Optimizing Input management practices for sustainable Maize Production

ABSTRACT

A field experiment was conducted during *rabi*, season of 2021-22 and 2022-23 at the Agricultural research farm, Bihar Agricultural University, Sabour, Bhagalpur, to study the effect of different input management practices on growth parameters and total biomass production and yield of maize. The experiment was laid out ina randomizedblock design with three replications. The treatments consisted of seven nutrient management practices in combination with pest management practices viz, N_1 (100% RDF (150:75:50 $N:P_2O_5:K_2O$ kg ha^{-1}) through inorganic fertilizer + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_2 (50% RDN through inorganic fertilizer + 50% RDN through organic source + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_3 (SPAD based N management + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_4 (100% RDF through inorganic fertilizer + insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water), N_5 (50% RDN through inorganic fertilizer + 50% RDN through organic source + insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water), N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) and N_7 (Farmer's practice,120:40:30 $N:P_2O_5:K_2O$ kg ha^{-1}). The critical threshold value for SPAD readingwas taken under experimentation was 46.1.The growth parameters of maize,like plant height, leaf area index, biomass production and crop growth rate,were recorded at periodic intervals of (30, 60, 90, 120 DAS and at harvest). The results of the present study showed that the higher plant height (200.3 cm at 120 DAS), LAI (4.5 at 90 DAS), biomass (19156.0 kg ha^{-1}at harvest) and crop growth rate (24.2 g m^{-2} day^{-1} at 90-120 DAS) were obtained in treatment N_6, which was statistically superior to the treatment N_7. Total biomass production and yield of the maize crop wererecorded maximum from the treatment (N_6) with the value of total biomass (19538.33 kg ha^{-1}),stover yield (7103.33 kg ha^{-1}), grain yield (9896.67 kg ha^{-1}), stone yield (2538.33 kg ha^{-1}) and harvest index (49.65%).Therefore, this nutrient management practice, especially with SPAD-based nitrogen management withthe application of Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water,can be an effective tool in maximizingthe productivity of Maize crops.

Keywords: Growth Parameters, Input management practices, Maize, SPAD based N, Yield.

Introduction

In India, maize is the third most important food crop after rice and wheat. According to the latest data of (DAC&FW, 2019-20), it is being cultivated on 1.748 m ha, i.e. 20-25 % area during rabi season. The current maize production is 9.34 MT, with an average productivity of 4.42 t ha^{-1}. Maize contributes nearly 9 % ofthe national food production. Nutritionally, it is rich in carbohydrates (70%), contains about 10% of protein and 4% of oil (Jat et al. 2013), and is thus considered to ensure food and nutritional security. Being an exhaustive crop, the nutrient requirement of maize cannot be supplied only through native nutrient reserves, and the additional nutrient requirements have to be met from organic and inorganic sourcesof nutrients. Maize requires more N and P than other essential elements for the development of all growth stages. Balanced application of plant nutrients through the integration of organic and inorganic fertilizers has been provento enhance maize yield and soil fertility. Adoption of precision N management in maize crops increases the N use efficiency as well as reduces the N loss. Traditional farming following the blanket recommendation of fertilizer formaize crop can be replaced by the adoption of precision nutrient management, which saves the plant and soil health (Kumar et al. 2017). For many cropping systems in the tropics, application of N and P from organic and inorganic sources is essential to maximize and sustain high crop yield potential in continuous cultivation systems (Hartemik et al., 2000).

Focusing on income nutritional security, and sustainability, technologies like integrated input management have emerged as an option to grow a highly mining crop like maize.In comparison,the rice-maize system has proved to be a productive and profitable cropping system for eastern India and places where wheat productivity faces yield penalties due to delayed sowing after the late harvest of rice and terminal heat stress faced by wheat during its grain-filling period. Therefore, replacing the wheat crop with a more productive and remunerative maize crop can help in addressing the resource crush issues as well as the climate change and sustainability issues in a holistic manner. Efficient nutrient management is the key to increasing the productivity of maize;therefore,it requires the use of innovative and sustainable approaches.Precise information on the effect of different crop establishment methods, time of planting, and nutrient management strategies on the growth, productivity, and profitability of *rabi* maize isstill lacking. Keeping in view the above consideration, present study has been formulated on the different input management practices on growth and yield attributes of maize crop.

Materials and methods

The field experiment was conducted during the winter (*rabi*) season of 2021-22 and 2022-23, at the research farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar to delineate sustainability inmaize production system under varying source of organic and inorganic nutrients and their management along with seed treatment and insecticidal application. Source of input nutrient materials were supplied in the form of Urea (46% N), DAP (46% P_2O_5 and 18% N), and MOP (60% K_2O) and organic source of nitrogen given in the form of vermicompost. The seven nutrient management practices of maize crop viz N_1 (100% RDF (150:75:50 $N:P_2O_5:K_2O$ kg ha^{-1}) through inorganic fertilizer + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_2 (50% RDN through inorganic fertilizer + 50% RDN through organic source + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_3 (SPAD based N management + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_4 (100% RDF through inorganic fertilizer + insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water), N_5 (50% RDN through inorganic fertilizer + 50% RDN through organic source + insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water), N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) and N_7 (Farmer's practice,120:40:30 $N:P_2O_5:K_2O$ kg ha^{-1})were applied in the present study. The field experiment was laid in a randomized block design (RBD) with three replications. Maize was sown in the month of November with a spacingof 60 cm x 20 cm. At the time of sowing as basal application of half dose of nitrogen and full dose of P_2O_5 and K_2O were applied.The remaining half doses of nitrogen were applied at two splits on 25 and 55DAS respectively. In addition,the prescribed quantities of the organic manures viz., vermicompost was also applied as basal. Under the SPAD based treatments, nitrogen was top dressed in the form of urea at the rate of 20 kg ha^{-1}wheneverthe SPAD meterreading was below the critical threshold value 46.1 (average SPAD reading of 3 plants were taken). Maize crop washarvested at its 80% physiological maturity. Observations were recorded at periodic intervals (30, 60, 90 DAS, 120 DAS and at harvest) on growth parameters viz. plant height, Leaf area index (LAI), biomass production and crop growth rate (CGR). Total biomass production and yield parameters and yields were recorded atthe time of harvest. The data obtained with respect to crop growth parametersand yields were subjected for statistical analysis. The mean values were grouped for comparisons and the least significant differences among them were calculated at $P < 0.05$ confidence level using ANOVA statistics as outlined by Gomez and Gomez (1984).

Results and Discussion

There was progressive increase in plant height (Table 1) with increase in age of crop up to 120 DAS and slowed down thereafter indicating that grand growth period lies between 60-120 DAS. The plant height increased significantly with increasing level of nutrient management practice except at 30 DAS. Tallest plant produced (169.1 cm) with the treatment N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) which remained at par with the treatment N_4(165.9 cm) received 100% RDFthrough inorganic source along with insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water). LAI (Table 2) was recorded maximum (2.1 and 3.5 at 60, 120 DAS respectively) with N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) which remained at par with treatment received N_1 (100% RDF (150:75:50 $N:P_2O_5:K_2O$ kg ha^{-1}) through inorganic fertilizer + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_2 (50% RDN through inorganic fertilizer + 50% RDN through organic source + Seed treatment with Bavistin @ 2.5 g/kg of seed), N_3 (SPAD based N management + Seed treatment with Bavistin @ 2.5 g/kg of seed) and N_4 (100% RDF through inorganic fertilizer + insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water)at 60 and 120 DAS. A consistent increase in the biomass production (Table 3) occurred with the advancement of the crop growth stages and reached to maximum at time of maturity. It is evident from the data that biomass production increased significantly with the application of treatment N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) and that was significantly higher than the treatments ($N_{2,}N_5$ and N_7), although statistically at par with N_4 and N_3 at 60, 90 DAS. Likewise, Crop growth rate (Table 4)was more pronounced when treatment N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) (9.83 g m^{-2} day^{-1}) was given. Crop growth rate were recorded maximum with N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) (24.2 g m^{-2} day^{-1} and 14.6 g m^{-2} day^{-1} at the growth period of 90-120 DAS and at 120 DAS- Harvest respectively) which remained at par to the treatment received N_1 , $N_{2,}$ N_4 andN_5, but found significantly superior over inorganic source N_7(farmer's practice) (18.4 g m^{-2} day^{-1} and 9.7 g m^{-2} day^{-1} at the growth period of 90-120 DAS and at 120 DAS-Harvest respectively). Significantly highest stover yield recorded with N_6 (SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water) (7103.33 kgha^{-1}) but found significantly superior over N_7 (farmer's practice) (6766.67 kg ha^{-1}) and N_2(50% RDN through inorganic fertilizer + 50% RDN through organic source + Seed treatment with Bavistin @ 2.5 g/kg of seed) (6781.33 kg ha^{-1}). Similarly, grain yield enhanced significantly (9896.67 kg ha^{-1}) with the application of SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water (N_6) and the same trend was followed in stone yield also, where the maximum stone yield (2538.33 kg ha^{-1}) was recorded in N_6but remained at par to N_4 (2486.00 kg ha^{-1}) and the minimum stone yield was recorded (1665.0 kg ha^{-1}) in N_7 (farmer's practice). The harvest index of maize did not influence significantly with different nutrient management treatments.

Conclusion

Therefore, the results of this research also contribute to the existing knowledge by providing empirical evidence that clarifies thesignificant impact of various input management practices on sustainable maize production. Theinput management practices can be an effective tool in maximizing productivity of maize, while,SPAD based N management +insecticide application Chlorpyriphos 20 EC @ 0.02% or 0.2 ml/litre of water had the better performance in all the aspect of growth parameters, yield attributing characters and yield of maize crop.However, to stand up with a specific conclusion and suggestion the irrigation and weed management practices need to be incorporated under the experimentation in future.

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Table-1 Effect of nutrient and pest management practices on plant height of maize

Treatment	**Plant height (cm)**				
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
N_1	24.5	100.0	162.5	195.5	194.3
N_2	23.1	97.3	159.2	193.4	190.6
N_3	24.8	100.9	163.4	197.5	196.8
N_4	25.0	102.6	165.9	198.8	198.0

N_5	23.5	98.1	162.1	194.1	192.6
N_6	25.3	104.3	169.1	200.3	198.9
N_7	22.4	96.0	155.0	192.2	190.2
SEm (±)	1.01	0.29	1.62	0.93	1.21
CD (P=0.05)	NS	0.89	4.83	2.87	3.72

Table-2Effect of nutrient and pest management practices on LAI of maize

Treatment	Leaf area index (LAI)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
N_1	0.4	1.9	4.3	3.2	2.2
N_2	0.3	1.4	4.0	2.9	2.1
N_3	0.4	1.8	4.3	3.3	2.3
N_4	0.4	1.9	4.4	3.4	2.3
N_5	0.3	1.5	4.3	3.1	2.2
N_6	0.4	2.1	4.5	3.5	2.4
N_7	0.3	1.2	3.9	2.8	1.9
SEm (±)	0.02	0.10	0.30	0.23	0.29
CD (P=0.05)	NS	0.32	NS	0.68	NS

Table-3 Effect of nutrient and pest management practices on biomass production of maize

Treatment	Biomass (g m^{-2})				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
N_1	37.35	268.22	700.85	1384.99	1802.02
N_2	36.35	232.94	667.16	1264.18	1531.95
N_3	37.78	287.78	736.29	1434.45	1823.32
N_4	38.76	327.45	755.08	1469.67	1859.99
N_5	36.92	249.28	687.76	1334.40	1665.73
N_6	38.93	333.89	771.88	1498.80	1915.60
N_7	36.05	222.50	636.95	1190.28	1482.54
SEm (±)	0.982	15.80	18.21	44.07	41.93
CD (P=0.05)	NS	48.68	54.83	135.80	129.18

Table-4Effect of nutrient and pest management practices on CGR of maize

Treatment	CGR (g m^{-2} day^{-1})			
	30-60 DAS	60-90 DAS	90-120 DAS	120-Harvesst
N_1	7.70	14.4	22.8	12.6

N_2	6.55	14.5	19.9	10.5
N_3	8.33	15.3	23.2	12.9
N_4	9.62	14.5	23.6	13.1
N_5	7.08	14.6	21.6	11.0
N_6	9.83	14.9	24.2	14.6
N_7	6.22	13.3	18.4	9.7
SEm (±)	0.52	0.6	1.6	1.6
CD (P=0.05)	1.59	NS	4.9	4.8

Table-5 Effect of nutrient and pest management practices on total biomass production and yield of maize

Comment [A1]: be referenced in the text.

Treatment	Total biomass	Stover yield	Grain Yield	Stone Yield	Harvest index (%)
	(kg ha^{-1})				
N_1	18226.67	7050.00	9030.00	2146.67	48.98
N_2	15888.00	6781.33	7313.00	1793.67	48.12
N_3	18538.99	7072.33	9163.33	2303.33	49.20
N_4	18986.00	7123.33	9376.67	2486.00	49.61
N_5	16903.67	6991.00	7903.33	2009.33	48.76
N_6	19538.33	7103.33	9896.67	2538.33	49.65
N_7	15101.67	6766.67	6670.00	1665.00	48.07
SEm (±)	426.04	74.12	88.15	30.31	0.36
CD (P=0.05)	1388.36	228.40	271.62	93.39	NS

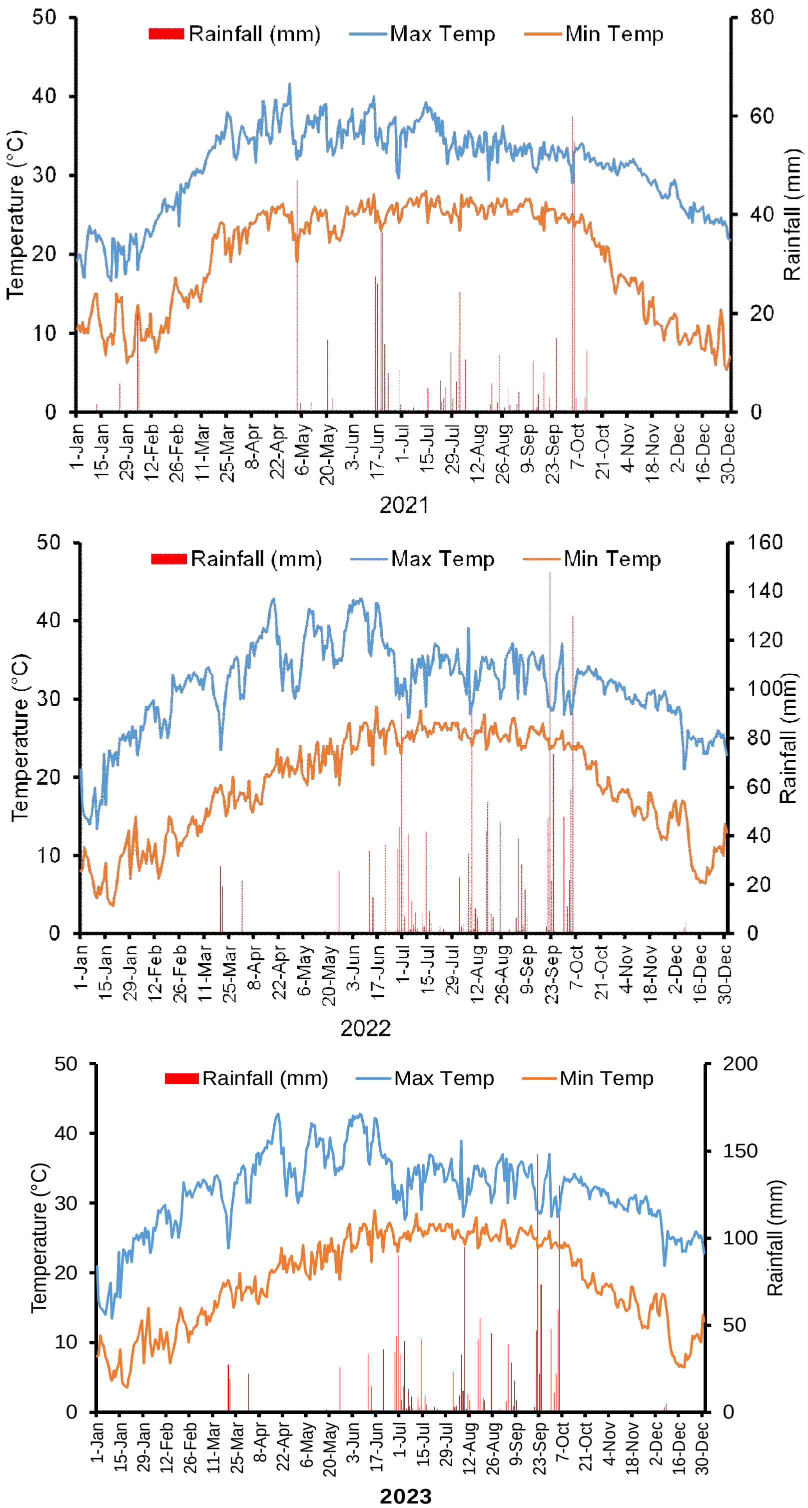

Figure 1. Meteorological data during experimental Years 2021, 2022, 2023

Comment [A2]: be referenced in the text.