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Effect of Integrated Nutrient Management on Nutrient uptake and Economics in Maize under different Microclimatic Regimes

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ABSTRACT: A field experiment was conducted at Assam Agricultural University, Jorhat during summer season of 2020 and 2021 with a view to study the effect of microclimatic regime and integrated nutrient management in maize and also the nutrient uptake by the crop and its availability in soil after harvest. The treatments consisted of three microclimatic regimes *viz.*, M_1: 15th February, M_2: 1st March and M_3: 15th March and four INM practices *viz.*, N_1: 100% RDF (60-40-40 kg/ha) N_2: 75% of RDN as urea + 25% RDN as vermicompost, N_3: 75% of RDN as urea + 25% RDN as FYM and N_4: 75% of RDN as urea + 25 % RDN as enriched compost. Experimental findings revealed that highest cob yield obtained in crop sown on 15th March which was at par with 1st March sowing in both the years. Kernel yield and stover yield also followed the same trend. Among the different integrated nutrient management practices application of 75 % of RDN as urea + 25 % RDN as enriched compost recorded highest cob yield, kernel yield and stover yield than RDF, but remain at par with 75 % of RDN as urea + 25 % RDN as vermicompost . The uptake of N, P, K by kernel and stover of maize and total uptake were also highest in 15th March sowing in both the years. Among the INM treatments, the highest N, P and K uptake by kernel, stover and their total uptake were recorded under the treatment 75 % of RDN through urea + 25 % RDN as enriched compost in both the years which remains at par with 75 % of RDN through urea + 25 % RDN as vermicompost. The highest gross return, net return were found in crop sown on 15th March with application of 75 % of RDN through urea + 25 % RDN as enriched compost.

Keywords: Maize, microclimate, INM, nutrient uptake.

INTRODUCTION

Maize (*Zea mays* L.) is the 3rd most important cereal crop after rice and wheat in India. “The Queen of Cereals.” Maize (*Zea mays* L.) is an important annual cereal crop belonging to the tribe Maydeae and family Poaceae and known to be one of the oldest cultivated crop in the world (Sleper and Poehlman 2006). Maize is one of the most versatile emerging cereal crop of Assam. It can be grown under varied agro-climatic condition throughout the year due to its photothermo-insensitive character, thereat called ‘Queen of Cereal’. In Assam, area under cultivation of maize is 41154 ha with production of 147902 MT and productivity of 3594 kg/ha during 2020-21(Directorate of Economics and statistics, Govt of Assam 2021). Maize (*Zea mays* L.) has become very popular due to its high productivity and ability to grow in different seasons. The summer maize is gaining popularity among farmers of Assam because of short growth period and high production potential of hybrid maize in irrigated as well as rainfed conditions.

Nutrient management strategies play a vital role in sustainable production of crop. High yielding hybrid maize varieties are found to be highly responsive to chemical fertilizer application. Excessive use of chemical fertilizers has been associated with decline in soil physical and chemical properties and crop yield (Kumar *et al*., 2016) and significant land problem such as degradation due to over exploitation of land, soil pollution caused by high application rate of fertilizer and pesticide application (Singh and Totawat 2000). Efficacy of organic sources to fulfill the nutrient demand of crop is not as assured as mineral fertilizers, but the joint use of inorganic fertilizers along with various organic sources is capable of higher crop productivity along with improving the soil quality on long- term basis. Hence, instead of applying recommended dose of nitrogen through chemical fertilizers, a strategy of integrated use of recommended dose of nitrogen through inorganic sources in combination with different organic sources, which is available locally should be develop to meet the nitrogen requirement of crops without deteriorating the soil and other natural resources. On the other hand, changing climatic condition like change in temperature regimes, shift in rainfall distribution and intensity are likely to influence crop microclimate and agricultural productivity through its impact on land and water resources, moreover directly influence crop calendar, crop growth and input efficiency. Hence, there is an urgent need to review the influence of local climate on the performance of crop in an area. The time of sowing is a non-monetary input playing significant role in crop growth and development and also likely to influence production and productivity of any crop. Adjustment of sowing date also helps to escape the unfavorable condition which adversely affects the maize yield. Finding the best date of sowing one can ensure optimum soil and climatic condition, which govern availability and uptake of nutrients by the crop.

MATERIALS AND METHOD

The experiment was carried out at Assam Agricultural University, Jorhat during the summer season of 2020 and 2021. The farm is geographically located at 26°45′N latitude and 94°12′E longitude and at an elevation of 87 meters above the mean sea level (MSL). Homogeneous fertility leveled having good drainage facility soil was selected for conducting the experiment. In the year 2020, during the crop growth period the maximum temperature and minimum temperature ranged from 25.3°C to 33.5°C and 12.4°C to 25.4°C respectively. The weekly average relative humidity during the morning hours ranged from 87 to 97 per cent while mean evening relative humidity ranged from 56 to 87 per cent. Based on 30 years of rainfall data from 1981 to 2010, the average normal rainfall of Jorhat during the crop growing period (Feb. to June) was workout as 821.8 mm. But during the time of experimentation the total precipitation was less than the average *i.e*. 780.8 mm, out of which maximum 146.5 mm was received in 25th SMW (Standard Meteorological Week) and minimum 0.4 mm of rainfall recorded in 8th SMW and 11th SMW while there is a complete absence of rainfall recorded only in 10th and 12th SMW. The bright sunshine hours during the crop growing period ranged from 0.5 to 7.25 hours/day. Number of rainy days during the growth period was 43 days.

In the year 2021, the maximum and minimum temperature during the crop growth was ranged from 26°C to 34.1°C and 11.7°C to 25°C respectively. The crop received 538.3 mm rainfall during the growing period which was less than the normal average rainfall. The distribution of rainfall was uneven and maximum rainfall 73.5 mm was received in 25th SMW and minimum rainfall 0.8 mm of rainfall recorded in 14th SMW. The complete absence of rainfall was recorded in 7th SMW, 8th SMW, 12th SMW, 15th SMW and 17th SMW. The crop received bright sunshine hours ringing from 1.0 to 9.1 hours/day during the growing period. The total numbers of rainy days during the period was 41 days.

The experiment was laid out in a split plot design with three replications. The treatments consisted of three microclimatic regimes *viz*., M_1: 15th February, M_2: 1st March and M_3: 15th March and four INM practices *viz.*, N_1: 100% RDF (60-40-40 kg/ha N-P_2O_5, K_2O) N_2: 75% of RDN through urea + 25% RDN through vermicompost, N_3: 75% of RDN through urea + 25% RDN through FYM and N_4: 75% of RDN through urea + 25 % RDN through enriched compost. The soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.12 and 5.18), medium in organic carbon (0.65 % and 0.71 %), available P_2O_5 (22.68 kg/ha and 22.87 kg/ha) and available K_2O (144.50 kg/ha and 147.60 kg/ha) while low in available N (229.47 kg/ha and 221.32 kg/ha) in 2020 and 2021 respectively. The maize variety PAC 751 was sown as per treatment. Manures and fertilizer was applied as per treatment.

Table 1: Different nutrient content of the organic manures are as follows.

Nutrients (%)	FYM	Vermicompost	Enriched compost
N	0.5	1.55	2.1
P	0.2	0.8	1.2
K	0.5	1.36	2.3

RESULTS AND DISCUSSION

Grain and stover yield. The data presented in Table 2 revealed that microclimate significantly influenced the cob yield of maize. Maximum cob yield without husk (56.11 q/ha and 56.86 q/ha in 2020 and 2021 respectively) was observed in crop sown on 15th March which was at par with 1st March in both the years of studies. The lowest cob yield without husk (51.69 q/ha and 52.53 q/ha) was recorded under 15th February in 2020 and 2021, respectively.

The data showed that microclimatic regime significantly influenced the kernel yield in maize. The highest kernel yield (40.72 q/ha in 2020 and 41.30 q/ha in 2021) was found in 15th March sowing which was at par with crop sown on 1st March (39.37q/ha and 40.28 q/ha) in 2020 and 2021, respectively. The lowest value (36.08 q/ha and 37.33 q/ha in 2020 and 2021, respectively) was observed under 15th February. There was an increasing trend in stover yield of maize with delay in sowing date from 15th February to 15th March. The maximum stover yields (79.83 q/ha and 80.42 q/ha) were recorded under 15th March sowing in 2020 and 2021, respectively. However, in 2021 crop sown on 15th March was remained at par with 1st March sowing. This might be due to the maximum absorption and utilization of solar energy resulted in highest value of growth and yield attributes due to favourable weather condition which finally increased the kernel and stover yield. This finding is in agreement with Panda and Dutta (2019).

Effect of integrated nutrient management on cob yield of maize were also found to be significant. Highest cob yield (57.51 q/ha and 57.51 q/ha in 2020 and 2021, respectively) was under the treatment 75 % of RDN through urea + 25 % RDN as enriched compost which was at par with the treatment 75 % of RDN through urea + 25 % RDN as vermicompost in both the years. The lowest value was observed in treatment 100 % RDF.

The maximum kernel yield (41.33 q/ha and 42.55 q/ha in 2020 and 2021, respectively) was recorded under the treatment 75 % of RDN through urea + 25 % RDN as enriched compost and the minimum kernel yield (35.11 q/ha and 36.22 q/ha in 2020 and 2021, respectively) was recorded under RDF. Kernel yield obtained from 75 % of RDN through urea + 25 % RDN as enriched compost was found at par with kernel yield obtained in treatment 75 % of RDN through urea + 25 % RDN as vermicompost. However, 12.8 % and 10.63 % higher kernel yield of maize were recorded under 75 % of RDN through urea + 25 % RDN as enrich compost in 2020 and 2021 as compared to application of RDF.

Stover yield was significantly affected by integrated nutrient management practices. Stover yields in 2020 (80.00 q/ha) and 2021 (80.78 q/ha) were found to be highest under the treatment 75 % of RDN through urea + 25 % RDN as enriched compost which was at par with 75 % of RDN through urea + 25 % RDN as vermicompost. These treatments recorded significantly higher stover yield than RDF. These results were in agreement with Bezboruah and Dutta (2022). Similar findings were also observed by Borah *et al.* (2018).

Higher cob and stover yields found in INM practices with 75 % of RDN through urea + 25% RDN through enriched compost treatment was due to increased availability of nutrients, hormones and minerals from enriched compost. During the time of preparation of enriched compost ingredient like rock phosphate, *Azospirillum* and PSB were used for enrichment. Rock phosphate contains calcium in the mineral form apetite. As we know, one of the important functions of calcium is to enhance the NO_3- uptake. *Azospirillum* is a free-living nitrogen fixing bacteria. It can promote plant growth. They colonize by adhesion, the root surface or the intercellular spaces of the host plant roots (Mc Cully, 2001). The beneficial effect of *Azospirillum* may derive both from its nitrogen fixation and stimulating effect on root development (Doebereiner and Pedrosa 1987). On the other hand, PSB can solubilize the fixed soil P and applied phosphate resulting in higher crop yields. Phosphate (P)- and potassium (K)-solubilizing bacteria may enhance mineral uptake by plants through solubilizing insoluble P and releasing K from silicate in soil (Goldstein and Liu 1987). Ultimately all these factors maintained a favourable soil physical, chemical and biological environment resulting better growth and development in yield attributes that ultimately had reflected in grain and stover yield of crop.

N, P and K content in kernel and stover of maize: The effect of different microclimatic regimes on N, P and K content in kernel & stover of maize were not significant (Table 3). However, the content of all the three major nutrients in kernel and stover increased marginally with delay in sowing from 15th February to 15th March.

There were no significant differences in N, P and K content of kernel and stover of maize due to different integrated nutrient management practices (INM). However, the highest values of all these major nutrients were recorded in crops grown under the treatment 75 % of RDN through urea + 25 % RDN as enriched compost in both the years

N, P and Kuptake: The N, P and K uptake by kernel, stover and their total uptake were highest under crop sown on 15th March in both the years (Table 4, 5). However, in case of P uptake by stover in 2021 and K uptake by kernel in 2020 and 2021, the crop sown on 15th March remain at par with crop sown on 1st March. These treatments recorded significantly higher nutrient uptake than 15th February sowing. However, the content increased with late sowing of crop which might be the resultant of trend of uptake of these nutrients by the crop sown at different microclimate. It might be due to the development of leaf canopy and root system were probably affected adversely under early sown condition and consequently the crop was unable to absorb or utilize nutrients properly as compared to the late sowing.

The highest N, P and K uptake by kernel, stover and their total uptake were recorded under the treatment 75 % of RDN through urea + 25 % RDN as enriched compost in both the years which remains at par with 75 % of RDN through urea + 25 % RDN as vermicompost. These INM treatments recorded higher uptake than the recommended dose of fertilizer. This might be due to the application of organic manure which may enhanced the available nutrient status of soil and resulted in higher uptake by the plants. Significantly higher uptake of nutrients was recorded with the application of 75 % of RDN as urea + 25 % RDN as enriched compost that favours soil microclimate which encourages the crop for more uptake of nutrients which in turn reflected in the crop yield. The uptake of nutrients being the manifestation of both nutrient concentrations in kernel, stover, increased as a consequence of increase in both these attributes. Similar result was reported by Borah and Dutta (2018). The increased nutrient uptake might be attributed to favourable soil condition and better root growth which might be enable the crop to explore more volume of soil under different management practices. These findings are in agreement with Jinjala *et al.* (2016); Verma *et al.* (2017); Borah *et al*. (2018).

Economics: The data presented in table 6 revealed that highest gross return (Rs. 89,576.67/ha and 90,860.00/ha in 2020 and 2021, respectively) and net return (Rs. 62,000.17/ha and 63,283.50/ha in 2020 and 2021, respectively) were obtained in 15th March which was followed by crop sown on 1st March. Highest benefit-cost ratio was found in crop sown on 15th March followed by 1st March.

Among the different INM treatments, the highest gross return (Rs. 90,933.33/ha and Rs. 93,622.22/ha in 2020 and 2021, respectively) and net return (Rs. 62,097/ha and Rs 64,786.22/ha in 2020 and 2021 respectively) were recorded in the treatment 75 % of RDN as urea + 25 % RDN as enriched compost. Highest benefit -cost ratio was found in recommended doses of Fertilizer due to low cost of cultivation followed by the treatment 75 % of RDN as urea + 25 % RDN as enriched compost.

Table 2: Impact of microclimate and integrated nutrient management on yield of hybrid maize.

Treatments	Cob yield (q/ha)		Kernel yield (q/ha)		Stover yield (q/ha)	
Microclimatic regimes	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**
15th Feb	51.69	52.53	36.08	37.33	75.58	77.70
1st March	54.95	55.62	39.37	40.28	77.92	79.42
15th March	56.11	56.86	40.72	41.30	79.83	80.42
SEm (±)	0.66	0.46	0.90	0.66	0.41	0.42
CD(0.05)	2.29	1.58	3.10	2.30	1.42	1.44
Integrated nutrient Management						
100% RDF (60:40:40 kg/ha)	50.67	51.45	35.11	36.22	74.89	76.94
75% of RDN as urea + 25% RDN as vermicompost	56.27	56.83	40.33	41.22	78.89	79.89
75% of RDN as urea + 25% RDN as FYM	52.56	53.00	38.11	38.55	77.33	79.11
75% of RDN as urea+ 25 % RDN as enriched compost	57.51	58.73	41.33	42.55	80.00	80.78
SEm (±)	0.89	0.74	1.04	0.74	0.71	0.55
CD (0.05)	2.59	2.17	3.02	2.17	2.07	1.59

*RDN: Recommended doses of nitrogen; *FYM: Farm Yard Manure ; * RDF: Recommended doses of fertilizer; *NS: Non significant

Table 3: Effect of microclimate and integrated nutrient management on N, P and K content (%) in kernel and stover of maize.

Treatments	Content in kernel (%)						Content in stover (%)					
	N		P		K		N		P		K	
	2020	2021	2020	2021	2021	2021	2020	2021	2020	2021	2020	2021
Microclimatic regimes												
15th Feb	1.444	1.492	0.318	0.321	0.644	0.653	1.071	1.221	0.131	0.133	1.031	1.034
1st March	1.467	1.501	0.324	0.330	0.653	0.654	1.150	1.283	0.132	0.139	1.044	1.053
15th March	1.483	1.523	0.326	0.349	0.655	0.655	1.183	1.300	0.134	0.140	1.056	1.058
S. Em (±)	0.02	0.02	0.01	0.003	0.001	0.002	0.16	0.16	0.002	0.002	0.001	0.01
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated nutrient management												
100 % RDF (60-40-40 kg N-P_2O_5-K_2O/ha)	1.408	1.462	0.316	0.326	0.647	0.652	1.078	1.211	0.131	0.136	1.04	1.041
75 % of RDN as inorganic + 25% RDN by vermicompost	1.487	1.526	0.328	0.335	0.652	0.654	1.157	1.290	0.133	0.138	1.044	1.052
75 % of RDN as inorganic + 25% RDN by FYM	1.446	1.501	0.318	0.327	0.649	0.653	1.116	1.249	0.132	0.137	1.043	1.044
75 % of RDN as inorganic + 25 % RDN by enriched compost	1.519	1.532	0.329	0.345	0.655	0.656	1.189	1.322	0.134	0.138	1.047	1.056
S. Em (±)	0.04	0.02	0.01	0.004	0.002	0.002	0.04	0.04	0.002	0.0014	0.001	0.02
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of microclimate and integrated nutrient management on uptake of nitrogen, phosphorus and potassium by maize kernel and stover.

Treatments	Uptake by kernel (kg/ha)						Uptake by stover (kg/ha)					
	N		P		K		N		P		K	
	2020	2021	2020	2021	2021	2021	2020	2021	2020	2021	2020	2021
Microclimatic regimes												
15th Feb	52.10	55.73	11.47	11.99	23.25	24.38	80.23	94.76	9.90	10.34	77.91	80.37
1st March	57.94	60.60	12.75	13.31	25.71	26.35	89.45	101.94	10.29	11.03	81.33	83.59
15th March	60.38	62.96	13.27	14.43	26.69	27.05	94.81	104.63	10.70	11.26	84.27	85.11
S. Em (±)	1.57	1.06	0.29	0.14	0.57	0.43	0.43	1.30	0.05	0.19	0.39	0.33
CD(P=0.05)	5.42	3.67	1.00	0.48	1.99	1.50	1.49	4.48	0.19	0.64	1.36	1.13
Integrated nutrient management												
100 % RDF (60-40-40 kg N-P_2O_5-K_2O/ha)	49.41	53.05	11.34	11.83	22.72	23.69	80.37	93.21	9.91	10.48	77.90	80.11
75 % of RDN as inorganic + 25% RDN by vermicompost	60.14	62.92	13.02	13.82	26.32	26.96	90.89	103.00	10.44	11.00	82.40	84.07
75 % of RDN as inorganic + 25% RDN by FYM	55.05	57.95	12.31	12.62	24.75	25.22	86.37	98.56	10.24	10.87	80.63	82.64
75 % of RDN as inorganic + 25 % RDN by enriched compost	62.64	65.13	13.34	14.71	27.09	27.83	95.02	107.00	10.59	11.16	83.76	85.28
S. Em (±)	2.28	1.44	0.33	0.32	0.70	0.49	0.86	1.27	0.09	0.12	0.71	0.81
CD (P=0.05)	6.66	4.21	0.98	0.93	2.05	1.42	2.50	3.70	0.27	0.35	2.08	2.35

Table 5: Effect of microclimate and integrated nutrient management on total nitrogen, phosphorus and potassium uptake by maize.

Treatments	Total uptake (kg/ha)					
	N		P		K	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**
Microclimatic regimes						
15th Feb	132.33	150.50	21.38	22.34	101.16	104.75
1st March	147.39	162.53	23.04	24.34	107.04	109.93
15th March	155.19	167.58	23.97	25.69	110.96	112.16
S. Em (±)	1.26	2.18	0.25	0.29	0.37	0.50
CD(P=0.05)	4.37	7.56	0.86	1.02	1.29	1.73
Integrated nutrient management						
100 % RDF (60-40-40 kg N-P_2O_5-K_2O/ha)	129.78	146.26	21.25	22.31	100.62	103.80
75 % of RDN as inorganic + 25% RDN by vermicompost	151.02	165.92	23.46	24.82	108.71	111.03
N_3: 75 % of RDN as urea + 25% RDN by FYM	141.42	156.51	22.54	23.49	105.38	107.86
N_4: 75 % of RDNasurea + 25 % RDN by enriched compost	157.66	172.13	23.93	25.88	110.84	113.11
S. Em (±)	2.08	2.07	0.32	0.33	0.86	0.94
CD (P=0.05)	6.08	6.03	0.94	0.97	2.51	2.74

*RDN: Recommended doses of nitrogen; *FYM: Farm Yard Manure; * RDF: Recommended doses of fertilizer; *NS: Non significant

Table 6: Effect of microclimate and integrated nutrient management on economics of maize.

Treatments	Cost of cultivation (Rs/ha)		Gross return (Rs/ha)		Net return (Rs/ha)		B:C ratio	
	2020	2021	2020	2021	2020	2021	2020	2021
Microclimatic regimes								
M_1: 15th Feb	27576.50	27576.50	79383.33	82133.33	51806.83	54556.83	1.96	2.07
M_2: 1st March	27576.50	27576.50	86606.67	88623.33	59030.17	61046.83	2.23	2.30
M_3: 15th March	27576.50	27576.50	89576.67	90860.00	62000.17	63283.50	2.35	2.40
Integrated nutrient management								
100% RDF (60-40-40 kg N-P_2O_5-K_2O kg/ha)	19680.00	19680.00	77244.44	79688.89	57564.44	60008.89	2.93	3.05
75 % of RDN as inorganic + 25% RDN by vermicompost	28350.00	28350.00	88733.33	90688.89	60383.33	62338.89	2.13	2.20
75 % of RDN as urea + 25% RDN by FYM	33440.00	33440.00	83844.44	84822.22	50404.44	51382.22	1.51	1.54
75 % of RDN as urea + 25 % RDN by enriched compost	28836.00	28836.00	90933.33	93622.22	62097.33	64786.22	2.15	2.25

CONCLUSIONS

From the two year study it can be concluded that maize crop sown on 15th March with 75 % of RDN as urea + 25 % RDN as enriched compost is beneficial in Assam condition.

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