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RESPONSE OF MAIZE (*Zea mays* L.) TO INTEGRATED NUTRIENT MANAGEMENT UNDER IRRIGATED AREA OF PUNJAB

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ABSTRACT

The present investigation entitled, "Effect of integrated nutrient management on growth and yield of maize (*Zea mays* L.)" was carried out at Students' Research Farm of the Department of Agriculture, Mata Gujri College, Fatehgarh Sahib during *kharif* season of 2017. The soil of the experimental field was gangetic alluvial having clay loam texture with pH 7.5. It was moderately fertile, with available nitrogen (295.15 kg ha^{-1}), available phosphorus (18.70 kg ha^{-1}) and potassium (237.84 kg ha^{-1}). Experiment was laid out in randomized block design with eight integrated nutrient management treatments *viz.*, T_1- control, T_2- 100% RDF, T_3- 75% NPK + FYM @ 7.5 t ha^{-1}, T_4- 50% NPK + Vermicompost @ 5 t ha^{-1}, T_5- 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}, T_6- 75% NPK + Azotobactor (4 kg ha^{-1}) + PSB (5 kg ha^{-1}), T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) and T_8- 50% NPK + Vermicompost @5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobacter (4 kg ha^{-1}). The treatments were replicated thrice. On the basis of results summarized, at 30 DAS the maximum plant height (cm), dry matter accumulation (g plant^{-1}) and Leaf area index was recorded with the application of 100% RDF which was at par with 75% NPK + FYM @ 7.5 t ha^{-1} + PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) and 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}. However, at 60, 90 DAS and at harvest stage the application of 75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) gave best results in term of growth characters and yield which was statistically at par with the application of 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1} and T_3 75% NPK + FYM @ 7.5 t ha^{-1}. Application of 75% NPK + FYM @ 7.5 t ha^{-1} + PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) gave the maximum net returns and maximum benefit: cost ratio (1.64) was observed by the application of 75% NPK + Vermicompost @ 1.25 t ha^{-1} + FYM @ 3.75 t ha^{-1} .

(Key words: INM, vermicompost, azotobator, PSB, growth and yield)

INTRODUCTION

Maize has been an important cereal crop owing to its highest production potential and adaptability to wide range of environment hence called as 'Queen of Cereals'. Maize is a plant belonging to the family of grasses (Poaceae). In India, area, production and productivity of maize are 9.76 m ha, 26.14 m t and 26.80 kg ha^{-1} respectively. Maize occupied 116 thousand hectares, with a production of 445 thousand tonnes in the Punjab State during 2016-17. The average yield was 38.35 q ha^{-1} (15.34 quintal acre^{-1}) (Anonymous, 2017). Maize is being used as staple food in many countries. It is highly nutritive crop as its grain comprises of 72% starch, 10% protein, 4.8% oil, 5.8% fiber, 3.0% sugars and 1.7% ash. It shares a major contribution in farmer's economy of developing countries (Tagne *et al.,*2008). The use of organic manures alone might not meet the plant requirement due to presence of relatively low level of nutrients. Therefore, in order to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic manures in conjunction with inorganic fertilizers to obtain optimum yields (Ramalakshmi *et al.*, 2012). In maize, application of biofertilizers increased growth and yield in many researches. Increased roots, shoot weight with dual inoculation in maize have been reported by (Chabot *et al.,* 1993). Farmyard manure (FYM) is also considered as an important source of macro and micronutrients to increase crop yield. Due to higher prices of inorganic fertilizers, farmers in India could easily manage to prepare FYM in their farms and to apply them in fields. Manure contains all the plant nutrients needed for crop growth including trace elements. The availability or efficiency of manure utilization by a crop is determined by the method of its application, time to incorporate and the rate of manure decomposition by microorganisms in soil (Herbert, 1998).Vermicomposts possess outstanding biological properties and have microbial populations significantly larger and more diverse compared to conventional composts. Soil supplemented with vermicompost showed better plant growth compared to soil treated with inorganic fertilizers or cattle manure (Kalembasa, 1996 and Subler *et al.*, 1998).

MATERIALS AND METHODS

An experiment was carried out in randomized block design with eight treatments and replicated thrice. The treatments consisted of T_1- control, T_2- 100% RDF, T_3- 75%

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NPK + FYM @ 7.5 t ha^{-1}, T_4- 50% NPK + Vermicompost @ 5 t ha^{-1}, T_5- 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}, T_6- 75% NPK + Azotobactor (4 kg ha^{-1}) + PSB (5 kg ha^{-1}), T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) and T_8- 50% NPK + Vermicompost @5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobacter (4 kg ha^{-1}). Observations have been recorded from selected plants with different characters of growth attributes *viz;* Plant height (cm), dry matter accumulation (g plant^{-1}), leaf area index and yield attributes viz., Number of cobs plant^{-1}, length of cob (cm), test weight (g), number of grain cobs^{-1}, grain yield (q ha^{-1}), stubble yield (q ha^{-1}), biological yield (q ha^{-1}), harvest index (%) (Donad, 1958), net return and B:C ratio. The field was ploughed and given pre-sowing irritation. After the preparatory tillage, field was divided into 24 different plots of 4m x 3m size. The pretreated seed of variety Pioner-3401 were sown by dibbling method on 20th of July. RDF (Recommended dose of fertilizer) of NPK for maize was 120, 60, 40 kg ha^{-1}. Applied 1/3 N and full of dose P_2O_5 and K_2O as basal and the remaining dose of N was applied as topdressing in two splits at knee high stage and at Pre-tasselling stage. The amount of vermicompost, FYM, Azotobacter and PSB was applied at per treatment wise.

$$LAI = \frac{\text{Leaf Area}}{\text{Ground Area}} \times 100$$

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100$$

RESULTS AND DISCUSSION

Growth attributes

Data revealed that the integrated nutrient management treatments [Table 1], at 30 DAS the maximum plant height was observed under the treatment T_2-100% RDF(56.99 cm)and at 60, 90 DAS the maximum plant height was recorded under the treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1})(201.67 cm and 207.17 cm respectively). Whereas, minimum was observed under T_1- control (29.40 cm 129.56 cm and 131.93 cm respectively). Nehra *et al.* (2001) reported that the nitrogen from fertilizer helped in the promotion of growth during the early stages and while organic sources of nutrients improved crop growth during later stages.The maximum dry matter was recorded at 30 DAS with treatment T_2-100% RDF (27.62 g plant^{-1}) and at 60, 90 DAS maximum dry matter was recorded under the treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) (104.12 g plant^{-1} and 221.06 g plant^{-1}). Mahesh *et al.* (2010) revealed that combined application of recommended dose of NPK (150:75:40 kg ha^{-1})+ FYM @ 10 t ha^{-1} recorded higher plant height, total dry matter production (g plant^{-1}).Among the integrated nutrient management treatments, maximum leaf area index was recorded at 30 DAS with treatment T_2-100% RDF (1.31) and at 60, 90 DAS the maximum leaf area index was recorded under the treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) (2.70 and 4.07).It has been shown by various workers that in the soil with low N status, plant encourages nodulation, whereas in soil having adequate N availability or foliar feeding of urea, nodulation gets affected. One has to strike a balance between fertilizer application and use of N_2-fixing bacteria without compromising the productivity and profitability of the system were reported by Kumar *et al.*(2018).At 30 DAS under the treatment T_2-100% RDF gave best results in growth parameters (plant height, LAI, dry matter) because utilization of fertilizer by the plants is usually higher and they are readily available to crop. Plant heights significantly increased due to application of FYM, which resulted in better crop growth like plant height, leaf index area and ultimately more dry matter accumulation. It might due to application of organic matter and bio-fertilizer and helped in higher nutrient mobility also reported by Nanjappa *et al.* (2001).Kumar *et al.*(2005) reported that the growth parameters, yield attributes and yield of maize crop were found the maximum when 100% NPK was applied with farmyard manure @ 10 tonnes ha^{-1}.Yadav *et al.* (2008) reported that the organic manures are essential to increase the organic C of the soil and support a number of other beneficial micro-organisms in it. These organisms not only thrive on this source but also produce plant growth-promoting substances.Panwar (2008) reported that the integrated nutrient management has significant effect on growth parameters of maize crop, which was found in a field trial conducted at ICAR research field Umiam, Meghalaya.Maize crop vigor was observed to be better under integrated nutrient management than sole application of FYM or Urea also reported by Chapagain (2010).

Yield attributes

Yield attributing characters *viz*., number of cobs plant^{-1}, length of cobs, and number of grains cob^{-1}, test weight (g), grain yield (q ha^{-1}), stubble yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) showed positive correlation with yield. The data from the Table 2 revealed that the maximum number of cobs plant^{-1}was noticed at the treatments T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) followed by the treatment T_5- 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}.The maximum length of cobs was recorded with the treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1})which was at par of treatment T_5- 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1} and T_3- 75% NPK + FYM @ 7.5 t ha^{-1}. The maximum test weight and the highest number of grains cob^{-1} were recorded with the treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1})which was at par with treatment T_5- 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1} and the treatment T_3- 75% NPK + FYM @ 7.5 t ha^{-1} and recorded significantly superior over rest of the treatments.Wagh (2002) concluded that number of cobs, length of cob,number of grains cob^{-1} and test weight (g) were significantly more with the application of 100% RDF (225:50:50 NPK kg ha^{-1}) + 5 @ FYM t ha^{-1} + Azatobactor + PSB than other fertilizer and FYM levels. Samsul *et al.* (2012) indicated that the application of 75% recommended dose of chemical fertilizer + vermicompost @ 2 t ha^{-1} recorded significantly highest number of cobs plant^{-1} followed by 75% recommended dose of chemical fertilizer

+ FYM @ 2 t ha^{-1} and 100 % recommended dose of fertilizer.The maximum grain yield (q ha^{-1}), stubble yield (q ha^{-1}) and biological yield (q ha^{-1}) were recorded with the treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) and it was found at par with treatment T_5- 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}. However, the lowest yield was recorded in the control condition. The maximum harvest index was recorded with treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) followed by the treatment T_5-75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1} and the treatment T_3- 75% NPK + FYM @ 7.5 t ha^{-1}. The treatment which received the maximum amount of recommended dose of nitrogen through residue mixed FYM in preceding wheat crop had higher value of all the yield components than the treatments, which received 100% RDF through chemical fertilizers. The application of organic matter significantly increased 5.75% more grain yield with the application of FYM @ 10 t ha^{-1} results founded by Chauhan (2010). Similar findings were also been described by Nanjappa *et al.* (2001). They recorded maximum grains row^{-1} with 75% RDF + FYM @ 6 t ha^{-1}, which was at par with RDF (150:75: 40 kg NPK kg ha^{-1}) alone and significantly superior over 50% RDF + FYM @ 12 t ha^{-1} and FYM @ 24 t ha^{-1} treatments. The grain weight plant^{-1} was recorded maximum with 75% RDF + FYM @ 6 t ha^{-1}, which was at par with RDF alone and both these treatments were significantly superior over rest of the treatments. Brar *et al.* (2001) reported that grain yield and stover yield (t ha^{-1}) were significantly higher under 150 kg N + 41.3 kg P_2O_5 along with FYM @ 10 t ha^{-1}. Zaremanesh *et al.* (2017) showed that nitrogen fertilizer and bio-fertilizer significantly increased grain weight and grain yield. Shilpashree *et al.* (2012) reported the increase in the grain yield with FYM and vermicompost application along with NPK fertilizers may be due to the fact that added FYM and vermicompost served as store house of several macro and micro-nutrients, which are released during the process of mineralization. In addition to release of plant nutrients from the organic matter, the organic acids formed in the decomposition process also release the native nutrients in soil and increases their availability to plants.Tripathi *et al.* (2004) reported that length of cob, grains cob^{-1} and grains weight cob^{-1} were significantly higher under 60 N kg ha^{-1} + 30 kg P_2O_5 along with FYM @ 12 t ha^{-1}. The data on economics of various integrated nutrient management treatments revealed [Table 3] that the maximum net returns was noted in the treatment T_7-75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) and have been second highest benefit cost ratio (1.62). The highest benefit : cost ratio (1.64) was noted with the treatment T_5- 75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}. Application of 75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobactor (4 kg ha^{-1}) was lead to increase growth and yield attributes might be due to availability of more nutrients to the crop which ultimately increased the productivity of crop. High grain and stubble yield resulted in high gross income.Ezung and Jamir (2019) revealed that though the combination of 100 % RD of N through vermicompost and 75 cm x 25 cm spacing obtained higher yield and net return, the combination of 75 % RD of N through vermicompost and 75 cm x 25 cm spacing showed better B:C ratio (2.51). Woldesenbet *et al.* (2014) reported that the application of 5 t ha^{-1} FYM in combination with 75% inorganic NP has increased grain yield and the economic evaluation indicated that the application of 5 t ha^{-1} FYM + 75% inorganic NP gave the highest net return. Jinjala *et al.* (2016) reported that the highest net return and B:C ratiowas recorded with the application of 100% RDN from chemical fertilizer with bio-fertilizer.Tetarwal *et al.* (2011) reported that the application of RDF + Azotobacter + PSB gave significantly higher benefit : cost ratio.Meshram *et al.* (2018) reported that the cost of cultivation was marginally increased when the nutrients were applied through the combination of different source, but due to higher grain and straw yields, the net return and B:C ratio were also higher under the integrated use of organic and inorganic source of nutrients.

Table 1. Effect of integrated nutrients management on growth attributes parameters of maize

Treatment details	Plant height (cm)				Dry matter accumulation (g plant^{-1})				Leaf area index		
	30DAS	60 DAS	90 DAS	At harvest stage	30DAS	60 DAS	90 DAS	At harvest stage	30DAS	60 DAS	90 DAS
T_1= Control	29.40	129.56	131.93	132.72	14.01	65.07	134.62	137.94	0.36	1.38	2.24
T_2=100 % RDF of NPK	56.99	167.22	172.12	173.94	27.62	85.28	184.36	189.18	1.31	2.07	3.09
T_3=75% NPK + FYM @ 7.5 t ha^{-1}	43.82	185.38	190.28	191.74	21.24	94.87	202.54	204.91	0.78	2.47	3.76
T_4=50% NPK + Vermicompost @ 5 t ha^{-1}	31.54	138.34	141.14	141.82	14.27	69.88	144.12	152.29	0.42	1.52	2.39
T_5=75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}	53.51	189.95	196.08	197.57	25.81	97.21	209.96	212.07	1.18	2.65	3.84
T_6=75% NPK + Azotobacter (4 kg ha^{-1}) + PSB (5 kg ha^{-1})	38.36	156.14	159.08	161.27	17.92	79.29	170.80	178.84	0.66	1.90	2.86
T_7=75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobacter (4 kg ha^{-1})	54.74	201.67	207.17	210.04	26.55	104.12	221.06	223.36	1.23	2.70	4.07
T_8=50% NPK + Vermicompost @ 5 t ha^{-1} + PSB (5 kg ha^{-1}) + Azotobacter (4 kg ha^{-1})	33.83	147.27	151.16	153.00	15.37	74.56	162.28	164.75	0.46	1.62	2.72
SEm (±)	**1.55**	**5.88**	**6.10**	**6.01**	**0.74**	**3.19**	**6.36**	**6.67**	**0.03**	**0.08**	**0.11**
CD (P = 0.05)	**4.69**	**17.85**	**18.50**	**18.23**	**2.25**	**9.67**	**19.29**	**20.22**	**0.09**	**0.24**	**0.34**

Where: - RDF = Recommended Dose of Fertilizer, PSB = Phosphate Solubilizing Biofertilizer, FYM = Farmyard manure

Table 2. Effect of integrated nutrient management on yield attributes and yield parameters of maize

Treatments	Cob plant^{-1}	Length of cob (cm)	Test weight (g)	No. of grains cob^{-1}	Grain yield (q ha^{-1})	Stubble yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1= Control	1.03	11.76	208.67	173.37	28.17	81.23	109.39	25.73
T_2=100 % RDF of NPK	1.97	18.57	228.00	333.01	58.87	122.76	181.63	32.41
T_3=75% NPK + FYM @ 7.5 t ha^{-1}	2.37	20.04	235.00	387.14	64.67	132.82	197.48	32.76
T_4=50% NPK + Vermicompost @ 5 t ha^{-1}	1.20	14.33	214.33	246.65	35.67	96.27	131.94	27.05
T_5=75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}	2.37	21.67	238.67	404.95	67.00	136.92	203.92	32.87
T_6=75% NPK + Azotobacter (4 kg ha^{-1}) + PSB (5 kg ha^{-1})	1.67	17.72	225.33	280.35	51.50	115.21	166.71	30.90
T_7=75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobacter (4 kg ha^{-1})	2.53	21.93	246.67	416.22	69.00	141.67	210.67	32.77
T_8=50% NPK + Vermicompost @ 5 t ha^{-1} + PSB (5 kg ha^{-1}) + Azotobacter (4 kg ha^{-1})	1.30	16.71	222.33	228.81	41.67	104.22	145.88	28.57
SEm (±)	**0.07**	**0.65**	**5.72**	**10.87**	**1.85**	**4.09**	**5.21**	**0.79**
CD (P = 0.05)	**NS**	**1.97**	**17.35**	**32.98**	**5.62**	**12.41**	**15.79**	**NS**

Where: - RDF = Recommended Dose of Fertilizer, PSB = Phosphate Solubilizing Biofertilizer, FYM = Farmyard manure

Table 3. Effect of integrated nutrients managements on economics of crop

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1= Control	44929	64505.67	19576.67	0.43
T_2=100 % RDF of NPK	51046.5	124822.33	73776.33	1.44
T_3=75% NPK + FYM @ 7.5 t ha^{-1}	53268	136618.33	83350.33	1.56
T_4=50% NPK + Vermicompost @ 5 t ha^{-1}	55487	83165.33	27678.33	0.49
T_5=75% NPK + Vermicompost @ 1.25 t ha^{-1}+ FYM @ 3.75 t ha^{-1}	53267	141084.33	87817.33	1.64
T_6=75% NPK + Azotobacter (4 kg ha^{-1}) + PSB (5 kg ha^{-1})	51732	112043.00	60311.00	1.16
T_7=75% NPK + FYM @ 7.5 t ha^{-1}+ PSB (5 kg ha^{-1}) + Azotobacter(4 kg ha^{-1})	55482	145558.33	90076.33	1.62
T_8=50% NPK + Vermicompost @ 5 t ha^{-1} + PSB (5 kg ha^{-1}) + Azotobacter (4 kg ha^{-1})	57702	94106.67	36404.67	0.63

Where: - RDF = Recommended Dose of Fertilizer, PSB = Phosphate Solubilizing Biofertilizer, FYM = Farmyard manure

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