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Growth and development of maize (*Zea mays* L.) in response to different moisture conservation and integrated nutrient management practices under rainfed condition

Binoy Chhetri and AC Sinha

Abstract
A study was carried out to investigate the effect of moisture conservation practices and integrated nutrient management of growth and yield on maize (*Zea mays* L.) during pre kharif seasons of 2013 and 2014 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal. The result showed that the moisture conservation practices revealed that, the highest plant height (215.7 & 219.6 cm at harvest), leaf area index (LAI) (4.39 & 4.42 at 75 days after sowing), dry matter accumulation (DMA) (1198.1 & 1207.6 g m^{-2} at harvest), crop growth rate (CGR) (19.60 & 20.74 g. g m^{-2} at 61-75 days after sowing), grain yield (4014 & 4694 kg/ha), stover yield (11942 & 12184 kg/ha), harvest index (25.07 & 27.81%), nitrogen, phosphorus and potassium uptake (87.27 & 92.65, 52.72 & 55.91 and 102.03 & 106.23 kg/ha) and yield attributing characters was recorded under irrigation (M_1) as compared to other treatments. Among the integrated nutrient management, the highest plant height (215.5 & 218.1cm at harvest), LAI (4.25 & 4.27 at 75 days after sowing), DMA (1162.2 & 1171.3 g m^{-2} at harvest), CGR (19.15 & 19.85 g. g m^{-2} at 61-75 days after sowing), grain yield (3907 & 4502 kg/ha), stover yield (11518 & 11705 kg/ha), harvest index (25.03 & 27.54%) and nitrogen, phosphorus and potassium uptake (88.78 & 91.82, 49.52 & 53.45 and 97.33 & 101.38 kg/ha) was recorded under 75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha (N_3) as compared to other treatments. It may be concluded that maize grown with irrigation and supplied with 75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha (N_3) is best for obtaining overall gain on a sustainable basis.

Keywords: Growth, Maize, Nutrient uptake, Yield, Yield attributes

Introduction
Maize (*Zea mays* L.) is an annual C_4 plant belonging to the grassy family *Poaceae*, with its origin in Central America. In India, maize is the third most important food crops after rice and wheat and currently it is cultivated in an area of 8.49 million ha with a production of 21.28 metric tonnes and productivity of 2507 kg/ha (Rao *et al*., 2014) [22]. However, in West Bengal, maize productivity was 4059 kg per ha and production 522.4 thousand tons from the total area of 128.7 thousand hectares (Anon, 2014) [1].
Maize being a heavy feeder crop requires much more nutrients as compared to others and in order to meet those nutritional requirements the farmers are applying large quantities of inorganic fertilizers without understanding its negative impact in the fertility status of the soil as well as the concerned environment. On the other hand, organic source of fertilizers hold the key to the solution of current problems of fertilizers scarcity and expensiveness. Emphasis should be given on use of organic source of nutrients as 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 (Quansah, 2000) [19]. Unfortunately, alone use of organic sources does not result in spectacular increase in crop yields due to their low nutrient status but judicious combination of organic and inorganic fertilizers helps to maintain soil health and crop productivity too (Kumar *et al.,* 2007) [14]. In this context, the approach for integrated nutrient management provides a better solution for conjunctive use of inorganic and organic sources of plant nutrients for crop productivity as well as sustaining soil health.
In India, maize is cultivated as both kharif, pre kharif crop and rabi but its cultivation in winter is gaining more popularity due to minimum losses caused by biotic factors and greater response to applied plant nutrients. However, raising pre kharif crop without rainfall is a major challenge. Thus the major constraint for establishing a crop is the lack of adequate moisture in the seed zone (Hadda *et al*., 2000) [10].

Apart from this, the productivity of maize is also limited due to moisture stress (Rana *et al*., 2006) [21] and this could be achieved by soil and nutrient management practices as these are paramount concern to conserve soil moisture, to improve the soil productivity and fertility (Arora and Hadda, 2003) [2]. Therefore, the need for moisture conservation becomes an integral component to embark upon through following practice like mulching.

Moisture conservation could be greatly increased by imposition of mulches on soil surface (Singh *et al*., 2014) [27]. Mulch particularly restricts the transport of water vapor from soil surface to microclimate, which diminishes the direct evaporation loss of water (Yuan *et al.*, 2009) [33], increases the availability of soil water to the crops (Fuchs and Hadas, 2011) [7] and result the regulation of soil temperature (Ramakrishna, 2006) [20]. Considering the above mentioned reasons, this study was carried out to find out the performance of maize as influenced by moisture conservation practices and integrated nutrient management.

Materials and Method

A field experiment was conducted during pre kharif seasons of 2013 and 2014 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal (26o19′86″ N and 89o23′53″ E, 43 m above mean sea level). The climatic condition of terai zone is sub-tropical in nature with eminent characteristics of high rainfall, high humidity and prolonged winter. Physico-chemical properties of soil were as follows – sand (64.19%), silt (20.47 %), clay (15.34 %) measured by Inter-national Pipette method (Piper, 1950) [18], bulk density (1.42 g cc^1) measured by core sample method (Piper, 1950) [18], field capacity (36.59 %) field sample method (Piper, 1950) [18], soil pH (5.11) measured by Potentiometric method (Jackson, 1967) [12], Organic carbon (0.85%) measured by Tritrimetric determination (Walkley and Black, 1934) [29], total nitrogen (211.5%) measured by Modified Kjeldahl method (Jackson, 1967) [12], available phosphorous (18.24 kg/ha) measured by Bray's method (Jackson, 1967) [12] and available potassium (112.93 kg/ha) measured by Flame Photometer method (Jackson, 1967) [12]. The experiment was laid out in a split plot design with three replications with objectives to study effect of moisture conservation and integrated nutrient management practices on performance of maize. Four levels of moisture conservation practices *viz.* M_0: without irrigation and without mulch, M_1: Irrigation as and when required, M_2: Dry weed biomass mulch @5.0 t/ha M_3: FYM mulch @ 5.0 t/ha were assigned to main plots and four levels of integrated nutrient management *viz*. N_1: 100% RDF 80 kg/ha N + 40 kg/ha P + 40 kg/ha K, N_2:100% RDF + Phosphate solubilising bacteria + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha and N_4:50% RDF + PSB + *Azotobacter* + 50% vermicompost @ 2.5t/ha for sub plot and source of nutrients were urea for nitrogen, single super phosphate for phosphorus and muriate of potash for potassium. The results were analyzed taking consideration of pre harvest parameters *viz*. plant height, dry matter accumulation (DMA), leaf area index (LAI) (Watson, 1947) [31] and crop growth rate (CGR) (Watson, 1952) [32] whereas post-harvest parameters were number of cobs/plant, number of grain/cob, hundred seed weight (g) (100 seed weight), cob length (cm), cob girth (cm), seed yield (kg/ha), stover yield (kg/ha), harvest index (%) and nutrient uptake. The data obtained from this study for two years were analyzed statistically following split- plot design as per the procedure given by Gomez and Gomez (1984) [9]. CD values at P=0.05 were used to determine the significance of difference between treatment means.

Result and Discussions

Effect of moisture conservation and integrated nutrient management practices on crop growth of maize

Irrespective of moisture conservation practices and integrated nutrient management on maize plant height kept on increasing till the last observation recorded at harvest. The highest plant height (215.7 & 219.6 cm at harvest), leaf area index (LAI) (4.39 & 4.42 at 75 days after sowing), dry matter accumulation (DMA) (1198.1 & 1207.6 g m^{-2} at harvest), crop growth rate (CGR) (19.60 & 20.74 g. g m^{-2} at 61-75 days after sowing) was recorded under irrigated plot compared to the other treatments. This might be due to available of soil moisture which helps to develop suitable environment for root growth and improve micro environment for their growth (Table 1). Plant height increases on application of irrigation at critical stages of maize (Girijesh *et al*., 2014) [8]. However, under different amount of irrigation, plant height, dry matter accumulation, leaf area and crop growth were significantly influenced at different stages of crop growth (Wang *et al.*, 2004) [30]. However, moisture conservation practices by FYM and dry weed bio mass mulch also significantly influenced the growth components of maize and it showed better growth performance in mulched condition as compared to unmulched condition (Sharma *et al.,* 2009) [24]. Maximum plant height (209.8 & 212.9cm cm at harvest), leaf area index (4.19 & 4.22 at 75 days after sowing), dry matter accumulation (1127.5 & 1135.8 g m^{-2} at harvest) and crop growth rate (18.26 & 18.88 g. g m^{-2} at 61-75 days after sowing) of maize was recorded on application of FYM mulch as compared to the dry weed bio mass mulch and other treatments (without irrigation and mulch). This might be due to the surface cover by FYM and dry weed biomass mulch enhanced the conservation and availability of soil moisture in soil which improves the soil physical properties, nutrient status in soil and which ultimately increases the growth of maize. Spreading of FYM as mulching materials increased the soil moisture which enhanced the crop growth and development (Singh *et al.*, 2014) [27]. The growth parameters such as dry matter accumulation, LAI and CGR were higher on irrigated plots (De and Bandyopadhyay, 2013) [4] and mulching and irrigation significantly increased leaf area index of spring maize (Singh *et. al*., 2015) [26].

Higher plant height (215.5 & 218.1cm at harvest), leaf area index (4.25 & 4.27 at 75 days after sowing), dry matter accumulation (1162.2 & 1171.3 g m^{-2} at harvest DMA) and CGR (19.15 & 19.85 g. g m^{-2} at 61-75 days after sowing) was recorded under 75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha (N_3) followed by 100% RDF + PSB + *Azotobacter* (N_2) and lowest values of growth parameters was recorded under 50% RDF + PSB + *Azotobacter* + 50% vermicompost 2.5 t/ha (N_4) (Table 1). This might be due to the availability and absorption of higher amount of macro and micro nutrients in soil on application of vermicompost along with inorganic fertilizers. Similar results also made by Hebbarai *et al.*, 2006 [11], Dadarwal *et al.*, 2009 [3] & Dilshad *et al.,* 2011.

Effect of moisture conservation and integrated nutrient management practices on yield attributing characters and yield of maize

Yield attributing characters *viz.* number of cob/plant number of rows/cob, grain weight/cob, 100-grain weight, number of grain/cob, length of cob, cob girth and yield *viz.* grain, stover and harvest index (%) presented in Table 2 & 3. Among the moisture conservation practices, highest yield attributing characters (number of cob/plant (1.42 & 1.55) number of rows/cob (16.11 & 17.96), grain weight/cob (80.16 & 82.02), 100-grain weight (34.11 & 36.10 g), number of grain/cob (335.48 & 340.40), length of cob (17.83 & 19.21cm), cob girth (15.04 & 16.52 cm) (Table 2) and grain yield (4014 & 4694 kg/ha), stover yield (11942 & 12184 kg/ha), harvest index (25.07 & 27.81%) was recorded under irrigation (M_1) compared to the other treatments (Table 3). This might be due to improved moisture content in soil resulting enhanced the crop growth, increase in yield attributing characters and ultimately yield. Elzubeir and Mohamed (2011) [6] also find the highest yield attributing parameters like cob girth, cob length on application of two irrigations at silking and grain development stage. Moisture conservation practices by FYM and dry weed biomass mulch also increased yield attributing characters such as number of rows/cob, 100 grain weight, number of grain/cob, length of cob, girth of cob, grain yield and stover yield (Table 2 and 3) and similar observations was also reported by Kumar (2015) [13].

The highest yield attributing characters (number of cob/plant (1.40 & 1.53) number of rows/cob (16.39 & 17.79), grain weight/cob (78.17 & 80.56), 100-grain weight (33.57 & 35.58 g), number of grain/cob (317.41 & 320.60), length of cob (18.00 & 19.86 cm), cob girth (15.34 & 16.72 cm) (Tables 2) and grain yield (3907 & 4502 kg/ha), stover yield (11518 & 11705 kg/ha) and harvest index (25.03 & 27.54%) (Table 3) was recorded with treatments receiving 75% RDF in combination with PSB + *Azotobacter* + vermicompost @ 5.0 t/ha (N_3). As, integrated use of nutrients significantly influenced the yield and yield attributing characters *viz.* grain weight/cob, number of grain/cob and test weight (Ravikumar, 2009) [23]. 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 rows/cob of maize, grain/row, 100 grain weight, number of grain/cob, length of cob 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 availability and absorption of nutrients by crop.

Table 1: Effect of integrated nutrient management and moisture conservation practices on growth of maize

Treatments		Plant height (cm) (At harvest)		Leaf area index (At 75 DAS)		Dry matter accumulation (g m^{-2}) (At harvest)		Crop growth rate (g. g m^{-2}) (At 61-75 DAS)	
Moisture Conservation Practices (M)		YI	YII	YI	YII	YI	YII	YI	YII
MO		191.8	192.9	3.91	3.93	948.2	957.1	15.19	15.56
M1		215.7	219.6	4.39	4.42	1198.1	1207.6	19.60	20.74
M2		204.5	206.7	4.09	4.11	1078.2	1086.7	16.95	17.45
M3		209.8	212.9	4.19	4.22	1127.5	1135.8	18.26	18.88
S. Em (±)		2.21	1.64	0.02	0.02	5.32	5.12	0.30	0.36
C.D. (0.05)		7.65	5.68	0.07	0.07	18.37	17.66	1.05	1.24
Integrated Nutrient Management (N)									
N1		202.9	204.9	4.12	4.14	1065.3	1073.2	16.80	17.45
N2		208.5	210.7	4.18	4.21	1108.2	1115.7	17.93	18.54
N3		215.5	218.1	4.25	4.27	1162.2	1171.3	19.15	19.85
N4		194.	198.4	4.04	4.07	1016.4	1027.1	16.12	16.78
S. Em(±)		1.57	1.63	0.02	0.02	2.40	2.51	0.11	0.12
C.D. (0.05)		4.57	4.76	0.06	0.05	7.03	7.32	0.35	0.37
Interaction									
MONI		189.2	190.6	3.88	3.89	932.0	938.7	14.71	15.16
MON2		195.2	196.5	3.94	3.96	961.8	968.3	15.41	15.63
MON3		201.1	202.2	4.01	4.03	1001.7	1011.5	16.43	16.68
MON4		181.6	182.5	3.81	3.82	897.5	909.8	14.19	14.79
M1N1		212.9	215.3	4.34	4.37	1169.6	1178.9	18.87	20.19
MIN2		218.8	223.0	4.42	4.45	1215.5	1223.4	20.02	21.16
M1N3		228.1	233.0	4.52	4.55	1283.7	1293.4	21.51	22.54
M1N4		203.0	207.2	4.28	4.32	1123.5	1134.6	18.01	19.08
M2N1		202.9	203.5	4.08	4.09	1055.8	1063.1	16.09	16.52
M2N2		208.1	209.1	4.12	4.14	1105.6	1114.6	17.60	18.09
M2N3		212.6	214.6	4.19	4.21	1155.8	1164.7	18.63	19.23
M2N4		194.5	199.5	3.97	3.98	995.4	1004.4	15.48	15.94
M3N1		206.7	210.2	4.16	4.19	1103.9	1111.7	17.55	17.95
M3N2		212.1	214.3	4.23	4.26	1149.6	1156.3	18.68	19.29
M3N3		220.3	222.6	4.28	4.31	1207.4	1215.4	20.01	20.97
M3N4		200.2	204.5	4.10	4.13	1049.3	1059.9	16.81	17.33
M x N	S. Em (±)	3.13	3.26	0.04	0.03	10.64	10.23	0.61	0.71
	C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
N x M	S. Em (±)	3.50	3.26	0.04	0.04	6.76	6.71	0.37	0.42
	C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

YI=2013 and YII=2014. M_0: without irrigation and without mulch, M_1: Irrigation as and when required, M_2: Dry weed biomass mulch @ 5.0 t/ha, M_3: FYM mulch @ 5.0 t/ha:

N_1: 100% RDF 80:40:40 Kg/ha N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha,

N_4:50% RDF + PSB + *Azotobecter* + 50% vermicompost @ 2.5 t /ha

Table 2: Effect of integrated nutrient management and moisture conservation practices on yield attributes of maize

Treatments		Number of cob/plant		Number of grain/cob		100- grain weight (g)		Cob length (cm)		Cob girth (cm)		Number of rows/cob		Grain weight/cob	
Moisture Conservation Practices (M)		YI	YII	YI	YII	YI	YII	YI	YII	YI	YII	YI	YII	YI	YII
MO		1.18	1.26	236.21	238.92	27.88	29.30	13.64	14.89	12.83	13.82	12.64	13.55	68.46	69.59
M1		1.42	1.55	335.48	340.40	34.11	36.10	17.83	19.21	15.04	16.52	16.11	17.96	80.16	82.02
M2		1.27	1.39	311.41	314.88	30.48	31.96	14.92	16.43	13.89	14.86	14.47	15.24	74.96	76.52
M3		1.35	1.47	319.87	324.11	31.24	32.97	16.08	17.34	14.42	15.42	15.28	16.41	76.75	78.41
S. Em(±)		0.06	0.06	13.39	7.29	1.21	0.96	0.81	0.79	0.43	0.18	0.70	0.68	2.42	2.29
C.D. (0.05)		0.18	0.19	42.35	25.02	4.02	3.30	2.80	2.39	1.47	0.61	2.29	2.11	7.28	6.93
Integrated Nutrient Management (N)															
N1		1.28	1.37	296.36	300.47	29.93	31.46	14.71	16.06	13.66	14.54	13.93	15.16	74.18	76.13
N2		1.33	1.46	305.12	309.69	31.66	33.10	16.06	17.49	14.48	15.53	15.13	16.26	76.05	78.21
N3		1.40	1.53	317.41	320.60	33.57	35.58	18.00	19.46	15.34	16.72	16.39	17.79	78.97	80.56
N4		1.18	1.32	284.08	287.54	28.59	30.19	13.72	14.86	12.69	13.83	13.06	13.95	71.14	71.88
S. Em(±)		0.03	0.04	7.31	6.26	1.33	1.10	0.49	0.56	0.76	0.66	0.52	0.47	1.43	1.19
C.D. (0.05)		0.12	0.14	21.31	18.28	3.90	3.21	NS	1.95	NS	NS	1.78	1.54	4.91	4.10
Interaction															
MONI		1.20	1.23	235.80	238.71	26.96	28.03	12.86	14.18	12.50	13.18	11.98	12.92	69.30	67.86
MON2		1.23	1.30	240.69	243.10	28.94	29.66	13.76	15.10	13.58	14.41	13.18	14.17	70.95	69.65
MON3		1.27	1.37	252.69	254.28	30.71	31.73	15.52	16.65	14.28	15.32	14.07	15.03	72.11	71.52
MON4		1.00	1.13	215.66	219.59	24.93	27.82	12.43	13.64	10.96	12.38	11.33	12.09	65.99	64.83
M1N1		1.37	1.53	329.72	334.69	32.97	34.64	16.93	18.43	14.42	15.73	15.31	17.62	80.34	78.38
MIN2		1.43	1.57	335.76	343.04	34.95	36.89	18.70	19.88	15.46	16.89	16.90	18.22	82.78	80.72
M1N3		1.57	1.67	354.81	360.05	37.77	40.29	20.65	21.93	16.39	18.71	18.11	20.27	87.29	84.89
M1N4		1.30	1.47	321.63	323.83	30.75	32.62	15.06	16.62	13.88	14.79	14.13	15.73	77.68	76.64
M2N1		1.23	1.33	305.17	308.30	29.64	31.12	14.32	15.51	13.56	14.28	13.77	14.52	76.12	74.22
M2N2		1.30	1.43	319.46	321.86	30.98	32.74	15.25	16.85	14.35	14.94	14.78	15.35	79.26	76.54
M2N3		1.33	1.50	325.19	328.37	32.48	34.34	16.91	18.86	15.00	16.27	16.44	17.25	80.20	78.61
M2N4		1.20	1.30	295.80	300.97	28.82	29.65	13.44	14.49	12.67	13.96	12.93	13.86	70.49	70.49
M3N1		1.30	1.40	314.76	320.19	30.13	32.06	14.93	16.10	14.18	14.99	14.68	15.61	78.75	76.26
M3N2		1.37	1.53	324.56	330.76	31.66	33.12	16.54	18.12	14.54	15.89	15.67	17.29	79.85	77.30
M3N3		1.47	1.57	336.96	339.68	33.30	35.99	18.93	20.42	15.69	16.60	16.94	18.64	82.65	80.84
M3N4		1.23	1.37	303.22	305.79	29.89	30.71	13.93	14.71	13.29	14.20	13.86	14.13	73.38	72.58
MxN	S. Em (±)	0.12	0.12	14.62	12.52	2.67	2.20	0.98	1.59	1.52	1.31	1.39	1.37	4.85	4.59
	C.D. (0.05)	0.36	0.37	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x M	S. Em (±)	0.11	0.11	18.43	13.07	2.61	2.13	1.78	1.49	1.38	1.54	1.31	1.27	4.44	4.15
	C.D. (0.05)	0.33	0.35	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

YI=2013 and YII=2014. M_0: without irrigation and without mulch, M_1: Irrigation as and when required, M_2: Dry weed biomass mulch @ 5.0 t/ha, M_3: FYM mulch @ 5.0 t/ha: N_1: 100% RDF80:40:40Kg/ha
N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha, N_4:50% RDF + PSB + *Azotobecter* + 50% vermicompost @ 2.5 t /ha

Table 3: Effect of integrated nutrient management and moisture conservation practices on yield and nutrient uptake of maize

Treatments	Grain yield (kg/ha)		Stover yield (kg/ha)		Harvest index (%)		Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
Moisture Conservation Practices (M)	YI	YII	YI	YII	YI	YII	YI	YII	YI	YII	YI	YII
MO	2603	2846	9483	9667	21.41	22.76	75.68	77.20	39.72	43.16	84.05	87.02
M1	4014	4694	11942	12184	25.07	27.81	87.27	92.65	52.72	55.91	102.03	106.23
M2	3133	3442	10783	10866	22.41	23.94	79.90	82.84	43.12	46.29	89.28	92.98
M3	3623	4084	11276	11449	24.24	26.32	83.87	86.08	47.93	51.86	94.41	98.89
S. Em(±)	1.08	1.03	0.52	0.54	0.67	0.52	1.34	1.61	1.05	0.87	1.16	1.29
C.D. (0.05)	3.75	3.57	1.79	1.88	2.31	1.94	4.01	4.91	3.07	2.54	4.01	3.97
Integrated Nutrient Management (N)												
N1	3169	3558	10540	10731	22.84	24.68	79.25	82.07	44.57	48.50	90.84	94.57
N2	3510	3875	10977	11161	23.90	25.55	84.36	87.04	46.59	50.51	93.85	97.68
N3	3907	4502	11518	11705	25.03	27.54	88.78	91.82	49.52	53.45	97.33	101.38
N4	2786	3128	10048	10270	21.34	23.09	74.35	77.85	42.80	44.76	87.75	91.49
S. Em(±)	0.45	0.98	0.25	0.24	0.25	0.56	0.87	0.59	0.52	0.61	1.11	0.54

C.D. (0.05)		1.32	2.86	0.75	0.73	0.75	1.61	3.01	2.06	1.79	2.11	3.24	1.86
Interaction													
MONI		2565	2679	9320	9388	21.56	22.18	73.06	74.28	38.63	42.81	83.26	86.14
MON2		2748	2993	9621	9668	22.21	23.59	78.71	79.60	40.73	44.45	85.78	88.72
MON3		3068	3433	10018	10117	23.43	25.30	83.22	84.32	42.69	47.33	87.93	90.96
MON4		2030	2280	8976	9098	18.43	20.01	67.74	70.58	36.82	38.04	79.26	82.25
M1N1		3773	4421	11641	11793	24.48	27.23	85.14	90.36	51.14	54.54	99.07	102.88
MIN2		4321	4805	12135	12264	26.26	28.13	89.15	95.36	53.40	56.94	103.22	107.99
M1N3		4612	5638	12820	12935	26.45	30.34	93.45	100.29	56.54	60.63	108.73	114.17
M1N4		3351	3906	11172	11346	23.08	25.57	81.17	84.59	49.81	51.52	97.11	99.88
M2N1		2995	3277	10562	10629	22.08	23.53	77.85	80.89	41.71	45.95	87.85	91.76
M2N2		3222	3492	11056	11146	22.56	23.83	82.72	84.23	43.84	47.44	90.85	93.85
M2N3		3695	4082	11559	11646	24.21	25.94	87.85	89.58	46.59	49.52	93.33	96.78
M2N4		2619	2916	9955	10043	20.79	22.44	71.41	76.66	40.33	42.26	85.06	89.52
M3N1		3346	3855	110.39	11115	23.26	25.70	80.93	82.73	46.81	50.71	93.16	97.49
M3N2		3750	4211	11496	11565	24.59	26.66	86.87	88.96	48.42	53.22	95.56	100.14
M3N3		4255	4853	12074	12124	26.04	28.57	90.58	93.07	52.26	56.31	99.33	103.63
M3N4		3144	3411	10493	10593	23.05	24.33	77.08	79.56	44.24	47.21	89.59	94.33
MxN	S. Em (±)	0.90	1.96	1.03	1.08	1.33	1.12	2.68	3.22	1.03	1.23	2.32	1.08
	C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x M	S. Em (±)	1.34	1.99	0.67	0.69	0.80	1.07	2.48	2.85	1.89	1.62	2.25	2.29
	C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

YI=2013 and YII=2014. M_0: without irrigation and without mulch, M_1: Irrigation as and when required, M_2: Dry weed biomass mulch @ 5.0 t/ha, M_3: FYM mulch @ 5.0 t/ha:
N_1: 100% RDF 80:40:40Kg/ha N: P_2O_5: K_2O, N_2:100% RDF + Phosphate solubilising bacteria (PSB) + *Azotobacter*, N_3:75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha,
N_4:50% RDF + PSB + *Azotobecter* + 50% vermicompost @ 2.5 t /ha

Effect of moisture conservation and integrated nutrient management practices on nutrient uptake of maize

The highest nutrient uptake *viz.* Nitrogen (87.27 & 92.65 kg/ha), phosphorus (52.72 & 55.91 kg/ha) and potassium (102.03 & 106.23 kg/ha) were recorded under irrigated plot (Table 3). This might be due to adequate supply of moisture that influenced the nutrient uptake of N, P and K. This result also confirmed by Mudalagiriyappa *et al.*, (2012) [16] in sorghum. Among the moisture conservation practices, FYM mulch and dry weed biomass mulch recorded highest uptake of N, P and K as application of FYM not only efficiently conserved the soil moisture but also provided the better availability of nutrients and improved the soil physical properties. Moreover, moisture conservation practices by mulching increases the NPK uptake because of slow decomposition and mineralization which benefited the maize crop in terms of yield and nutrient uptake (Narendra and Gautam, 2004) [17].

The highest uptake of nitrogen (88.78 & 91.82 kg/ha), phosphorus (49.52 & 53.45 kg/ha) and potassium (97.33 & 101.38 kg/ha) was recorded with treatments receiving 75% RDF + PSB + *Azotobacter* + vermicompost @ 5.0 t/ha (N_3). This might be due to higher biomass and grain yield as uptake is the resultant of higher dry matter content and percentage of nutrients content in crop (Table 3). The application of vermicompost along with inorganic fertilizers significantly influenced the nutrient uptake by maize (Meena *et al.*, 2006) [15]. In this study, beneficial effect of vermicompost has observed as it enhances uptake of major plant nutrients like N, P and K. Moreover, many authors like Shukla and Tyagi, (2009) [25] and Verma *et al.* (2006) [28] also reported that balanced and integrated nutrient supply caused significantly higher uptake of primary nutrients.

It may be concluded that higher growth and yield was recorded under two irrigations each at vegetative and reproductive stage. Adoption of moisture conservation practices through mulching helped in improving the crop growth and yields in a sustainable way. However, non-availability of dry weed biomass mulching materials spreading of farm yard manure can also be recommended for better conservation of moisture. Integrated use of organic and inorganic nutrient proved to be better in terms of growth and yield of the maize and their combined application not only increased the availability of nutrients but also their uptake by the crop.

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