutrients by crop. Application of recommended dose of fertilizers and farm yard manure significantly increased the grain yield, stover yield and harvest index.[8] Combined use of organic and inorganic fertilizers increased maize grain yield over application of 100% RDF[32] and bio-fertilizers like *Rhizobium*, *Azotobacter* and phosphate solubilising bacteria.[33] The integrated use of nutrient significantly influenced yield and yield attributes such as grain weight per cob of maize, number of seeds per cob and test weight.[34,35]

Table 5a: Effect of nutrient management and moisture conservation practices on yield attributes of maize

Treatments	No. of cobs plant^{-1}			No. of grains cob^{-1}			Test weight [100--grain weight (g)]			Cob length (cm)		
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	1.18	1.26	1.22	236.21	238.92	237.57	27.88	29.30	28.60	13.64	14.89	14.27
M1	1.42	1.55	1.49	335.48	340.40	337.94	34.11	36.10	35.11	17.83	19.21	18.52
M2	1.27	1.39	1.33	311.41	314.88	313.14	30.48	31.96	31.22	14.92	16.43	15.70
M3	1.35	1.47	1.40	319.87	324.11	321.99	31.24	32.97	32.11	16.08	17.34	16.71
S. Em (±)	**0.06**	**0.06**	**0.04**	**13.39**	**7.29**	**9.77**	**1.21**	**0.96**	**0.86**	**0.81**	**0.79**	**0.59**
C.D. (0.05)	**0.18**	**0.19**	**0.12**	**42.35**	**25.02**	**33.81**	**4.02**	**3.30**	**2.98**	**2.80**	**2.39**	**2.01**
Nutrient Management (N)												
N1	1.28	1.37	1.33	296.36	300.47	298.42	29.93	31.46	30.69	14.71	16.06	15.41
N2	1.33	1.46	1.39	305.12	309.69	307.41	31.66	33.10	32.37	16.06	17.49	16.78
N3	1.40	1.53	1.47	317.41	320.60	319.01	33.57	35.58	34.58	18.00	19.46	18.73
N4	1.18	1.32	1.25	284.08	287.54	285.81	28.59	30.19	29.40	13.72	14.86	14.29
S. Em(±)	**0.03**	**0.04**	**0.02**	**7.31**	**6.26**	**5.54**	**1.33**	**1.10**	**0.82**	**0.49**	**0.56**	**0.48**
C.D. (0.05)	**0.12**	**0.14**	**0.07**	**21.31**	**18.28**	**16.17**	**3.90**	**3.21**	**2.41**	**NS**	**1.95**	**1.41**
Interaction												
M0NI	1.20	1.23	1.22	235.80	238.71	237.25	26.96	28.03	27.50	12.86	14.18	13.52
M0N2	1.23	1.30	1.27	240.69	243.10	241.90	28.94	29.66	29.30	13.76	15.10	14.43
M0N3	1.27	1.37	1.32	252.69	254.28	253.49	30.71	31.73	31.22	15.52	16.65	16.08
M0N4	1.00	1.13	1.07	215.66	219.59	217.62	24.93	27.82	26.38	12.43	13.64	13.03
M1N1	1.37	1.53	1.45	329.72	334.69	332.21	32.97	34.64	33.81	16.93	18.43	17.68
MIN2	1.43	1.57	1.50	335.76	343.04	339.40	34.95	36.89	35.92	18.70	19.88	19.29
M1N3	1.57	1.67	1.62	354.81	360.05	357.43	37.77	40.29	39.03	20.65	21.93	21.29
M1N4	1.30	1.47	1.38	321.63	323.83	322.73	30.75	32.62	31.68	15.06	16.62	15.84
M2N1	1.23	1.33	1.28	305.17	308.30	306.74	29.64	31.12	30.38	14.32	15.51	14.92
M2N2	1.30	1.43	1.37	319.46	321.86	320.66	30.98	32.74	31.86	15.25	16.85	16.05
M2N3	1.33	1.50	1.42	325.19	328.37	326.78	32.48	34.34	33.41	16.91	18.86	17.89
M2N4	1.20	1.30	1.25	295.80	300.97	298.38	28.82	29.65	29.24	13.44	14.49	13.97
M3N1	1.30	1.40	1.35	314.76	320.19	317.47	30.13	32.06	31.10	14.93	16.10	15.51
M3N2	1.37	1.53	1.45	324.56	330.76	327.66	31.66	33.12	32.39	16.54	18.12	17.33
M3N3	1.47	1.57	1.52	336.96	339.68	338.32	33.30	35.99	34.65	18.93	20.42	19.68
M3N4	1.23	1.37	1.30	303.22	305.79	304.51	29.89	30.71	30.30	13.93	14.71	14.32
M x N S. Em (±)	**0.12**	**0.12**	**0.08**	**14.62**	**12.52**	**11.08**	**2.67**	**2.20**	**1.65**	**0.98**	**1.59**	**0.96**
C.D. (0.05)	**0.36**	**0.37**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**0.11**	**0.11**	**0.08**	**18.43**	**13.07**	**13.69**	**2.61**	**2.13**	**1.67**	**1.78**	**1.49**	**1.02**
C.D. (0.05)	**0.33**	**0.35**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1}:

N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Table 5b: Effect of nutrient management and moisture conservation practices on yield attributes of maize

Treatments	Cob girth (cm)			No. of rows cob^{-1}			Grain weight cob^{-1} (g)]		
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	12.83	13.82	13.32	12.64	13.55	13.09	68.46	69.59	68.03
M1	15.04	16.52	15.78	16.11	17.96	17.04	80.16	82.02	81.09
M2	13.89	14.86	14.38	14.47	15.24	14.86	74.96	76.52	75.74
M3	14.42	15.42	14.92	15.28	16.41	15.85	76.75	78.41	77.71
S. Em (±)	**0.43**	**0.18**	**0.22**	**0.70**	**0.68**	**0.51**	**2.42**	**2.29**	**1.40**
C.D. (0.05)	**1.47**	**0.61**	**0.76**	**2.29**	**2.11**	**1.57**	**7.28**	**6.93**	**4.78**
Nutrient Management (N)									
N1	13.66	14.54	14.10	13.93	15.16	14.55	74.18	76.13	75.16
N2	14.48	15.53	15.01	15.13	16.26	15.69	76.05	78.21	77.13
N3	15.34	16.72	16.04	16.39	17.79	17.09	78.97	80.56	79.77
N4	12.69	13.83	13.27	13.06	13.95	13.51	71.14	71.88	71.51
S. Em(±)	**0.76**	**0.66**	**0.45**	**0.52**	**0.47**	**0.36**	**1.43**	**1.19**	**0.97**
C.D. (0.05)	**NS**	**NS**	**NS**	**1.78**	**1.54**	**1.25**	**4.91**	**4.10**	**3.34**
Interaction									
M0NI	12.50	13.18	12.84	11.98	12.92	12.45	69.30	67.86	68.58
M0N2	13.58	14.41	13.99	13.18	14.17	13.67	70.95	69.65	70.30
M0N3	14.28	15.32	14.80	14.07	15.03	14.55	72.11	71.52	71.82
M0N4	10.96	12.38	11.67	11.33	12.09	11.71	65.99	64.83	65.41
M1N1	14.42	15.73	15.07	15.31	17.62	16.46	80.34	78.38	79.36
MIN2	15.46	16.89	16.17	16.90	18.22	17.56	82.78	80.72	81.75
M1N3	16.39	18.71	17.55	18.11	20.27	19.19	87.29	84.89	86.09
M1N4	13.88	14.79	14.34	14.13	15.73	14.93	77.68	76.64	77.16
M2N1	13.56	14.28	13.92	13.77	14.52	14.15	76.12	74.22	75.17
M2N2	14.35	14.94	14.64	14.78	15.35	15.07	79.26	76.54	77.90
M2N3	15.00	16.27	15.64	16.44	17.25	16.84	80.20	78.61	79.40
M2N4	12.67	13.96	13.32	12.93	13.86	13.39	70.49	70.49	70.49
M3N1	14.18	14.99	14.59	14.68	15.61	15.15	78.75	76.26	77.51
M3N2	14.54	15.89	15.22	15.67	17.29	16.48	79.85	77.30	78.58
M3N3	15.69	16.60	16.14	16.94	18.64	17.79	82.65	80.84	81.75
M3N4	13.29	14.20	13.75	13.86	14.13	14.00	73.38	72.58	72.98
M x N S. Em (±)	**1.52**	**1.31**	**0.91**	**1.39**	**1.37**	**1.02**	**4.85**	**4.59**	**3.28**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**1.38**	**1.54**	**0.82**	**1.31**	**1.27**	**0.95**	**4.44**	**4.15**	**3.00**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1}:

N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1},N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Table 6: Effect of nutrient management and moisture conservation practices on yield of maize

Treatments	Grain yield (q ha^{-1})			Stover yield (q ha^{-1})			Harvest index (%)		
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	26.03	28.46	27.25	94.83	96.67	95.25	21.41	22.76	22.09
M1	40.14	46.94	43.54	119.42	121.84	120.13	25.07	27.81	26.44
M2	31.33	34.42	32.87	107.83	108.66	108.24	22.41	23.94	23.17
M3	36.23	40.84	38.53	112.76	114.49	113.12	24.24	26.32	25.28
S. Em (±)	**1.08**	**1.03**	**0.86**	**0.52**	**0.54**	**0.52**	**0.67**	**0.52**	**0.53**
C.D. (0.05)	**3.75**	**3.57**	**2.96**	**1.79**	**1.88**	**1.83**	**2.31**	**1.94**	**1.85**
Nutrient Management (N)									
N1	31.69	35.58	33.64	105.40	107.312	106.86	22.84	24.68	23.75
N2	35.10	38.75	36.93	109.77	111.608	111.19	23.90	25.55	24.73
N3	39.07	45.02	42.05	115.18	117.053	116.61	25.03	27.54	26.28
N4	27.86	31.28	29.57	100.48	102.70	102.09	21.34	23.09	22.21
S. Em(±)	**0.45**	**0.98**	**0.46**	**0.25**	**0.24**	**0.24**	**0.25**	**0.56**	**0.25**
C.D. (0.05)	**1.32**	**2.86**	**1.35**	**0.75**	**0.73**	**0.72**	**0.75**	**1.61**	**0.74**
Interaction									
M0NI	25.65	26.79	26.22	93.20	93.88	93.54	21.56	22.18	21.87
M0N2	27.48	29.93	28.71	96.21	96.68	96.45	22.21	23.59	22.90
M0N3	30.68	34.33	32.51	100.18	101.17	100.68	23.43	25.30	24.36
M0N4	20.30	22.80	21.55	89.76	90.98	90.37	18.43	20.01	19.22
M1N1	37.73	44.21	40.97	116.41	117.93	117.17	24.48	27.23	25.86
MIN2	43.21	48.05	45.63	121.35	122.64	122.00	26.26	28.13	27.19
M1N3	46.12	56.38	51.25	128.20	129.35	128.78	26.45	30.34	28.39
M1N4	33.51	39.06	36.28	111.72	113.46	112.59	23.08	25.57	24.33
M2N1	29.95	32.77	31.36	105.62	106.29	105.95	22.08	23.53	22.80
M2N2	32.22	34.92	33.57	110.56	111.46	111.01	22.56	23.83	23.19
M2N3	36.95	40.82	38.88	115.59	116.46	116.02	24.21	25.94	25.08
M2N4	26.19	29.16	27.68	99.55	100.43	99.99	20.79	22.44	21.6
M3N1	33.46	38.55	36.00	110.39	111.15	110.77	23.26	25.70	24.48
M3N2	37.50	42.11	39.81	114.96	115.65	115.31	24.59	26.66	25.63
M3N3	42.55	48.53	45.54	120.74	121.24	120.99	26.04	28.57	27.31
M3N4	31.44	34.11	32.78	104.93	105.93	105.43	23.05	24.33	23.69
M x N S. Em (±)	**0.90**	**1.96**	**0.92**	**1.03**	**1.08**	**1.05**	**1.33**	**1.12**	**1.06**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**1.34**	**1.99**	**1.17**	**0.67**	**0.69**	**0.68**	**0.80**	**1.07**	**0.69**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1}:
N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Nutrients Uptake

Moisture conservation practices significantly influenced nitrogen, phosphorus and potassium uptake. The highest nitrogen, phosphorus and potassium uptake were recorded under irrigated plot (M1).This is because of increases grain and stover yield and enhances availability of water to the crop (Table 7). Adequate supply of moisture in general is known to influence positively on the growth and dry matter production of crop directly as well as indirectly by increasing the availability and utilization of nutrient and increase the nutrient uptake of N, P and K in sorghum.[36] Among the moisture conservation practices, FYM mulch and dry weed biomass mulch recorded highest uptake of N, P and K which was mainly due to increased availability of soil moisture and nutrients in root zone which helped to improve the nutrient content in grain and stover (Table 7). Spreading of FYM as mulch materials not only efficiently conserved the soil moisture and provided better availability of nutrients but also improved the soil physical properties.[37] Moisture conservation practices by mulching increased the NPK uptake because of slow decomposition and increased nutrient availability due to mineralization which benefited the maize crop in terms of yield and nutrient uptake.[38]

It would further be found that uptake of nitrogen, phosphorus and potassium in maize was more in 2014 than in 2013 due to higher biomass and grain yield in 2014 (Table 7). Difference in uptake due to nutrient management treatments were greatly due to difference in biomass yield as because the uptake was the resultant of dry matter content and percentage of nitrogen, phosphorus and potassium content in both grain and stover. The uptake of nitrogen, phosphorus and potassium through grain and stover of maize increased under adequate supply of nutrients. Among the nutrient management practices highest N, P and K uptake was recorded with treatment receiving 75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1} (N_3) followed by 100% RDF + PSB + *Azotobacter* (N_2), 100% RDF, (N_1) and the lowest N, P and K uptake was observed under 50% RDF +PSB+ *Azotobacter* + 50% vermicompost 2.5 t ha^{-1} (N_4) (Table 7). The uptake of N, P and K by maize was found higher due to application of 75% recommended dose of fertilizer and 2.7 t ha^{-1} vermicompost.[39,40] Organic matter, like vermicompost and enriched compost, enhanced plant nutrients uptake (N, P and K)[41] and balanced and integrated nutrient supply shows significant higher uptake of primary nutrients.[42]

Table 7: Effect of nutrient management and moisture conservation practices on nutrient uptake of maize

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
Moisture Conservation Practices (M)	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**	**YI**	**YII**	**Pooled**
M0	75.68	77.20	76.44	39.72	43.16	41.44	84.05	87.02	85.54
M1	87.27	92.65	89.94	52.72	55.91	54.32	102.03	106.23	104.13
M2	79.90	82.84	81.40	43.12	46.29	44.71	89.28	92.98	91.13
M3	83.87	86.08	84.98	47.93	51.86	49.90	94.41	98.89	96.66
S. Em (±)	**1.34**	**1.61**	**1.00**	**1.05**	**0.87**	**0.82**	**1.16**	**1.29**	**0.96**
C.D. (0.05)	**4.01**	**4.91**	**3.00**	**3.07**	**2.54**	**2.42**	**4.01**	**3.97**	**2.99**
Nutrient Management (N)									
N1	79.25	82.07	80.66	44.57	48.50	46.54	90.84	94.57	92.70
N2	84.36	87.04	85.76	46.59	50.51	48.56	93.85	97.68	95.77
N3	88.78	91.82	90.30	49.52	53.45	51.49	97.33	101.38	99.36
N4	74.35	77.85	76.10	42.80	44.76	43.78	87.75	91.49	89.62
S. Em(±)	**0.87**	**0.59**	**0.36**	**0.52**	**0.61**	**0.53**	**1.11**	**0.54**	**0.50**
C.D. (0.05)	**3.01**	**2.06**	**1.24**	**1.79**	**2.11**	**1.83**	**3.24**	**1.86**	**1.74**
Interaction									
M0NI	73.06	74.28	73.67	38.63	42.81	40.72	83.26	86.14	84.70
M0N2	78.71	79.60	79.16	40.73	44.45	42.59	85.78	88.72	87.25
M0N3	83.22	84.32	83.77	42.69	47.33	45.01	87.93	90.96	89.44
M0N4	67.74	70.58	69.16	36.82	38.04	37.43	79.26	82.25	80.75
M1N1	85.14	90.36	87.75	51.14	54.54	52.84	99.07	102.88	100.98

MIN2	89.15	95.36	92.26	53.40	56.94	55.17	103.22	107.99	105.60
M1N3	93.45	100.29	96.87	56.54	60.63	58.59	108.73	114.17	111.45
M1N4	81.17	84.59	82.88	49.81	51.52	50.67	97.11	99.88	98.50
M2N1	77.85	80.89	79.37	41.71	45.95	43.83	87.85	91.76	89.81
M2N2	82.72	84.23	83.48	43.84	47.44	45.64	90.85	93.85	92.35
M2N3	87.85	89.58	88.72	46.59	49.52	48.06	93.33	96.78	95.06
M2N4	71.41	76.66	74.04	40.33	42.26	41.29	85.06	89.52	87.29
M3N1	80.93	82.73	81.83	46.81	50.71	48.76	93.16	97.49	95.32
M3N2	86.87	88.96	87.91	48.42	53.22	50.82	95.56	100.14	97.85
M3N3	90.58	93.07	91.83	52.26	56.31	54.29	99.33	103.63	101.48
M3N4	77.08	79.56	78.32	44.24	47.21	45.72	89.59	94.33	91.96
M x N S. Em (±)	**2.68**	**3.22**	**2.00**	**1.03**	**1.23**	**1.06**	**2.32**	**1.08**	**1.01**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x M S. Em (±)	**2.48**	**2.85**	**1.77**	**1.89**	**1.62**	**1.53**	**2.25**	**2.29**	**1.73**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1}:
N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

Economics

The highest gross return (Rs. 47164 and Rs. 63369 ha^{-1}), net returns (Rs. 24174 and Rs. 39039 ha^{-1}) and return per rupee investment (1.05 and 1.55) were recorded under irrigation (M_1) (Table 8). The higher profitability of this treatment was due to higher grain yield and lower total cost obtained as a result of better moisture conservation and improving soil fertility. The lowest gross return (Rs. 30585.25 and Rs. 38421 ha^{-1}), net return (Rs. 7595 and Rs. 14091 ha^{-1}) and return per rupee investment (0.33 and 0.61) were recorded under without irrigation and mulch (M_0). Straw mulching showed significantly higher net returns and benefit: cost ratio over spreading FYM mulch and no mulching on linseed.[8] Moisture conservation practices by mulching were better resulting in higher availability of moisture to the crops under rainfed condition which increased the net return and B: C ratio.[43]

Table 8: Effect of nutrient management and moisture conservation practices on economics of maize cultivation

	Economics of Maize Production					
	YI			YII		
Treatments	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Return/rupee investment	Gross return (Rs. ha-1)	Net return (Rs. ha-1)	Return/rupee investment
Moisture Conservation Practices (M)						
M0	30585.25	7595.25	0.33	38421	14091.50	0.61
M1	47164.50	24174.50	1.05	63369	39039.50	1.55
M2	36812.75	13022.75	0.54	46467	21337.50	0.88
M3	42570.25	18580.25	0.77	55134	29805.50	1.16
Nutrient Management (N)						
N1	37235.75	14245.75	0.65	48033	23704.50	0.96
N2	41242.50	18177.5	0.82	52312	27918.00	1.12

N3	45907.25	18917.25	0.67	60777	32763.00	1.10
N4	32735.50	7245.50	0.28	42228	15929.00	0.60
Interaction						
M0NI	31313.75	8323.75	0.38	36166	11837.50	0.48
M0N2	32289.00	9234.00	0.42	40405	16011.00	0.64
M0N3	36049.00	9059.00	0.32	46345	18331.00	0.62
M0N4	23852.50	862.50	0.03	30780	4481.00	0.17
M1N1	44332.75	21342.75	0.91	59683	35354.50	1.32
MIN2	50771.75	27716.75	1.18	64867	40473.00	1.50
M1N3	54191.00	27201.00	0.92	76113	48099.00	1.53
M1N4	39374.25	13884	0.51	52731	26432.00	0.93
M2N1	35191.25	12201	0.53	44239	19910.50	0.77
M2N2	37858.50	14803.50	0.64	47142	22748.00	0.87
M2N3	43416.25	16426.25	0.57	55107	27093.00	0.88
M2N4	30773.25	5283.25	0.20	39366	13067.00	0.47
M3N1	39315.50	16325.50	0.68	52042	27713.50	1.01
M3N2	44062.50	21007.50	0.87	56848	32454.00	1.19
M3N3	49996.25	23006.25	0.77	65515	37501.0	1.17
M3N4	36942.00	11452.00	0.42	46048	19749.00	0.68

YI=2014 and YII=2015 M_0: without irrigation and without mulch, M_1: irrigation as and when required, M_2: dry weed biomass mulch @ 5.0 t ha^{-1}, M_3: FYM mulch @ 5.0 t ha^{-1}:
N_1: 100% RDF 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1}, N_4:50 % RDF + PSB + *Azotobacter* + 50 % vermicompost @ 2.5 t ha^{-1}

The highest gross return (Rs. 45907 and Rs. 60777 ha^{-1}) and net return (Rs. 27990 and Rs. 32763 ha^{-1}) was recorded with treatment receiving 75% RDF in combination with PSB + *Azotobacter* + vermicompost (VC) @ 5.0 t ha^{-1} (N_3) (Tables 8). This was due to the higher grain yield. But highest return per rupee investment (0.82 and 1.12) was recorded under treatment receiving 100% RDF and *Azotobacter* + PSB (N_2) due to the low cost of cultivation compared to the other treatments. The application of vermicompost and increased recommended dose of fertilizers from 50 to 100% increased the yield but net return and benefit cost ratio was low due to the high cost of cultivation[44] and recommended dose of NPK along with seed inoculation of *Azotobacter* resulted in higher net returns and B: C ratio of maize crop.[45] The highest net return per ha and net return per rupee invested was obtained with 100% NPK treatment.[46] Although nutrient management only gets the better opportunity to reduce the ill effect of soil health this is environmentally sound, socially acceptable and economically viable.

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Conflict of Interest
There are no known declared conflicts of interest related with this piece of research work.

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