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Nutrient concentration and uptake of quality protein maize at different irrigation and nutrient levels in new alluvial zone of West Bengal

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Abstract
The aim of the present study was to evaluate the effect of irrigation and nutrient levels on nutrient concentration in plant and nutrient uptake of quality protein maize. The experiment was conducted during 2017-18 and 2018-19 at Bidhan Chandra Krishi Viswavidyalaya, West Bengal constituting three irrigation schedules *viz.* IW/CPE 0.5 (I_1), IW/CPE 0.75 (I_2) and IW/CPE 1.0 (I_3) in main plots and four nutrient management practices *viz.* control (N_1), 100% RDF (N_2), 75% RDF + 2 t/ha vermicompost (N_3) and 75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$ (N_4) in sub plots. Pooled results revealed that the interaction of IW/CPE 1.0 and 75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$ (I_3N_4) exhibited higher nutrient content of plant; nitrogen, phosphorus and potassium uptake (194.58, 57.19 and 125.98 kg/ha respectively). Therefore, the study concludes that I_3N_4 can be recommended for improving nutrient uptake of QPM in West Bengal.

Keywords: Irrigation, nutrient concentration, nutrient uptake, quality protein maize

1. Introduction

Maize is considered as a promising option for diversifying agriculture in India and it now ranks as the third most important food grain crop in our country. The area under maize has slowly expanded over the past few years and predicted that this area would grow further to meet future food, feed and other demands, especially in view of the booming livestock and poultry producing sectors in the country. To minimize the prevalence and persistence of malnutrition in developing countries, when modified to produce a vitreous endosperm resembling that of conventional maize, maize that contains approximately double the amount of lysine and tryptophan has been named as “quality protein maize” (QPM). QPM is a cheap source of protein, given that farmers can grow, manage, harvest and consume it in the same way they do conventional maize varieties (Vasal, 1999) [12]. With improvements in maize breeding, quality protein maize, a new class of maize was developed at Purdue University, USA, in 1963 which combines the nutritional excellence of Opaque-2 maize (whose protein content is twice that of normal maize) with the kernel structure of conventional maize varieties (Vassal *et al*., 1993) [13]. The potentiality of maize manifested in the form of growth, grain yield and yield attributes, nutrient uptake is remarkably affected by various biotic and abiotic factors, of which irrigation and nutrient management are prime ones. Undoubtedly, being heavy feeder of nutrients and high productivity potential, maize crop requires huge quantity of continuous and assured nutrient supply throughout the growing period from germination to grain filling stage. Thus proper nutrient management for QPM hybrid is important to realize higher yields. On the other hand, soil moisture is the primary factor that limits the crop production, particularly in case of maize grown during *rabi* and *pre-kharif* season. Moreover, water management like improper scheduling, lack of proper drainage *etc*. often leads to reduction in yields. For efficient water management, scheduling of irrigation to the crop should be done on the basis of IW/CPE ratio. Besides, there is a dearth of research on the performance of QPM under influence of different irrigation schedules and nutrient levels in new alluvial zone of West Bengal. Keeping these points in view, a field experiment was conducted with the objective of assessing the impact of irrigation and nutrient levels on nutrient concentration in plant sample as well as nutrient uptake by the QPM plants in West Bengal.

2. Materials and Methods

The field experiment was conducted on quality protein maize during *rabi* seasons (November-March) of 2017-18 and 2018-19 at District Seed Farm, AB Block, Bidhan Chandra Krishi Viswavidyalaya, encompassing the New Alluvial Zone of West Bengal, India. The experimental farm was a gently sloping drainage basin situated at an altitude of 9.75 m above mean sea level and intersected by 22˚93' N latitude, 88˚53' E longitude. As per USDA modern taxonomical classification, the experimental soil was under the order of Entisol and the great group was under Fluvaquents. The texture of the soil belonged to the class sandy loam with medium fertility status which had good drainage capacity. The experiment was laid out in split-plot design with three irrigation treatments in main plots *viz.* IW/CPE 0.5 (I_1), IW/CPE 0.75 (I_2) and IW/CPE 1.0 (I_3) and four nutrient management treatments in sub-plots *viz.* control (N_1), 100% RDF (120: 60: 60 N: P_2O_5: K_2O kg/ha) (N_2), 75% RDF+ 2 t/ha vermicompost (N_3) and 75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$ (N_4), replicated thrice. Irrigation was given based on IW/CPE ratio when cumulative pan evaporation (CPE) from an USWB class A open pan evaporimeter reached to a particular value. The depth of each irrigation was fixed at 5 cm with the help of 'V' notch and the ridge and furrow method of irrigation was followed. Irrigations at IW/CPE 0.5, 0.75 and 1.0 were given when CPE reached 100, 67 and 50 mm respectively if no rain occurred between two irrigations. Fertilizer doses were calculated as per treatment and applied to each plot using urea, single super phosphate (SSP) and muriate of potash (MOP). Entire dose of phosphorus and potassium and 50% recommended dose of nitrogen were applied as basal and remaining 25% N at knee high stage and 25% N at tasseling. $ZnSO_4$ @ 25 kg/ha and vermicompost @ 2 t/ha were given at the time of land preparation. Seed rate used in this experiment for QPM was 20 kg/ha to ensure desired plant population. Row to row spacing was maintained at 45 cm. and plant to plant spacing was adjusted to 20 cm.

2.1 Chemical analysis of plants and plant nutrient uptake

2.1.1 Collection and preparation of plant samples

The grain and straw samples collected at harvest were washed first with tap water followed by distilled water to remove any soil or sand particles sticking to them. Then, the samples were sundried for seven days. After that, the samples were dried in hot air oven at 75 ^{0}C with ventilation to constant weight. The grain and straw samples together were then ground to fine powder and were kept in polythene containers separately with labelling for estimation of total N, P and K concentrations in those samples.

2.1.2 Chemical analysis of plants (after harvest)

a) Nitrogen content (%)

Nitrogen concentration present in the plant sample (grain + straw) was estimated for each treatment separately by Micro Kjeldahl's method (Piper, 1966) [8] and expressed in percentage.

b) Phosphorus content (%)

Phosphorus content of the plant sample (grain + straw) was estimated for each treatment separately by Vanado Molybdate Phosphoric yellow colour method (Jackson, 1973) [4] by using spectrophotometer at 470 nm and finally expressed in percentage.

c) Potassium content (%)

Potassium content present in the plant sample (grain + straw) was estimated for each treatment separately by using Flame Photometer method after making appropriate dilution (Jackson, 1973) [4] and expressed in percentage.

2.1.3 Nutrient uptake

Uptake of nutrient by plant was calculated by multiplying the percentage of concentration of the concerned nutrient present in the plant with its biomass. Uptake of N, P and K were expressed in kg ha^{-1}.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Per cent of nutrient concentration}}{100} \times \text{Biomass}$$

a) Nitrogen uptake (kg/ha)

Nitrogen uptake was calculated by estimating the nitrogen concentration in plant (grain and stover together) of quality protein maize and multiplied by their respective yield and divided by 100. It was expressed in kg/ha.

b) Phosphorus uptake (kg/ha)

It was calculated by estimating the phosphorus concentration in plant parts and multiplied by their respective yield and divided by 100. It was expressed in kg/ha.

c) Potassium uptake (kg/ha)

Potassium uptake was calculated by estimating the potassium concentration in plant (grain and stover together) of quality protein maize and multiplied by their respective yield and divided by 100. It was also expressed in kg/ha

2.1.4 Statistical analysis and interpretation of data

Data obtained on various variables were analyzed by 'Analysis of Variance' method (Panse and Sukhatme, 1967) [7]. The total variance (S^2) and d.f. (n-1) were partitioned into different possible sources. The variance due to replications, crops, irrigation and nutrient levels and their interactions were compared with error variance for finding out 'F' values and ultimately for testing the significance at 5 per cent level (P = 0.05). The tested errors for the treatments based on error variance were calculated. Wherever, the results were found to be significant, critical difference (C.D.) was calculated.

3. Results and Discussion

1. Nitrogen, phosphorus and potassium concentration of QPM plant

It appears from the Table 1 that the nutrient concentration of plant sample varied significantly due to different irrigation regimes. The highest nitrogen, phosphorus and potassium concentration were (0.64%, 0.18% and 0.44%; 0.68%, 0.18% and 0.44% during 2017-18 and 2018-19 respectively) obtained in I_3 (IW/CPE 1.0) treatment and the lowest concentration (0.46%, 0.14% and 0.36%; 0.45%, 0.14% and 0.32% during 2017-18 and 2018-19 respectively) were recorded in I_1 (IW/CPE 0.5). Plants grown under moisture stress by limiting supply of irrigation water under IW/CPE 0.5 had produced lower nutrient concentration over the years, which might be due to the less availability of nutrients from soil solution. Among different levels of nutrients, N_4 (75%

RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$) treatment produced significantly highest nitrogen, phosphorus and potassium concentration (0.62%, 0.19% and 0.43%; 0.63%, 0.19% and 0.43% during 2017-18 and 2018-19 respectively) followed by N_3 (75% RDF+ 2 t/ha vermicompost) and N_1 (Control) recorded the lowest concentration. Application of I_3N_4 treatment (Irrigation at IW/CPE 1.0 with 75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$) recorded maximum nitrogen, phosphorus and potassium concentration *i.e.* 0.73%, 0.22% and 0.47% during 2017-18 and 0.76%, 0.22% and 0.50% during 2018-19 respectively, which was significantly superior to all other treatment combinations. It reflects that more nutrients were available to plants from organically substituted treatments as compared to sole mineral fertilizer and control treatment. It was the result of synergistic effect of organic and inorganic sources on mineralization, moisture conservation and reduction of nutrient losses due to sustained supply of essential nutrients as organic manures improve the activities of microorganisms and increase nutrient use efficiency by improving cation exchange capacity of soil (Gasser, 1964) [3]. Integration of organic and inorganic sources of nutrients increases the NPK concentration in alfalfa, maize and sugarcane (Lioveras *et al*., 2004; Sial *et al*., 2007; Bokhtiar and Sakurai, 2005) [6, 11, 1]. The treatment I_1N_1 (Irrigation at IW/CPE 0.5 with control) recorded the minimum NPK concentration of 0.38%, 0.10% and 0.31% during 2017-18 and 0.36%, 0.10% and 0.26% during 2018-19 respectively. Similar trends were followed in case of all these three nutrient concentrations in pooled data.

2. Nitrogen, phosphorus and potassium uptake and total nutrient uptake

Nutrient uptake is the product of yield and nutrient content, considerable increase in either nutrient content or in yield may increase the uptake. Nitrogen, phosphorus and potassium uptake by plant were recorded and presented in Table 2. It revealed that I_3 (IW/CPE 1.0) provided highest nitrogen uptake by the plants *i.e.* 146.67, 164.73 and 155.70 kg/ha during 2017-18, 2018-19 and pooled respectively whereas minimum values (86.77, 89.82 and 88.29 kg/ha respectively) were encountered with I_1 (IW/CPE 0.5). Application of N_4 (75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$) recorded highest nitrogen uptake (147.09, 157.84 and 152.46 kg/ha respectively). However, N_1 (Control) recorded minimum uptake of this nutrient among all treatments during both the experimental years. The interaction effect of irrigation regimes and nutrient management practices on nutrient uptake was significant. Pooled data exhibited that the maximum value of nitrogen uptake (194.58 kg/ha) was registered under I_3N_4 (Irrigation at IW/CPE 1.0 with 75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$) and treatment I_1N_1 (Irrigation at IW/CPE 0.5 with control) resulted the minimum uptake of 56.60 kg/ha. Same trends were seen in 2017-18 and 2018-19. It has also been reported that the phosphorus and potassium uptake were significantly influenced by irrigation and nutrient levels as stated in Table 2. Both phosphorus and potassium uptake were maximum in case of treatment I_3 where irrigation was scheduled at IW/CPE 1.0 (41.21 and 99.76 kg/ha; 43.65 and 105.97 kg/ha during 2017-18 and 2018-19 respectively). Greater amount of these two parameters were recorded with N_4 (75% RDF + 2 t vermicompost + 25 kg/ha $ZnSO_4$) and significant reduction was observed with nutrient omissions while the poor result was recorded with control. The phosphorus and potassium uptake were significantly higher with the application of irrigation water at IW/CPE 1.0 and fertilized with 75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$ (55.65 and 118.58 kg/ha; 58.73 and 133.39 kg/ha during 2017-18 and 2018-19 respectively) while the lowest contents were noted when the crop received irrigation at IW/CPE 0.5 along with no fertilizer application. The pooled analysis revealed that I_3N_4 (Irrigation at IW/CPE 1.0 with 75% RDF + 2 t vermicompost + 25 kg/ha $ZnSO_4$) achieved the highest values of these parameters and I_1N_1 (Irrigation at IW/CPE 0.5 with control) resulted the minimum phosphorus and potassium uptake. The increased N uptake might be due to increased availability of nitrogen to the crop and higher biomass production. These results are in confirmation with the findings of Karki *et al.* (2005) [5] and Verma *et al.* (2006) [14]. Similar trend was also observed in case of P and K uptake. This increase in uptake of phosphorus and potassium has been attributed to the increase in the availability of phosphorus and potassium in soil due to mineralization of the added organic manures releasing nutrients into available forms as a result of narrowing of C: N ratio with the combined application of both inorganic and organic source of nutrients. Similar results were also reported by Verma *et al.* (2006) [14], Shashidhar *et al.* (2009) [10]. While considering the total nutrient uptake, the highest nutrient uptake was seen in I_3 (IW/CPE 1.0) (287.64, 314.35 and 301.00 kg/ha in 2017-18, 2018-19 and pooled data respectively) followed by I_2 (IW/CPE 0.75). In case of nutrient management practices, the uptake was highest in N_4 (75% RDF + 2 t vermicompost + 25 kg/ha $ZnSO_4$) (292.71, 311.44 and 302.07 kg/ha in 2017-18, 2018-19 and pooled data respectively) followed by N_3 (75% RDF+ 2 t/ha vermicompost). Interaction of irrigation and nutrient levels was significant for total nutrient uptake. It was significantly higher in plants of treatment irrigated at IW/CPE 1.0 and fertilized with 75% RDF + 2 t vermicompost + 25 kg/ha $ZnSO_4$ (I_3N_4) (359.60, 395.89 and 377.75 kg/ha during 2017-18, 2018-19 and pooled data respectively) while I_1N_1 registered the lowest total nutrient uptake.

Table 1: Effect of irrigation and nutrient management on nitrogen, phosphorus and potassium concentration of QPM plant

Treatments	Nitrogen content of plant (%)			Phosphorus content of plant (%)			Potassium content of plant (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Irrigation(I)									
I_1 (IW/CPE 0.5)	0.46	0.45	0.46	0.14	0.14	0.14	0.36	0.32	0.34
I_2 (IW/CPE 0.75)	0.53	0.55	0.54	0.17	0.17	0.17	0.39	0.39	0.39
I_3 (IW/CPE 1.0)	0.64	0.68	0.66	0.18	0.18	0.18	0.44	0.44	0.44
SEm (±)	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00
CD at 5%	0.04	0.05	0.03	0.01	0.02	0.01	0.02	0.03	0.02
Nutrient management (N)									
N_1 (Control)	0.43	0.45	0.44	0.12	0.12	0.12	0.35	0.33	0.34
N_2 (100% RDF)	0.54	0.56	0.55	0.17	0.16	0.16	0.39	0.37	0.38
N_3 (75% RDF+ 2 t/ha	0.58	0.59	0.59	0.18	0.17	0.17	0.41	0.40	0.40

vermicompost)									
N_4 (75% RDF + 2 t vermicompost + 25 kg/ha $ZnSO_4$)	0.62	0.63	0.63	0.19	0.19	0.19	0.43	0.43	0.43
SEm (±)	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
CD at 5%	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Interaction (I × N)									
I_1N_1	0.38	0.36	0.37	0.10	0.10	0.10	0.31	0.26	0.29
I_1N_2	0.45	0.46	0.46	0.15	0.14	0.14	0.36	0.32	0.34
I_1N_3	0.49	0.49	0.49	0.16	0.14	0.15	0.37	0.34	0.36
I_1N_4	0.53	0.51	0.52	0.17	0.16	0.16	0.39	0.36	0.38
I_2N_1	0.42	0.42	0.42	0.12	0.12	0.12	0.36	0.35	0.35
I_2N_2	0.53	0.55	0.54	0.18	0.17	0.17	0.39	0.38	0.39
I_2N_3	0.56	0.58	0.57	0.18	0.18	0.18	0.39	0.40	0.40
I_2N_4	0.60	0.63	0.62	0.19	0.19	0.19	0.42	0.42	0.42
I_3N_1	0.50	0.55	0.53	0.13	0.14	0.14	0.40	0.37	0.38
I_3N_2	0.65	0.68	0.67	0.18	0.17	0.18	0.43	0.42	0.43
I_3N_3	0.68	0.72	0.70	0.19	0.18	0.19	0.46	0.46	0.46
I_3N_4	0.73	0.76	0.75	0.22	0.22	0.22	0.47	0.50	0.48
	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I
SEm (±)	0.01 0.01	0.02 0.02	0.01 0.01	0.01 0.01	0.01 0.01	0.00 0.00	0.01 0.01	0.01 0.01	0.00 0.01
CD at 5%	0.03 0.05	NS NS	0.03 0.04	NS NS	NS NS	0.01 0.01	NS NS	NS NS	0.01 0.02

Table 2: Effect of irrigation and nutrient management on nitrogen, phosphorus and potassium uptake of QPM

Treatments	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Irrigation(I)									
I_1 (IW/CPE 0.5)	86.77	89.82	88.29	26.81	26.86	26.84	66.21	63.50	64.85
I_2 (IW/CPE 0.75)	110.23	120.61	115.42	35.10	36.67	35.89	80.73	84.92	82.82
I_3 (IW/CPE 1.0)	146.67	164.73	155.70	41.21	43.65	42.43	99.76	105.97	102.86
SEm (±)	2.16	3.65	2.12	0.79	1.32	0.77	1.34	1.57	1.03
CD at 5%	8.50	14.32	6.92	3.11	5.17	2.51	5.27	6.16	3.37
Nutrient management (N)									
N_1 (Control)	74.98	83.20	79.09	20.19	22.11	21.15	61.30	60.76	61.03
N_2 (100% RDF)	109.69	121.33	115.51	33.50	34.28	33.89	78.62	80.29	79.46
N_3 (75% RDF+ 2 t/ha vermicompost)	126.47	137.85	132.16	38.24	39.08	38.66	88.97	91.96	90.47
N_4 (75% RDF + 2 t vermicompost + 25 kg/ha $ZnSO_4$)	147.09	157.84	152.46	45.58	47.43	46.51	100.04	106.17	103.10
SEm (±)	1.28	2.08	1.22	0.64	0.83	0.53	0.67	1.11	0.65
CD at 5%	3.80	6.18	3.50	1.92	2.48	1.51	2.00	3.29	1.86
Interaction (I × N)									
I_1N_1	56.19	57.00	56.60	14.79	15.68	15.24	45.41	41.32	43.36
I_1N_2	80.73	86.47	83.60	26.11	25.72	25.91	63.49	60.22	61.85
I_1N_3	96.27	101.54	98.91	30.77	29.93	30.35	73.38	70.43	71.90
I_1N_4	113.87	114.25	114.06	35.58	36.10	35.84	82.57	82.03	82.30
I_2N_1	72.19	77.57	74.88	20.05	21.37	20.71	61.84	63.53	62.68
I_2N_2	104.74	116.85	110.80	35.15	36.39	35.77	76.93	81.90	79.42
I_2N_3	121.97	132.56	127.26	39.70	41.44	40.57	85.18	91.16	88.17
I_2N_4	142.03	155.47	148.75	45.52	47.47	46.49	98.96	103.09	101.03
I_3N_1	96.55	115.03	105.79	25.73	29.27	27.50	76.65	77.42	77.04
I_3N_2	143.60	160.67	152.13	39.23	40.74	39.99	95.45	98.76	97.11
I_3N_3	161.17	179.45	170.31	44.25	45.87	45.06	108.34	114.31	111.33
I_3N_4	185.38	203.78	194.58	55.65	58.73	57.19	118.58	133.39	125.98
	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I	I×N N×I
SEm (±)	2.22 2.89	3.60 4.80	2.12 2.80	1.12 1.25	1.44 1.82	0.91 1.10	1.16 1.68	1.92 2.29	1.12 1.42
CD at 5%	6.59 10.14	10.71 16.91	6.07 8.67	3.32 4.19	4.29 6.31	2.62 3.37	3.46 6.01	5.70 7.82	3.22 4.36

Table 3: Effect of irrigation and nutrient management on total nutrient uptake of QPM

Treatments	Total uptake (kg/ha)		
	2017-18	2018-19	Pooled
Irrigation(I)			
I_1(IW/CPE 0.5)	179.79	180.17	179.98
I_2(IW/CPE 0.75)	226.06	242.21	234.13
I_3(IW/CPE 1.0)	287.64	314.35	301.00
SEm(±)	1.85	4.00	2.21
CD at 5%	7.28	15.72	7.19
Nutrient management (N)			
N_1 (Control)	156.47	166.06	161.27
N_2(100% RDF)	221.81	235.90	228.86

N_3 (75% RDF+ 2 t/ha vermicompost)	253.68	268.90	261.29
N_4 (75% RDF + 2 t vermicompost + 25 kg/ha $ZnSO_4$)	292.71	311.44	302.07
SEm(±)	1.62	2.21	1.37
CD at 5%	4.82	6.57	3.93
Interaction (I × N)			
I_1N_1	116.40	114.00	115.20
I_1N_2	170.32	172.40	171.36
I_1N_3	200.42	201.90	201.16
I_1N_4	232.02	232.38	232.20
I_2N_1	154.08	162.47	158.28
I_2N_2	216.82	235.15	225.99
I_2N_3	246.85	265.16	256.01
I_2N_4	286.51	306.04	296.27
I_3N_1	198.93	221.72	210.32
I_3N_2	278.28	300.16	289.22
I_3N_3	313.76	339.63	326.70
I_3N_4	359.60	395.89	377.75
	I×N N×I	I×N N×I	I×N N×I
SEm(±)	2.81 3.06	3.83 5.20	2.37 3.02
CD at 5%	8.35 10.16	11.38 18.39	6.81 9.28

3. Correlation between biomass yield and nutrient uptake

Determining the fine scale relationship between biomass yield and the concomitant nutrient uptake would provide valuable information on how to optimize cultivation management. In our study, the correlation matrix (Table 4 and 5) showed a significantly very strong positive correlation between biomass yield and nitrogen, phosphorus and potassium uptake as well as total nutrient uptake under different irrigation and nutrient levels in a two year field experiment on QPM suggesting that both the biomass yield and nutrient uptake are increased to a comparable extent simultaneously by improved irrigation scheduling and nutrient management practices. In addition, the nutrient effect seems to be promoted by the irrigation regimes (Ram *et al*., 2013 and Coventry *et al*., 2011) [9, 2], where the soil water is unable to meet the growth demands and irrigation therefore becomes important in terms of yield. The positive correlation between these studied parameters indicates that if biomass yield increases then the nutrient uptake will be increased automatically and even the slight decrease in biomass yield will also cause a reduction in nitrogen, phosphorus and potassium uptake as well as total nutrient uptake.

Table 4: Correlation matrix between biomass yield and nutrient uptake (2017-18)

	Biomass yield	N uptake	P uptake	K uptake	Total uptake
Biomass yield	1				
N uptake	0.98	1			
P uptake	0.98	0.97	1		
K uptake	0.99	0.99	0.97	1	
Total uptake	0.99	1.00	0.98	1.00	1

Table 5: Correlation matrix between biomass yield and nutrient uptake (2018-19)

	Biomass yield	N uptake	P uptake	K uptake	Total uptake
Biomass yield	1				
N uptake	0.97	1			
P uptake	0.98	0.97	1		
K uptake	0.98	0.99	0.98	1	
Total uptake	0.98	1.00	0.98	1.00	1

4. Relationship between biomass yield and nutrient uptake

In order to study the variation in nutrient uptake in relation to biomass yield, relationships between biomass yield and nutrient uptake were developed which showed that the yield showed polynomial relationship with uptake during both the experimentation years. In case of nitrogen, phosphorus and potassium uptake as well as total nutrient uptake during 2017-18, a positive relationship existed between biomass yield and nutrient uptake with 96, 97, 97 and 97 per cent variation (R^2= 0.959, R^2= 0.965, R^2= 0.974 and R^2= 0.974) in nutrient uptake due to biomass yield of QPM.

A linear relationship between biomass yield and nutrient uptake during 2018-19 is presented in the Fig. 2. Thus it was observed that the model was able to explain 94%, 96%, 96% and 96% of the total variation in nitrogen, phosphorus, potassium and total nutrient uptake through a polynomial function. The results obtained from Fig 2 indicate that the relationship involving the biomass yield and nutrient uptake was polynomial and the coefficient of determination (R^2) (R^2= 0.941, R^2= 0.964, R^2= 0.959 and R^2= 0.960) was significant at 1% level of significance. So the model could account for a considerable variability in the nutrient uptake of QPM.

Relationship between biomass yield and nutrient uptake (2017-18)

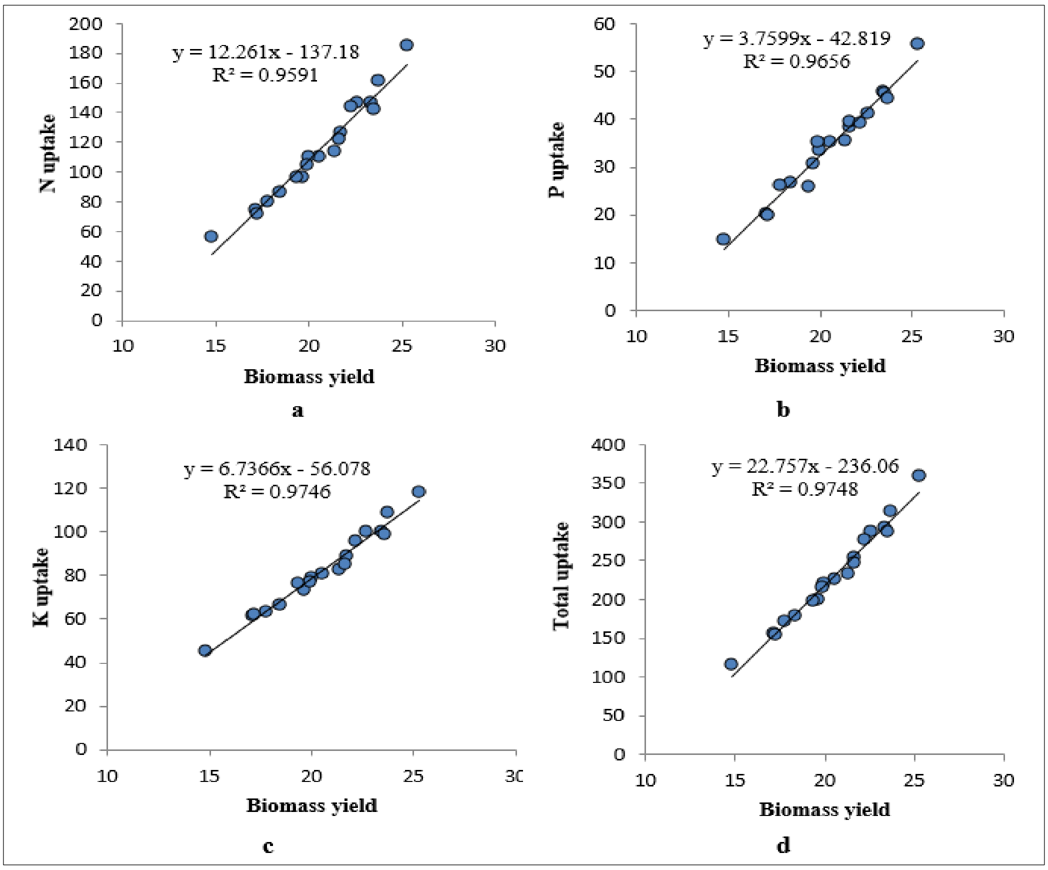

Fig 1: Relationship between biomass yield and nutrient uptake of QPM in 2017-18; a) Nitrogen uptake b) Phosphorus uptake c) Potassium uptake d) Total nutrient uptake

Relationship between biomass yield and nutrient uptake (2018-19)

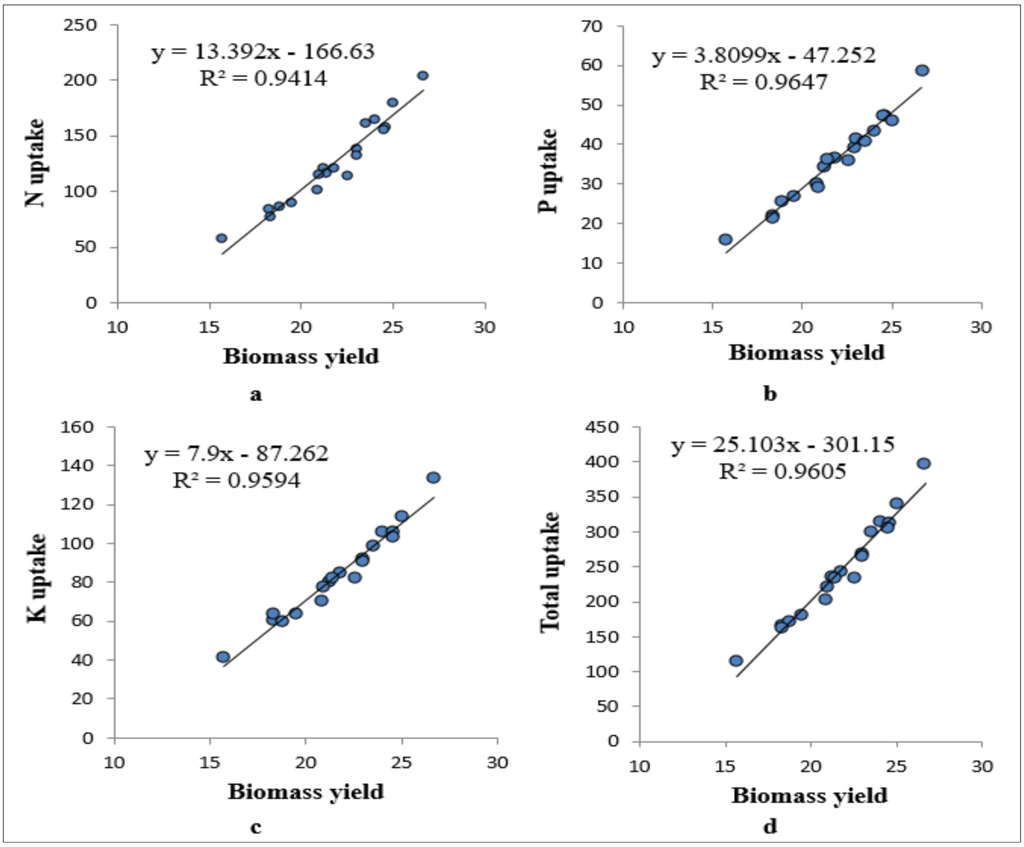

Fig 2: Relationship between biomass yield and nutrient uptake of QPM in 2018-19; a) Nitrogen uptake b) Phosphorus uptake c) Potassium uptake d) Total nutrient uptake

4. Conclusion

Thus the present study indicates the impact of irrigation and nutrient management in explaining the biomass yield and nutrient uptake of QPM. Among irrigation regimes, IW/CPE 1.0 (I_3) showed significantly maximum nutrient concentration in plant sample and nitrogen, phosphorus, potassium uptake as well as total nutrient uptake under different irrigation and nutrient levels in a two year field experiment on QPM. Application of 75% RDF along with 2 t/ha vermicompost and 25 kg/ha $ZnSO_4$ (N_4) excelled other treatments in terms of the above parameters and the interaction of irrigation at IW/CPE 1.0 with 75% RDF + 2 t/ha vermicompost + 25 kg/ha $ZnSO_4$ (I_3N_4) was found superior to other treatment combinations. Finally, keeping the research outcomes in mind, it may be recommended that irrigation scheduling at IW/CPE 1.0 along with the use of 75% RDF + 2 t vermicompost+ 25 kg/ha $ZnSO_4$ can be advocated to the farmers for enhancing the nutrient content as well as nutrient uptake of quality protein maize in new alluvial zone of West Bengal.

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