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Full Length Research Paper

Integrated nutrient management in winter maize (*Zea mays* L.) sown at different dates

Neeraj K uma r Ver ma

Depart m ent of Agronom y, Brahm anand Maha v i dyal aya, Rat h (Hami rpur), 210431, I ndi a .
E-mail: nkverma1061@rediffmail.com.

Abstract

A field experiment was conducted during rabi season of 2006 to 2007 and 2007 to 2008 to study the effect of sowing dates and integrated nutrient management on growth, yield and quality of winter maize. The trial was laid out in split plot design with three replications, assigning total 27 treatment combinations i.e. three sowing dates (15 October, 25 October and 5 November) in main plots and three levels of nitrogen from inorganic fertilizer urea (50, 100 and 150 N_20 kg ha^{-1}) and two organic fertilizer (FYM, *Azospirillum*) and control in sub plots. The crop sown on 25 October significantly enhanced the growth and grain yield than early sowing 15 October and late sowing 5 November while, 150 kg of N_2O ha^{-1} application significantly increased over 100 and 50 kg N_2O ha^{-1}. However, N_2O application through FYM was found statistically at par with N_2O application through the *Azospirillum* in growth and grain yield during both years. But, application of 100 kg ha^{-1} with 7.50 t ha^{-1} FYM at the sowing of 25 Oct significantly influenced the growth, yield and quality of maize and was recorded 9.35 and 23.07% more grain yield over the other treatment combinations.

Key w o rd s: Ra bi m ai ze, so wi ng d at e s, i nt eg rat ed n ut ri ent m anagem ent (I NM), su st ai nabl e, gro wt h, yi el d .

INTRODUCTION

In cereals, maize is grown throughout the year mainly due to photo-thermo-insensitive character, hence called 'queen of cereal'. There are several factors that affect the productivity of winter maize; however, the fertilizer management is one of the most important factors that affect the growth and yield of maize (Anonymous, 1979). Another factor, time of sowing is a non monetary input which plays significant role in production and productivity of any crop. Maize is an exhaustive crop requires all types of macro and micro nutrients for better growth and yield potential. Among the various nutrients, nitrogen is the principal nutrients for better harvest require approximately 150 N_20 kg ha^{-1} (Prasad et al, 1987).

Effective supply of nitrogen through inorganic and organic sources may increase the production of maize as well as improve the quality of food grains and soil environment. Crop responses to organic and biological nutrient carriers are not as spectacular as fertilizer but the supplementary and complementary use of such sources is known to enhance the utilization efficiency of fertilizers (Yadav, 1998). The main advantages of organic fertilizer are ecological balance, low cost of cultivation, clean environment and nutritious food without reducing the human health (Hedge and Sudhakar, 2001).

Farm Yard Manure (FYM) is the decomposition of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle, on an average it contains; 0.5% N, 0.2% P and 0.5% K and Azospirillum is an important free living organism that can fix atmospheric nitrogen in to the soil ranging from 20 to 30 kg ha^{-1} (Reddy and Reddy, 2003). In order to sustain soil fertility and productivity and to reap rich harvest of maize, it is important that FYM and Azospirillum (bio-fertilizers) have to be applied in adequate quantity, due to ever increasing cost of inorganic chemical fertilizers, their

Abreviations: Kg ha_{-1}, Kilogram per hectare; **FYM,** farm yard manure; **INM,** integrated nutrient management; **N_2O,** nitrogen; P_2O_5, phosphorus; **K_2O,** potashium; **t ha $^{-1}$,** tonne per hectare; **cm,** centimeter.

use in combination with organic sources has become imperative for sustained crop production (Nanjappa et al., 2001).

Organic agriculture achieves high plant yield by making efficient use of organic residues: To fertilize soil, it uses composted harvest residues and animal manure. This saves 50 to 150 kgN_2O, depending upon the crop, in synthetic nitrogen fertilizer per hectare which would otherwise need to be produced using not renewable fuels. Studies have shown that conventional arable farming operations in England consume some 17000 L of fossil fuels embodied in fertilizers per 100 ha of land each year. If one compares a field where chemical fertilizers have been used to grow the crops and field where organic inputs such as farm yard manure, vermicompost and panchagavya have been used, one can clearly see the presence of earthworms, millipedes and ants is more in an organic field.

There is large areas are in semi-arid region where cattle rearing is main business of most of the farmers and they ever faced deficiency of green fodder, thus the maize will be helpful to solve this problem and it is very well known that maize plant has a large amount of vegetative part, to which we can incorporate within the soil, consequently, it will be helpful in maintaining soil fertility and productivity as organic residues helps to enriching the soil conditions. To overcome from above hazards, this is needed to promote, minimizing the use of chemical fertilizers and replace with organic resources. Thus, present investigation of maize cultivation in Uttar Pradesh (U.P.) will be helpful in increasing the production and productivity of maize as well as maintaining soil health, minimizing cost of cultivation and to solve the future problems.

MATERIALS AND METHODS

The experiment was conducted at the Brahmanand Mahavidyalaya Agricultural Research Farm, Post- Rath, District- Hamirpur, State- Uttar Pradesh, PIN- 210431, India during the winter (rabi) season of 2006 to 2007 and 2007 to 2008. The soil of experimental field was ‘parwa’ with slightly alkaline in reaction (pH 7.6) which was low in available nitrogen, medium in available phosphorus and high in available potassium containing 200.83 N_2O, 29.28 P_2O_5 and 474.16 K_2O kg ha^{-1} and 0.56% organic carbon content. The trial was laid out in split plot design with three replications assigning 27 treatment combinations of 3 sowing dates (15 Oct, 25 October and 5 November) in main plots, three level of inorganic nitrogen supply through urea (50, 100 and 150 N_20 kg ha^{-1}) and two levels of organic nitrogen (FYM 7.5 t ha^{-1} before 15 days of sowing in soil and Azospirillum by seed inoculation @ 500g per 10 kg of seed) and control in sub plots.

Hybrid ganga safed-2 variety of maize was sown according to the dates decided in the treatment, maintaining 45 cm row-to-row and 30 cm plant to plant distance with the seed rate of 25 kg ha^{-1} at 2.5 cm depth. N_2O according to treatment and uniform dose of 60 kg P_2O_5 and 40 kg K_2O were applied in each plot, half of nitrogen and full dose of phosphorus and potash were applied as basal dose and remaining dose of nitrogen as top dressing after first irrigation at seedling stage was applied. Others compulsory activities such as interculture and plant protection measures were applied as need based. To evaluate the leaf area Index (LAI) following formula was used:

LAI = Leaf Area / Ground area (Watson, 1947)

RESULTS AND DISCUSSION

Effect of sowing dates

All round improvement in growth and development characters such as, plant height and dry matter accumulation per plant were found significantly maximum in 25 Oct sowing date. It also enhanced the leaf area index resulting in more photosynthesis and food matter accumulation for longer period, which improved the growth, development and dry matter production per plant with respective date of sowing due to optimum sowing time, suitable growth period and favourable climatic conditions especially temperature. Plant maturity and silking was also significantly affected under different dates of sowing during both years. The significantly more number of days to maturity was observed in 25 October sowing followed by 15 October and 5 November dates of sowing during both the years and the average number of days to maturity were also more in 25 October sowing as compared to other dates of sowing, also supported by Andrew et al. (2006).

In respect to yield attributes such as, diameter of cob and weight of cobs per plant were found significantly higher in 25 October sowing date over 15 October and 5 November dates of sowing in both years. This could be due to the better growth and development of crop.

Similarly, the grain yield was also increased significantly with the sowing of maize on 25 October than early and late sown crop. Kolawole et al. (2009) reported that these enhancement were due to more diameter of cob and weight of cobs per plant might be due to the better translocation system in maize plant enhance the production of yield due to the fact that good photosynthetic accumulated in leaves and its transfer to economic part like grains, cobs etc. ultimately a fact the higher rate of photosynthesis. Percent of protein content in grain significantly affected due to dates of sowing in both years, the highest protein value was recorded in 25 October sowing followed by 15 October and 5 November, the order of growth, yield attributes, yield and quality parameters were as 25 October>15 October>5 November.

Effect of inorganic source

The data given in Table 1 to 3 revealed that the nitrogen supplied through the inorganic source significantly

Table 1. Growth characters of winter hybrid maize as influenced by dates of sowing and nitrogen sources.

Treatments	Plant height (cm) at 30 DAS			Leaf Area Index at 30 DAS			Dry
	2006 to 07	2007 to 08	Pooled	2006 to 07	2007 to 08	Pooled	2006 to
Dates of Sowing							
15 Oct- D_1	10.67	10.94	10.81	32.97	30.77	31.87	2.07
25 Oct- D_2	10.81	11.09	10.95	33.38	31.20	32.29	2.30
5 Nov- D_3	9.73	9.98	9.86	30.12	27.86	28.99	1.88
SE±	0.13	0.15		0.20	0.26		0.01
C.D. at 5%	0.37	0.42		0.58	0.74		0.05
Inorganic source of N_2O application							
50 kg N_2O ha^{-1} - N_1	10.22	10.48	10.35	31.56	29.34	30.45	1.99
100 kg N_2O ha^{-1} - N_2	10.42	10.69	10.56	32.20	30.03	31.12	2.07
150 kg N_2O ha^{-1} - N_3	10.57	10.84	10.71	32.72	30.45	31.59	2.20
SE±	0.21	0.23		0.31	0.36		0.03
C.D. at 5%	N.S.	N.S.		0.83	0.73		0.08
Organic source of N_2O application							
Control – O_0	10.27	10.49	10.38	31.58	29.34	30.46	2.03
FYM – O_1	10.51	10.91	10.71	32.57	30.41	31.49	2.13
Azospirillum – O_2	10.43	10.71	10.57	32.32	30.08	31.20	2.09
SE±	0.21	0.23		0.31	0.36		0.03
C.D. at 5%	N.S.	N.S.		0.63	0.73		0.08
C.V. (%)	7.46	8.12		3.61	4.50		5.30

N.S.- Non-Significant.

influenced the plant height, leaf area index and number of days to maturity and silking were recorded significantly higher in 150 N_20 kg ha^{-1} application followed by 100 N_20 kg ha^{-1} and 50 N_20 kg ha^{-1} in both years. In regards to plant height at early stage of crop growth (30 days), N_20 dose were at par amongst each other, while at 60 days, 150 N_20 kg ha^{-1} was found statistically at par with 100 N_20 kg ha^{-1}. It was mainly due to the increase in nitrogen content in soil which was responsible for all round enhancement of growth, increase metabolic activities, assimilation rate and cell division within the plant (Cyrus et al. 2010).

Onasanya et al. (2009) found that the maximum dry matter accumulation per plant was the positive effect of growth characters; significantly more value was recorded with 150 N_2O kg ha^{-1}. The 50 N_20 and 100 N_20 kg ha^{-1} doses were found statistically at par with each others during both the years. A differential response of nitrogen levels

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Table 2. Growth characters of winter hybrid maize as influenced by dates of sowing and nitrogen sources.

Treatments	Growth characters						
	Plant height (cm) at harvest			Leaf Area Index 90 DAS			Dry
	2006 to 07	2007 to 08	Pooled	2006 to 07	2007 to 08	Pooled	2006
Dates of Sowing							
15 Oct- D_1	179.25	183.99	181.62	175.95	166.82	171.39	157
25 Oct- D_2	186.02	202.61	194.32	200.05	191.50	195.78	160
5 Nov- D_3	171.71	175.04	173.38	141.37	132.22	136.80	146
SE±	1.00	1.20		1.47	1.19		1.5
C.D. at 5%	2.79	3.33		4.10	3.30		4.3
Inorganic source of N_2O application							
50 kg N_2O ha^{-1} - N_1	173.99	178.40	176.20	165.14	155.96	160.55	150
100 kg N_2O ha^{-1} - N_2	182.92	187.72	185.32	171.99	162.88	167.44	154
150 kg N_2O ha^{-1} - N_3	190.07	195.52	192.80	180.24	171.50	175.87	159
SE±	1.47	1.74		2.10	1.75		2.3
C.D. at 5%	2.97	3.51		4.23	3.53		4.7
Organic source of N_2O application							
Control – O_0	179.39	184.15	181.77	167.70	158.94	163.32	151
FYM – O_1	184.76	189.80	187.28	176.74	187.44	182.09	157
Azospirillum – O_2	182.82	187.69	185.26	172.82	163.96	168.39	154
SE±	1.47	1.74		1.93	1.80		2.3
C.D. at 5%	2.97	3.51		3.88	3.22		4.7
C.V. (%)	2.98	3.43		4.11	3.60		4.1

also found that it may be due to optimum and regular supply of nitrogen nutrient to plant from soil during growth period by more assimilation rate and its integral part of protein, the building blocks of plant.

The grain yield was increased significantly maximum with 150 N_20 kg ha^{-1} followed by other doses of nitrogen supply. The respective dose of nitrogen (150 N_20 kg ha^{-1}) increased 2.39 and 7.64% more grain yield over 100 N_20 and 50 N_20 kg ha^{-1} nitrogen doses, respectively given in Table 5. The higher grain yield/unit area was due to the more diameter of cob. The results were confirmed with the findings of Moser et al. (2006). Table 5 showed that content of protein in grains were recorded highest with in 150 N_20 kg ha^{-1} application followed by 100 N_20 and 50 N_20 kg ha^{-1} in both the years and also, mean value. It was mainly due to sufficient amount of nitrogen nutrient to the winter maize crop and regular supply of nutrient for increasing growth and reproductive phases from the soil. The results were closely rela

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Table 3. Days to maturity and silking of winter hybrid maize as influenced by dates of sowing and nitrogen sources.

Treatments	Developmental characters				
	Days to silking			Days to matu	
	2006 to 07	2007 to 08	Pooled	2006 to 07	2007 to 08
Dates of sowing					
15 Oct- D_1	51.88	50.74	51.31	141.51	140.40
25 Oct- D_2	53.55	52.66	53.11	143.25	141.96
5 Nov- D_3	49.48	48.26	48.87	138.51	137.52
SE±	0.16	0.13		0.32	0.29
C.D. at 5%	0.46	0.36		0.91	0.82
Inorganic source of N_2O application					
50 kg N_2O ha^{-1} - N_1	51.25	50.11	50.68	139.40	138.33
100 kg N_2O ha^{-1} - N_2	51.44	50.88	51.16	141.25	140.14
150 kg N_2O ha^{-1} - N_3	52.22	50.88	51.55	142.63	141.40
SE±	0.24	0.02		0.50	0.45
C.D. at 5%	0.49	0.04		1.02	0.90
Organic source of N_2O application					
Control – O_0	51.22	50.33	50.78	139.92	138.89
FYM – O_1	52.07	50.95	51.51	141.92	140.70
Azospirillum – O_2	51.63	50.48	51.06	141.44	140.28
SE±	0.24	0.17		0.50	0.45
C.D. at 5%	0.49	0.34		1.02	0.90
C.V. (%)	1.74	1.24		1.32	1.18

Table 4. Yield attributes of winter hybrid maize as influenced by dates of sowing and nitrogen sources.

Treatments	Yield attributing characters				
	Diameter of cob (cm) at harvest			Weight of cobs $plant^{-1}$ (g) a	
	2006 to 07	2007 to 08	Pooled	2006 to 07	2007 to 08
Dates of sowing					
15 Oct- D_1	4.31	4.15	4.23	84.40	92.10
25 Oct- D_2	4.73	4.81	4.77	89.02	97.15
5 Nov- D_3	4.25	4.14	4.20	78.08	76.28
SE±	0.02	0.02		0.48	0.28
C.D. at 5%	0.06	0.07		1.29	0.80

Table 4. Contd.

Inorganic source of N_2O application					
50 kg N_2O ha^{-1} - N_1	4.22	4.09	4.16	81.57	79.48
100 kg N_2O ha^{-1} - N_2	4.42	4.29	4.36	83.48	81.58
150 kg N_2O ha^{-1} - N_3	4.88	4.53	4.71	86.45	84.48
SE±	0.03	0.04		0.72	0.28
C.D. at 5%	0.07	0.08		1.44	0.58
Organic source of N_2O application					
Control – O_0	4.31	4.17	4.24	82.81	80.55
FYM – O_1	4.53	4.40	4.47	85.03	83.20
Azospirillum – O_2	4.45	4.33	4.39	83.66	81.70
SE±	0.03	0.04		0.72	0.28
C.D. at 5%	0.07	0.08		1.44	0.58
C.V. (%)	2.98	3.68		3.15	1.29

Table 5. Yield and quality in winter hybrid maize as influenced by dates of sowing and nitrogen sources.

Treatments	Yield (q ha^{-1})and quality attributing characters				
	Grain Yield (q ha^{-1})			Protein (%) in grain at	
	2006 to 07	2007 to 08	Pooled	2006 to 07	2007 to
Dates of Sowing					
15 Oct- D_1	35.49	34.91	35.20	8.09	8.07
25 Oct- D_2	39.97	37.69	38.83	8.26	8.23
5 Nov- D_3	30.47	29.26	29.87	8.03	7.88
SE±	0.30	0.22		0.01	0.01
C.D. at 5%	0.84	0.62		0.03	0.03
Inorganic source of N_2O application					
50 kg N_2O ha^{-1} - N_1	33.25	32.24	32.75	8.04	8.01
100 kg N_2O ha^{-1} - N_2	35.09	34.12	34.61	8.22	8.18
150 kg N_2O ha^{-1} - N_3	35.52	35.39	35.46	8.13	8.10
SE±	0.41	0.34		0.01	0.01
C.D. at 5%	0.84	0.69		0.03	0.03
Organic source of N_2O application					
Control – O_0	33.64	32.82	33.23	8.07	8.04

Table 5. Contd.

FYM – O_1	35.92	34.91	35.42	8.19	8.1
Azospirillum – O_2	35.31	34.03	34.67	8.13	8.1
SE±	0.41	0.34		0.01	0.0
C.D. at 5%	0.84	0.69		0.03	0.0
C.V. (%)	4.40	3.73		0.79	0.6

prolonged release of nutrients from FYM, increase the efficiency and favourable conditions.

The increased leaf area index by supplied nutrients from FYM also increased photosynthesis assimilates in plant which finally pushed for increasing dry matter accumulation. The results were conformity with the findings of Sujatha et al. (2008). Yield attributing characters viz. diameter of cob and weight of cobs/plant were also calculated significantly more in FYM source of nitrogen application (Table 4), maximum grain yield/unit area were also recorded with the addition of FYM source of nitrogen which was significant more over control in both the year (Table 5). However, the FYM source of nitrogen application was at par with Azospirillum application in both years. Lelei et al. (2009) reported that the production of grain yield and percentage of protein from per unit area was the resultant of increased leaf area index and weight of cobs/plant. It may be due to better growth, development and dry matter accumulation with proper supply of nutrient to plant and increase the availability to other plant nutrients with the respective source of nitrogen application.

Conclusion

It is clear from the results of investigation that with the application of 7.5 t FYM/ha and this much quantity of Azospirillum, can produce the same grain yield of winter maize. As the application of inorganic fertilizer of 100 N_2O kg ha^{-1} with FYM enhanced the crop yield when sowing on 25 October rather than 15 October and 5 November, respectively.

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