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Minakshi Bezboruah
Department of Agronomy,
Assam Agricultural University,
Jorhat, Assam, India

Rinjumoni Dutta
Department of Agronomy,
Assam Agricultural University,
Jorhat, Assam, India

Corresponding Author:
Minakshi Bezboruah
Department of Agronomy,
Assam Agricultural University,
Jorhat, Assam, India

Effect of integrated nutrient management on growth and yield of summer maize (*Zea mays*)

Minakshi Bezboruah and Rinjumoni Dutta

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Abstract
A field experiment was carried out at Instructional Cum-Research Farm (ICR) of Assam Agricultural University, Jorhat during the year 2019 to find out the effect of INM practices to growth and yield of summer maize. The experiment was laid out in randomized block design with nine treatments and replicated thrice. The soil of the experimental site was sandy loam in texture, acidic in reaction, medium in organic carbon (0.72), low in available N (156.19 kg/ha) and medium in available P_2O_5 (23.78 kg/ha) and K_2O (161.50 kg/ha). The maize seed of the variety VMH-53 was sown on 15th of March (2019) and harvested by two pickings on 10th June and 15th June. Experimental findings revealed that growth attributing characters like plant height, number of leaves per plant, leaf area index as well as various yield attributing characters *viz*., weight of cob with and without husk, length of cob, number of rows/cob, grains/row, grains/cob, 1000 grain weight, weight of grain per cob was recorded highest under the treatment T_3 containing 100% RDF + *Azospirillum* + PSB + 2 sprays of vermiwash at 25 & 40 DAS which was at par with 75% RDF + 25% of N replaced by vermicompost + Azospirillum + PSB + 2 sprays of vermiwash at 25 & 40 DAS. The highest grain and stover yield being 43.04 q/ha and 89.66 q/ha respectively was produced from RDF + *Azospirillum* + PSB + 2 sprays of vermiwash at 25 & 40 DAS (T_3) which was at par with the grain yield 41.81 q/ha and stover yield 87.42 q/ha obtained from 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS (T_6).

Keywords: Integrated, management, summer, maize, *Zea mays*

Introduction
Maize (*Zea mays*) is one of the most versatile crops grown throughout the tropical as well as temperate regions of the world. Maize is the third most important food grain in India after wheat and rice. Maize has wider adaptability under varied agro-climatic condition. Maize has high genetic potential than any other cereals crops. Hence, it is known as “miracle crop” and also as “queen” of cereals. Maize is one of the most promising crop for diversifying agriculture in upland areas of India. Due to its increasing market price and high production potential in both irrigated and rainfed condition it has becoming a very popular cereal in India. Globally, maize is cultivated on 159 million ha (Mha) in more than 150 countries. In India, Maize is cultivated on 8.3 million ha with production and productivity of 21 million tones and 2.5 tones/ha. About 28% of maize produces in India is used for food purposes, about 11% as livestock feed, 48% as poultry feed, 12% in wet milling industry and 1% as seed.
In Assam, the soil and climatic conditions are very much suitable for maize cultivation. The total area and productivity is very low in comparison to other states of India, it occupies an area only about 20 thousand hectares with productivity of 7q/ha which is very low from all India average. Maize in the state is primarily grown for human consumption only, demand for some other purposes like poultry feed and fodder is also increased rapidly in Assam, for which maize area can be increased to a great extent and efforts are made to make use of maize for such purposes.
Maize is a heavy feeder crop and its productivity is mainly dependent on nutrient management. The adequate and balanced supply of plant nutrients is of critical importance in improving the productivity of maize. Chemical fertilizers are considered as the primary source of plant nutrients. Chemical fertilizers no doubt have boosted the crop growth and yield, but to a large extent these have contributed to deterioration of soil physical, chemical and biological condition. Excessive use of chemical fertilizers has been associated with decline in soil

physical and chemical properties and crop yield 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 *et al*., 2000) [5]. Application of both organic and inorganic fertilizers not only increases the crop yield also to maintain the soil physical, chemical and biological conditions. By applying appropriate combination of different organic manures and inorganic fertilizers, highest productivity of crops without deteriorating the soil can be achieved. An integrated use of inorganic and biofertilizers should be opted for maximizing economic yield and to improve soil health. (Syed ismail *et al*., 2001) [8]. Therefore, it is very important to identify the best type of organic manure and the best combination of organic and inorganic fertilizers to enhance the productivity.

Materials and Method

A field experiment was conducted on summer maize at the Instructional-cum-Research Farm, Assam Agricultural University, Jorhat during the year 2019. The climatic condition of Jorhat is sub-tropical humid with warm summer and cold winter. The weekly mean maximum temperature ranged from 33.8^{0}C to 24.5^{0}C and mean minimum temperature ranged from 15.1^{0}C to 25.7^{0}C during the period of crop growth. The total amount of rainfall received was 1113.90 mm with a maximum average rainfall of 192.2mm on 30th April to 6th May. The weekly average relative humidity during morning ranged from 95 per cent to 93 per cent and in evening ranged from 78 per cent to 61 per cent. The maize seed of the variety VMH-53 was sown on 15th of March (2019) and harvested by two pickings on 10th june and 15th june. Representative soil samples were collected prior to the experiment to study the physico chemical properties of the experimental plot. The soil was sandy loam in texture, acidic in reaction, medium in organic carbon (0.72), low in available N (156.19 kg/ha) and medium in available P_2O_5 (23.78 kg/ha) and K_2O (161.50 kg/ha).

A rectangular shaped upland plot 25m in length and 33.3 m in breath equivalent to 550m^2 was selected prior to the layout of the experiment for the experiment in the year 2019. Individual plot size is 13.44 m^2 (3.20 m× 4.20 m).

The treatments consisted of both soil and foliar application of fertilizers *viz*., T_1 [60:40:40 kg/ha NPK (RDF)], T_2 [RDF + *Azospirillum* + PSB], T_3 [RDF + *Azospirillum* + PSB + 2 sprays of vermiwash at 25 & 40 DAS], T_4 [75% N of RDF + 25% of N replaced by vermicompost], T_5 [75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB], T_6 [75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS], T_7 [50% N of RDF + 50% of N replaced by vermicompost], T_8 [50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB], T_9 [50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS]. N was applied in 2 split doses. First top dressing was done at knee height stage and second was before tasseling. Vermicompost was applied in respective plots one day before sowing. Two sprays of vermiwash was applied as foliar sprays to the growing crop. First spray was applied at knee height stage and the other one applied before tasseling of the crop. Seeds of maize were treated with *Azospirillum* + PSB 12hrs before sowing and sown in respective plots.

The data collected on different observations were analysed statistically using analysis of variance technique. The levels of significance used in 'F' and 't' tests was 0.05 probability.

Result and Discussion

Different crop growth parameters were significantly influenced by INM practices except number of leaves per plant. The highest plant height and leaf area index was found to be highest under the treatment T_3 which was at par with the treatment T_6. Better growth in inorganic treatment or recommended dose of fertilizers as compared to organic fertilizers might be due to the use of chemical fertilizers as they are readily available to plants immediately after application and more particularly with the respect to major nutrients like N, P and K to plants at earlier stages of plant growth. (Swarup *et al*., 1998) [7].

Yield attributes and yield of maize were significantly influenced by different INM practices. The highest weight of cob with or without husk, length of cob, rows per cob, grains per row, 1000 grain weight were observed in INM practices as compared to RDF alone. All parameters related to yield under INM practices were found to be statistically significant over control practices. The highest value of yield attributing characters were found highest in T_3 *viz.*, 100% RDF + Azospirillum + PSB + 2 sprays of vermiwash at 25 & 40 DAS. This might be due to the nutrient availability in the soil. Maize is a heavy feeder crop. Application of chemical fertilizers increased the available nutrients in the soil at the early stage of the crop. In case of a short duration variety like VMH-53 (85-90 days) nutrient uptake become slow after tasseling. Use of recommended dose of fertilizers along with organic sources increased nutrients availability and provided nutrition in plant ready form immediately. Joshi *et al*. (2013) [3] found that maize crop produce significantly higher number and weight per cob of grains, test weight, grain yields and stover yields with conjoin application of recommended dose of NPK + 10 t FYM/ha compared to other organic sources or 50 % RD of inorganic fertilizers. T_3 was at par with T_6 containing 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS. It clearly shows that integration of inorganic and organic sources integration of organic and inorganic sources improved nitrogen use efficiency by plant as a result the maize yield was increased. Clarson (2004) [1] and Singh *et al*. (2005) [6] reported that bio fertilizers are involved in uptake of plant nutrients like phosphorus, nitrogen and potassium besides enhancement of tolerance to attack by soil pathogens and improvement of soil stability.

Higher grain and stover yield had found in T_3 i.e. 100% RDF + *Azospirillum* + PSB (50 g/kg of seed) + 2 sprays of vermiwash at 25 & 40 DAS. The highest grain yield 43.04 q/ha was recorded in T_3 which was 20.65% higher than the RDF alone. The higher yield might be due to use of recommended dose of chemical fertilizers along with organic manures improved the nutrients availability at the early stages of maize. T_3 was at par with T_6. This might be due to the fact that organic manures, biofertilizers could have provided required amount of available nutrients along with chemical fertilizers and improved chemical and biological properties of soil which ultimately reflected in increasing the growth parameters as well as yield attributing characters and which leads to increase in yield. Similar findings was observed by Endris and Dawid (2015) [2]. Vermiwash is coelomic fluid extraction contains several enzyme, plant growth hormones like cytokinins, gibberlines and vitamins along with micro and macro nutrients. In vermiwash nitrogen present in the form of mucus, nitrogenous excretory substances growth stimulating hormones and enzyme (Tripathi and Bhardwaj, 2004) [9]. *Azospirillum* is a free living nitrogen fixing bacteria.

It can promote plant growth. They colonize by adhesion, the root surface or intercellular spaces of host plant roots (McCully, 2001) [4]. *Azospirillum* promote plant growth by several mechanisms including N-fixation, phytohormone production such as auxins, gibberellins, cytokinins, nitric oxide as signals of plant growth promotion. PSB can solubilize the fixed soil P and applied phosphate resulting in higher crop yields. 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 the crop. So, among the different INM practices T_3 containing 100% RDF + *Azospirillum* + PSB + 2 sprays of vermiwash at 25 & 40 DAS resulted highest growth as well yield which was at par with T_6 containing 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS.

Table 1: Effect of INM practices on plant height, number of leaves per and LAI of summer maize

Treatments	Plant height (cm)		Number of leaves per plant		Leaf area index (LAI)	
	60 DAS	90 DAS	30 DAS	60 DAS	45 DAS	60 DAS
T_1=60:40:40 kg/ha NPK (RDF)	99.43	156.44	4.14	8.41	3.31	4.64
T_2= RDF + *Azospirillum* + PSB	105.81	164.21	4.52	8.75	3.43	4.92
T_3= RDF + *Azospirillum* + PSB + 2 sprays of vermiwash at 25 & 40 DAS	112.61	175.73	4.73	8.90	3.94	5.43
T_4= 75% N of RDF + 25% of N replaced by vermicompost	98.64	158.73	4.10	8.44	3.22	4.45
T_5= 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB	104.91	163.85	4.43	8.60	3.41	4.84
T_6= 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS	109.05	170.51	4.54	8.81	3.72	5.16
T_7=50% N of RDF + 50% of N replaced by vermicompost	97.31	154.74	4.03	8.33	3.04	4.41
T_8=50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB	100.43	160.83	4.25	8.51	3.43	4.63
T_9=50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS	101.14	162.33	4.30	8.61	3.42	4.74
S. Ed (±)	3.07	4.99	0.23	0.31	0.18	0.19
C.D (0.05)	6.50	10.57	NS	NS	0.39	0.41

Table 2: Effect of INM practices on number of rows per cob, grains per row, grains per cob, weight of cob with and without husk and length of cob without husk in summer maize

Treatments	No. of rows per cob	No. of grains per row	No. of grains per cob	Wt. of cob with husk (g/cob)	Wt. of cob without husk (g/cob)	Length of cob without husk (cm)
T_1=60:40:40 kg/ha NPK (RDF)	13.56	25.13	340.76	218.83	178.24	16.94
T_2= RDF + *Azospirillum* + PSB	14.60	29.12	424.86	245.83	200.54	19.82
T_3= RDF + *Azospirillum* + PSB + 2 sprays of vermiwash at 25 & 40 DAS	15.72	32.46	505.55	260.14	172.12	16.51
T_4= 75% N of RDF + 25% of N replaced by vermicompost	13.11	24.15	316.00	214.13	172.12	16.51
T_5= 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB	14.12	27.53	388.72	238.43	196.31	18.73
T_6= 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS	15.22	31.66	481.86	257.25	210.16	20.17
T_7=50% N of RDF + 50% of N replaced by vermicompost	12.92	23.61	305.04	209.17	169.23	16.13
T_8=50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB	13.83	25.83	357.23	225.34	184.23	17.14
T_9=50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS	14.11	26.44	376.03	230.82	189.16	17.83
S. Ed (±)	0.47	1.44	13.25	6.46	5.96	1.12
C.D (0.05)	0.99	3.06	28.09	13.70	12.61	2.37

Table 3: Effect of INM practices on 1000 grain weight (g), weight of grain per cob (g), cob yield (q/ha), stover yield (q/ha) and harvest index (%) of maize

Treatments	1000 grain weight (g)	Grain weight per cob	Grain yield (Q/HA)	Stover yield (q/ha)	Harvest index (%)
T_1=60:40:40 kg/ha NPK (RDF)	230.22	81.24	34.15	74.55	31.41
T_2= RDF + *Azospirillum* + PSB	232.72	107.92	38.12	82.42	31.75
T_3= RDF + *Azospirillum* + PSB + 2 sprays of vermiwash at 25 & 40 DAS	233.83	120.83	43.04	89.66	32.99
T_4= 75% N of RDF + 25% of N replaced by vermicompost	229.81	81.17	33.45	73.11	31.39
T_5= 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB	231.91	99.82	37.11	80.11	31.65
T_6= 75% N of RDF + 25% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS	233.00	117.45	41.81	87.42	32.30
T_7=50% N of RDF + 50% of N replaced by vermicompost	229.51	76.15	32.29	70.84	31.12
T_8=50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB	230.82	87.27	35.00	76.00	31.53
T_9=50% N of RDF + 50% of N replaced by vermicompost + *Azospirillum* + PSB + 2 sprays of vermiwash at 25&40 DAS	231.00	92.93	36.14	78.66	31.48
S. Ed (±)	2.72	5.57	1.57	3.08	2.71
C.D (0.05)	NS	11.85	5.37	6.52	NS

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