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Response of fertility level on different inbred line of maize (*Zea Mays* L.) productivity in Bihar

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Abstract
The field experiments were carried out on sandy loam soil at Sabour during *Rabi* season of 2012-13 and 2013-14 to evaluate appropriate fertility levels for promising inbreed of maize. The sandy loam soil of the experimental field was medium in organic carbon (0.56%), low available N (190.5 kg ha^{-1}), and medium in available P_2O_5 (28.3 kg ha^{-1}) and K_2O (165.8 kg ha^{-1}) content, having pH 7.2. The experiments were laid out in split-plot design and replicated thrice with four fertility *viz*. 80:40:20; 120:60:30; 160:80:40, 200:100:50 kg N-P_2O_5-K_2O ha^{-1} in main plots and six inbreed lines of maize *viz*. CML 161, CML 163, BML 6, BML 7, CM 600, VQL 1 in sub plot. The mean data showed that significant grain yield (27.38 q ha^{-1}), stover yield (93.21 q ha^{-1}), net return (Rs125158 ha^{-1}) and B:C ratio (3.15) were obtained with fertility level 160:80:40kg N:P_2O_5:K_2O/ha. Among different inbreed lines BML-6 produce significantly higher yield (32.10 q ha^{-1}), net return (Rs148689 ha^{-1}) and B:C ratio (3.80) which were at par with CML161 (30.76 q/ha, Rs142044 ha^{-1})**.** The uptake (kg ha^{-1}) of N (133.83), P (25.07), K (156.70) were noticed significant upto fertility level 160:80:40kg kg N:P_2O_5:K_2O ha^{-1} but remained at par to fertility level of 200:100:50 kg N-P_2O_5-K_2O ha^{-1}. Inbred line BML 7 removed significantly higher nutrients (kg ha^{-1}) N (144.20), P (27.43), K (174.84) which was comparable to removal by maize in breed lines BML 6 and CML 161. After two crop cycle the organic carbon, available N and K_2O was decline and the magnitude of decrease was less with highest fertility level 200:100:50 kg N:P_2O_5:K_2O/ha applied plots. However, available P_2O_5 was more over its initial values and highest under fertilized with 200:100:50 kg N:P_2O_5:K_2O/ha. Effect of inbred lines was also noticed, organic carbon, available N and K_2O was decline and the magnitude of decrease was less with VQL1. Whereas, available P_2O_5 was more over its initial value and highest with VQL1 due to its lower uptake by plant.

Keywords: Fertility, maize inbreeds, yield, economics, nutrient uptake

1. Introduction
Maize (Zea mays L.) is grown on an area of 9.5 m ha, with production and productivity of 25.0 mt and 26.3 q ha^{-1}, respectively (Anon.2018) in India. Maize assumes a special significance in Indian agriculture on account of its utilization as food, feed, fodder, silage and biochar besides several industrial uses. In India, Maize is grown though out the year under cereal crop due to photo thermal insensitive characters. The productivity of maize affected by various factors including weather and nutrients during winter season. Maize crop is more nutrient exhaustive crop and require balanced proportion of macro and micronutrients for optimum growth and yield potential. The maize inbred lines are also requiring high dose of nutrition for potential yield. Maize is an exhaustive crop requires a regulated and assured supply of nutrients particularly nitrogen throughout its growing period right from seedling stage to grain filling stage. Demand of plants for nitrogen is more than any other nutrient and it is noticed that its

deficiency at any stage of growth, especially at tasseling and silking stage, may lead to small, shriveled grains and virtual crop failure. Nitrogen deficiency is characterized by stunted and spindly plant growth with yellowing of green foliage particularly the lower leaves. Phosphorus is a fascinating plant nutrient. It is involved in a wide range of plant processes from permitting cell division to the development of a good root system and for ensuring timely and uniform ripening of the crop. It is most needed by young fast-growing tissues and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrates. In maize crop, phosphorus helps in development of all phases. It shows its deficiency mainly at the seedling stage, though it is needed most after flowering stage. In the recent years, maize hybrids are more popular among farmers due to its high yield potentials. For hybrid seed production, inbred lines of maize are essential. But the information on agronomic practices including balance fertilization is still scanty for inbred of maize. Keeping the above point in views an experiment was conducted to find out optimum fertility level for different inbred of maize in Bihar.

2. Material and Methods

The field experiments were carried out at Research farm, Bihar Agricultural University, Sabour during *Rabi* season of 2012-13 and 2013-14 to evaluate appropriate fertility levels for promising inbreed of maize. The sandy loam soil of the experimental field was medium in organic carbon (0.56%), low available N (190.5 kg ha^{-1}), and medium in available P_2O_5 (28.3 kg ha^{-1}) and K_2O (165.8 kg ha^{-1}) content, having pH 7.2. The experiments were laid out in split-plot design and replicated thrice with four fertility *viz*. 80:40:20; 120:60:30; 160:80:40, 200:100:50 kg N-P_2O_5-K_2O ha^{-1} in main plots and six inbreed lines of maize *viz*. CML 161, CML 163, BML 6, BML 7, CM 600, VQL 1 in sub plot. The different inbred of maize was sown on 2nd week of December of year 2012 and 2013 on levelled soil by opening 5 cm deep furrow at 60 cm x 20cm spacing. The different doses of fertilizers were applied as per the treatments. Full amount of phosphatic and potassic fertilizer, zinc and half amount of nitrogenous fertilizer were applied as uniformly as possible before sowing. The rest half of the nitrogenous fertilizer was applied as top dressing during the time of earthing up and detasseling stage. The field was kept free from weeds. Harvesting of corn was done at brown husk stage of cob by leaving border rows.

3. Results and Discussion

3.1 Effect of fertility on growth characters of maize inbred

Fertility level, F_3 (160:80:40 kgN:P_2O_5:K_2O ha^{-1}) recorded significant higher values of growth characters (plant height, and dry matter accumulation) but remained at par to fertility level F_4 (200:100:50 kgN:P_2O_5:K_2O ha^{-1}). Irrespective of variation in the level of fertility, balance application of N, P and K enables the crop to produce taller plants and more number of active leaves which ultimately caused more dry matter accumulation. The higher level of fertility accomplished the requirement of balanced maize nutrition and caused rapid division and elongation of cells that resulted in improvement in plant height. Similar effect of fertility levels on plant height were reported by Rafiq *et al*., (2010) and Dadarwal *et al.*, (2009) [2, 6].

It is obvious from data that inbred of maize caused significant effect on growth characters (plant height, and dry matter accumulation). Tallest plant was noticed with maize inbred BML7 (180 cm). Similarly significantly higher dry matter accumulation was observed with maize inbred BML7 (128.5g $plant^{-1}$). This is due to genetic morphology of the inbred line.

3.2 Effect of fertility on yield attributes and yield of maize inbred

Fertility level had improved yield attributes *i.e*, cob length, cob weight (g) $plant^{-1}$, number of grains cob^{-1}, grain yield (q ha^{-1}) and green fodder yield (q ha^{-1}) with successive increase in fertility level up to maximum level of fertility F_4 (200-100-50). However, the significant increase in cob length (15.38 cm), number of grains cob^{-1} (237) was notice upto F_2 (120-60-30) and further increase in fertility level resulted atpar values. Cob weight (g) was significantly increased with F_3 (160-80-40) and remained comparable to fertility level F_4 (200-100-50). That might be due to better supply of nutrients which led to the better plant height, more number of green leaves, and significant dry matter accumulation. All such improvement in growth parameter reflected profound growth and development and finely resulted insignificant increase in yield attributes of inbreds of maize. (Singh and Choudhary, 2008) [7]. Significant grain yield (27.38 q ha^{-1}) and stover yield (93.21 q ha^{-1}), were obtained with fertility level 160:80:40 kg N:P_2O_5:K_2O ha^{-1} which was remained comparable with higher fertility level 200-100-50 kg N:P_2O_5:K_2O ha^{-1}. This was attributed due to higher yield attributes *i.e*, cob length, cob weight (g) $plant^{-1}$, number of grains cob^{-1} with increase in fertility level, caused balance nutrition to the crop and finally resulted in higher yield (Singh and Choudhary, 2008) [7] of maize. This may probably be attributed to NPK being part of the essential nutrients required for the promotion of the meristematic and physiological activities such as plant leaf spread, root development, plant dry matter production etc leading to an efficient absorption and translocation of water and nutrients, interception of solar radiation and assimilation of carbon dioxide. These activities promote higher photosynthetic activities leading to the production of enough assimilate for subsequent translocation to various sink and hence the production of higher yield and yield component of maize. Namakha *et al*. (2008) [5] 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 it is integral part of protein the building blocks of maize plant.

The maize inbred differed in yield attributes and yield potential due to its genetic characteristics. Significantly longer cob (18.17cm) and higher cob weight (105.78g) were observed with BML 6 inbred line over rest of the inbred lines of maize. Significantly more numbers of grains cob^{-1} (257.5) was observed with BML 6 inbred line but atpar with inbred BML7 (248 grains cob^{-1}). BML 7 produced significantly higher test weight (202 g) which remained comparable to inbred BML 6 (197.5). This is due to bold seed of inbred BML 7. Different inbreed lines, BML-6 produce significantly higher yield (32.10 q ha^{-1}) over rest of the maize inbred. This was attributed due to higher yield attributes *i.e*, cob length, cob weight (g) $plant^{-1}$, number of grains cob^{-1} and finally resulted in higher grain yield. Whereas, BML-7 produce significantly higher stover yield (102.68 q ha^{-1}) over rest of the maize inbred. This was attributed due to higher growth attributes *i.e*, plant height and dry weight $plant^{-1}$ and finally resulted in higher stover yield.

3.3 Effect of fertility on economics of maize inbred

Increase in fertility level upto F_3 (160-80-40) significantly fetched higher net returns (Rs 125158 ha^{-1}) and B:C ratio (3.15) but remained comparable with further increase as

F_4(200-100-50). This was attributed due to higher yield attributes *i.e*, cob length, cob weight (g) plant^{-1}, number of grains cob^{-1}, higher grain and stover yield. Similar finding was repoted by Kumar *et. al*., (2014) [3] that yield of cob, corn and green fodder besides gross return, net return and benefit cost ratio increased significantly with application of 125% RDF.

Among different inbreed lines BML-6 produce significantly higher net return (Rs148689 ha^{-1}) and B:C ratio (3.80) which were superior over rest of the inbred of maize. This was happened due to higher yield attributes *i.e*, cob length, cob weight (g) plant^{-1}, number of grains cob^{-1}, higher grain yield of BML 6 resulted in higher economics.

3.4 Effect of fertility and maize inbred on nutrients uptake

The uptake (kg ha^{-1}) of N (133.83), P (25.07), K (156.70) were noticed significant upto fertility level 160:80:40kg kg N:P_2O_5:K_2O ha^{-1} but remained at par to fertility level of 200:100:50 kg N-P_2O_5-K_2O ha^{-1}. This was attributed due to higher grain and stover yield resulted in higher removal of nutrient from soil. Similar trend was observed by Wasnik, *et al*, (2012) [8].

Inbred line BML 7 removed significantly higher nutrients (kg ha^{-1}) N (144.20), P (27.43), K (174.84) which was comparable to removal by maize in breed lines BML 6 and CML 161. This was attributed due longer duration of crop and due to higher grain and stover yield resulted in higher removal of nutrient from soil.

3.5 Effect of fertility and maize inbred on soil nutrients status

After harvesting of 2nd year crop, it was observed that the organic carbon, available N and K_2O was decline over its initial values and the magnitude of decrease was less with highest fertility level 200:100:50 kg N:P_2O_5:K_2O ha^{-1} applied plots. However, available P_2O_5 was more over its initial values and highest under fertilized with 200:100:50 kg N:P_2O_5:K_2O/ha.

Effect of inbred lines was also noticed, organic carbon, available N and K_2O was decline and the magnitude of decrease was less with VQL1. Whereas, available P_2O_5 was more over its initial value and highest with VQL1 due to its lower uptake by plant.

Table 1: Effect of fertility levels on growth characters of different inbred lines of Rabi maize

Treatments	Plant height (cm)			Dry weight plant^{-1}(g)			Maturity (days)			Cob length (cm)		
	2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean
Fertility Levels (N, P_2O_5, K_2O kg ha^{-1})												
F_1 (80-40-20)	138.9	135.7	137.3	105.17	101.50	103.34	117	116	116.5	15.01	14.55	14.78
F_2 (120-60-30)	154.4	152.1	153.2	107.00	103.17	105.09	119	118	118.5	15.69	15.06	15.38
F_3 (160-80-40)	161.7	159.3	160.5	114.73	110.94	112.84	120	119	119.5	16.45	15.88	16.17
F_4 (200-100-50)	167.7	164.4	166.1	119.86	116.34	118.10	122	121	121.5	16.76	16.2	16.48
S Em ±	4.9	4.8	4.8	2.84	2.76	2.80	4	4	4	0.45	0.43	0.44
CD (P=0.05)	16.9	16.6	16.7	9.84	9.54	9.69	NS	NS	NS	1.54	1.49	1.52
Inbred lines												
V_1: CML 161	157.8	156.4	157.1	110.53	105.98	108.26	122	120	121	17.08	15.68	16.38
V_2: CML 163	164.8	161.5	163.2	113.13	109.62	111.38	124	123	123.5	16	15.12	15.56
V_3: BML 6	150.3	147.3	148.8	123.71	120.19	121.95	125	124	124.5	18.41	17.93	18.17
V_4: BML 7	181.5	177.9	179.7	130.80	126.14	128.47	124	123	123.5	17.14	16.8	16.97
V_5: CM 600	147.1	144.0	145.5	97.36	94.34	95.85	115	113	114	14.86	14.56	14.71
V_6: VQL 1	132.7	130.1	131.3	94.60	91.66	93.13	109	107	108	12.38	12.43	12.41
S Em ±	4.2	4.1	4.2	2.88	2.78	2.83	3	3	3	0.38	0.37	0.38
CD (P=0.05)	12.1	11.8	11.9	8.22	7.93	8.08	9	8	8.5	1.10	1.07	1.09

Table 2: Effect of fertility levels on yield attributes of different inbred lines of Rabi maize.

Treatments	Cob weight(g)			No of grains/cob			Test weight (g)		
	2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean
Fertility Levels (N, P_2O_5, K_2O kg ha^{-1})									
F_1 (80-40-20)	69.75	65.04	67.40	214	199	206.50	180.38	178.17	179.28
F_2 (120-60-30)	79.90	74.15	77.03	245	229	237.00	182.44	181.13	181.79
F_3 (160-80-40)	96.66	90.33	93.50	255	239	247.00	185.69	185.83	185.76
F_4 (200-100-50)	106.17	99.37	102.77	260	243	251.50	188.68	186.33	187.51
S Em ±	3.03	2.83	2.93	7	6	6.50	5.25	5.21	5.23
CD (P=0.05)	10.49	9.80	10.15	24	22	23.00	NS	NS	NS
Inbred lines									
V_1: CML 161	86.00	79.19	82.60	248	232	240	184.75	185.75	185.25
V_2: CML 163	80.61	75.55	78.08	244	229	236.5	185.00	184.00	184.50
V_3: BML 6	109.61	101.94	105.78	266	249	257.5	199.13	195.75	197.44
V_4: BML 7	100.03	93.75	96.89	256	240	248	201.75	202.25	202.01
V_5: CM 600	72.84	68.27	70.56	230	215	222.5	188.25	184.50	186.37
V_6: VQL 1	79.64	74.64	77.14	217	200	208.5	146.92	144.95	145.94
S Em ±	2.27	2.12	2.20	6	6	6	4.52	4.50	4.51
CD (P=0.05)	6.49	6.05	6.27	17	16	16.5	12.90	12.85	12.87

Table 3: Effect of fertility levels on yield and economics of inbred lines of Rabi maize.

Treatments	Grain yield (q/ha)			Stover yield (q/ha)			Net return (Rs /ha)			B:C ratio		
	2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean
Fertility Levels (N, P_2O_5, K_2O kg ha^{-1})												
F_1 (80-40-20)	24.01	21.07	22.54	81.13	76.85	78.99	108260	92315	100288	3.00	2.56	2.78
F_2 (120-60-30)	27.51	23.73	25.62	90.95	85.30	88.13	125620	105018	115319	3.20	2.68	2.94
F_3 (160-80-40)	29.17	25.58	27.38	96.38	90.04	93.21	135089	115227	125158	3.40	2.90	3.15
F_4 (200-100-50)	29.97	26.34	28.16	99.72	92.85	96.29	138297	118085	128191	3.33	2.85	3.09
S Em ±	0.54	0.47	0.51	2.66	2.47	2.57	3242	2871	3057	0.11	0.10	0.11
CD (P=0.05)	1.85	1.62	1.74	9.21	8.54	8.88	11219	9933	10576	0.38	0.32	0.35
Maize Inbred lines												
V_1: CML 161	32.80	28.71	30.76	95.18	87.46	91.32	153427	130661	142044	3.92	3.34	3.63
V_2: CML 163	26.59	23.07	24.83	95.38	89.89	92.64	122457	103202	112830	3.13	2.63	2.88
V_3: BML 6	34.41	29.78	32.10	93.79	88.39	91.09	161074	136303	148689	4.11	3.48	3.80
V_4: BML 7	29.67	26.11	27.89	106.06	99.29	102.68	141034	121204	131119	3.60	3.09	3.35
V_5: CM 600	21.66	19.06	20.36	85.07	80.17	82.62	94715	80246	87481	2.41	2.04	2.23
V_6: VQL 1	20.86	18.35	19.61	76.79	72.36	74.58	88192	74351	81272	2.25	1.89	2.07
S Em ±	0.47	0.41	0.44	2.28	2.13	2.21	2833	2505	2669	0.10	0.09	0.10
CD (P=0.05)	1.34	1.18	1.26	6.52	6.09	6.31	8095	7158	7627	0.29	0.26	0.28

Table 4: Effect of fertility levels on nutrients uptake (kg/ha) of different inbred lines of Rabi maize

Treatment	Total N (kg/ha)			Total P (kg/ha)			Total K (kg/ha)			Soil nutrients status (kg/ha) after 2nd year			
	2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean	OC%	N	P_2O_5	K_2O
Fertility Levels (N, P_2O_5, K_2O kg ha^{-1})													
F_1 (80-40-20)	114.51	108.58	111.55	19.69	18.47	19.08	120.21	113.66	116.94	0.45	173.15	31.29	152.76
F_2 (120-60-30)	129.57	121.45	125.51	23.80	22.07	22.94	147.14	137.67	142.41	0.47	174.07	31.15	153.16
F_3 (160-80-40)	138.02	129.64	133.83	25.98	24.15	25.07	162.11	151.28	156.70	0.47	176.76	33.39	155.52
F_4 (200-100-50)	142.90	134.00	138.45	27.37	25.40	26.39	170.79	158.89	164.84	0.48	177.67	33.41	160.51
S Em ±	3.39	3.17	3.28	1.03	0.95	0.99	6.74	6.26	6.50	0.01	3.82	1.01	2.64
CD (P=0.05)	11.71	10.98	11.35	3.56	3.29	3.43	23.33	21.65	22.49	0.04	13.21	3.50	9.12
Maize Inbred lines													
V_1: CML 161	142.63	132.55	137.59	26.21	24.07	25.14	156.22	143.46	149.84	0.47	180.23	32.22	156.73
V_2: CML 163	130.62	123.07	126.85	23.80	22.20	23.00	149.91	140.99	145.45	0.48	179.51	33.26	157.82
V_3: BML 6	143.48	134.95	139.22	27.55	25.59	26.57	161.94	152.13	157.04	0.46	171.07	31.23	154.33
V_4: BML 7	148.59	139.81	144.20	28.41	26.45	27.43	180.76	168.91	174.84	0.46	169.68	30.91	153.05
V_5: CM 600	115.23	108.96	112.10	20.14	18.86	19.50	130.30	122.64	126.47	0.47	173.32	32.15	154.64
V_6: VQL 1	106.94	101.15	104.05	19.17	17.95	18.56	121.25	114.11	117.68	0.47	178.64	34.11	156.35
S Em ±	2.94	2.76	2.85	0.87	0.81	0.84	5.31	4.95	5.13	0.01	3.12	0.73	2.19
CD (P=0.05)	8.40	7.89	8.15	2.50	2.32	2.41	15.18	14.15	14.67	0.02	8.93	2.10	6.26
Initial status										0.56	190.50	28.31	165.80

4. Conclusion

It can be concluded that fertility level 160:80:40kg $N:P_2O_5:K_2O$/ha was found optimum for higher yield and economics of maize inbred whereas, Inbred line BML-6 fetched highest yield and economics.

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