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Response of fertility gradients with FYM levels on yield, quality parameters and economics of Maize

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Abstract
A field experiment was carried out during *Kharif* season 2015 taking maize (variety Ganga Kaveri 41-19) to study the Influence of Fertility gradients and FYM levels on growth, productivity and quality parameters of Maize. The experiment was laid out with different Nine treatment combinations of 3 fertility gradients (L_1: 60 N: 40 P_2O_5 : 30 K_2O kg ha^{-1}, L_2: 120 N : 80 P_2O_5 : 60 K_2O kg ha^{-1} and L_3: 240 N, 160 P_2O_5,120 K_2O kg ha^{-1}) with 3 FYM level (F_0: 0 t FYM ha^{-1}, F_1: 5 t FYM ha^{-1} and F_2: 10 t FYM ha^{-1}) was laid in factorial randomized block design consisted of nine combinations (L_1F_0, L_1F_1, L_1F_2, L_2F_0, L_2F_1, L_2F_2, L_3F_0, L_3F_1, L_3F_2) followed under optimum agronomic management practices with three replications. Result revealed that the Significant effect of different treatment on yield attributing characters the highest value of cob length (14.96, 14.01 cm) and girth (13.99, 13.03 cm), number of grains $line^{-1}$ of cob (21.90, 21.10), number of lines cob^{-1} (13.30, 12.90), numbers of grain cob^{-1} (288.70, 272.60), grain weight cob^{-1} (58.54, 53.28 g), test weight (202.25, 193.98 g) and harvest index (22.93, 22.63%) was observed in treatment L_3 : (240:160:120; N:P_2O_5:K_2O kg ha^{-1}) and F_2 (10 t FYM ha^{-1}) respectively and lowest value was observed in treatment L_1 : (60:40:30; N:P_2O_5:K_2O kg ha^{-1}) and F_0 (0 t FYM ha^{-1}). Similarly significant effect of different treatment combinations highest values of cob length (15.71 cm) and girth (15.71 cm), number of grains $line^{-1}$ of cob (22.2), number of lines cob^{-1} (13.7), numbers of grain cob^{-1} (303.7), grain weight cob^{-1} (64.18 g), test weight (211.35 g) and harvest index (23.11%) were obtained in treatment combinations L_3F_2 :(240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}).The lowest value of cob length (11.20cm) and girth (9.39 cm), number of grains $line^{-1}$ of cob (18.4), number of lines cob^{-1} (10.9), numbers of grain cob^{-1} (201.8), grain weight cob^{-1} (31.48 g), test weight (155.95 g) and harvest index (21.61%) were obtained in treatment combinations L_1F_0 :(60:40:30; N:P_2O_5:K_2O kg ha^{-1} + 0 t FYM ha^{-1}). The yield of maize grain and stover was affected significantly due to various treatment combinations. The highest yield of grain and stover was recorded in combinations L_3F_2 where higher dose of fertilizer was applied (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) yielding 3387 kg ha^{-1} and 11317 kg ha^{-1}, respectively. The lowest yield of grain and stover was recorded in combinations L_1F_0 where lower dose of fertilizer was applied L_1F_0 (60:40:30; N:P_2O_5:K_2O kg ha^{-1} + 0 t FYM ha^{-1}) yielding 2167kg ha^{-1} and 7863 kg ha^{-1}, respectively. The significant effect of the treatment on crop quality parameters with higher application of fertilizers with FYM in treatment combination L_3F_2 (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) improved the grain protein (10.94%) and starch content (66.73 g/100g). However, integrated application of fertilizer with organic manure noticed remarkable maximum protein and starch content in maize. As regards economic viability with different treatment combinations of fertilizer levels with FYM levels significantly affected the maximum cost of cultivation and GMR (58735, 55360 Rs ha^{-1} respectively) having recorded in treatment combination L_3F_2, but highest value of NMR (12100 Rs ha^{-1}) was found in treatment combination L_3F_0 followed by L_2F_0 and highest B:C ratio was recorded in same treatment combination L_3F_0 (1.30).

Keywords: Fertility gradients, yield attributes, integrated fertilization, quality productivity, economics

Introduction
Maize (*Zea maize* L.*)* is the most important cereal crop grown throughout the world because it's high yield potential it is called "queen of cereal". In India, maize occupies the third place among the cereals after wheat and rice. Maize is cultivated in 9.43 million hectare with annual production of 24.35 million tones having average productivity of 25.83 q ha^{-1} (Agriculture statistical at a glance, 2014) [1]. Nutritionally it contains 60 to 68% starch and 7 to 15% protein, also it has more riboflavin content than wheat or rice crop and is rich in phosphorous and potash content.

Continuous application of chemical fertilizers in the absence of adequate organic manures have effected soil health, while sole use of organic manures without augmentation of inorganic

fertilizers may not be able to meet the high nutrient requirement of crop in bulk due to low nutrient content and slow acting nature. Integrated nutrient management, which includes potential source of nutrient like chemical fertilizer, bulky manures could help in mitigating these problems to some extent (Dhaliwal *et al*., 2007) [4]. It also plays an important role in sustainable agriculture by maintaining the productivity of crop in cereals based cropping sequences. Therefore, combination of organic manure with inorganic fertilizer may be beneficial to maximize the crop productivity and improve the soil properties. However, systematic study needs to develop package of practices for adoption of integrated nutrient management under agro-ecosystem of Madhya Pradesh. One of the reasons for lower production is imbalanced use of fertilizer by the farmers without knowing soil fertility status and nutrient requirement of crops causing adverse effect on soil health and crop growth, both in term of nutrient toxicity and deficiency.

Intensive cultivation of maize has caused considerable damage to the environment and natural resources including build-up of salinity or alkalinity, water logging, water pollution, depletion of groundwater and health hazards due to excessive use of agro chemicals and pesticides and release of higher methane gas to the environment. This has forced the farmers, scientists and policy makers to adopt integrated nutrient management approach to maize.

The organic sources besides supplying N, P and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate to plant to absorb the nutrients. But, it is also the fact that optimum yield level of maize production can't be achieved by using only organic manures because of their low nutrient content. Efficacy of organic sources to meet the nutrient requirement of crop is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long-term basis. Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers (Chandrashekara *et al*., 2000) [3].

Materials and methods

The present investigation entitled Influence of Fertility gradients and FYM levels on growth, productivity and quality parameters of maize was conducted during Kharif 2015 at the Research Farm of the Department of Soil Science and Agricultural chemistry Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (India) under the ongoing program of AICR Project on STCR. Jabalpur is situated in the south-eastern part of Madhya Pradesh at 23^0 13' North latitude, 79^0 57' East longitudes at an altitude of 393 meter above Mean Sea Level. Experimental field was fertile with even topography. The field had proper drainage facility in order to remove excess irrigated water during experimentation.

The experiment was undertaken with nine treatment combinations of 3 fertility gradients (L_1: 60 N: 40 P_2O_5 : 30 K_2O kg ha^{-1}, L_2: 120 N : 80 P_2O_5 : 60 K_2O kg ha^{-1} and L_3: 240 N, 160 P_2O_5,120 K_2O kg ha^{-1}) with 3 FYM level (F_0: 0 t FYM ha^{-1}, F_1: 5 t FYM ha^{-1} and F_2: 10 t FYM ha^{-1}) was laid in factorial randomized block design consisted of nine combinations (L_1F_0, L_1F_1, L_1F_2, L_2F_0, L_2F_1, L_2F_2, L_3F_0, L_3F_1, L_3F_2) followed under optimum agronomic management practices with three replications.

The experiment was conducted on Vertisols belonging to fine montmorillonite, Hypothermic family of *Typic Haplusterts with* pH 7.32, EC 0.247 dS $m^{-1,}$ organic carbon 4.93 g kg^{-1} and available N, P and K were 163.12, 17.53 and 385.51 kg ha^{-1}, respectively. The sowing of maize (cv. Ganga Kaveri 4119) seeds was done at a spacing of 45 × 20 cm in 10 m x 5 m plot size. The calculated amount of Farm yard manure (FYM) as per the treatment was applied and mixed thoroughly in the soil in well- prepared plot, one month before sowing. As per the treatments specification all the doses of phosphorus (P_2O_5) as single super phosphate and potash (K_2O) as muriate of potash were applied as basal dose during field preparation whereas half dose of nitrogen as urea was applied at the time of sowing and remaining half amount of nitrogen was top dressed in two equal split doses at 30 days and 55 days after sowing (DAS). The crop was irrigated as per requirements of crop and other culture practices were done one time weed control by hand weeding. The days of 50 percent tasseling and silking and yield attributing characters (cob length and girth, number of grains $line^{-1}$ of cob, number of lines cob^{-1}, numbers of grain cob^{-1}, grain weight cob^{-1}, test weight and harvest index) were recorded at maturity of crop. The quality parameter and yield of grain and stover were recorded after harvesting of crop. The economics of the treatment combinations was calculated on the basis of prevailing market price of the input and output the data of different parameters were statistically analysed as per procedure given by Gomez and Gomez, (1984) [6].

Results and discussion

Days to 50% tasseling and silking

It is evident from the data that there was marked significant difference in days to flowering of various treatments at days to 50% tasseling and 50% silking. The minimum days to flowering (50% tasseling and 50% silking) were obtained with treatment L_3 (240:160:120; N:P_2O_5:K_2O kg ha^{-1}) over L_1 and L_2. Similarly FYM levels F_2 (10 t FYM ha^{-1}) was recorded early flowering over other FYM levels and treatment combination L_3F_2 (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) was recorded early 50% tasseling and silking over control. High dose of fertilizers with FYM was recorded early flowering as compare low dose of fertilizers. Similar finding was reported by Samsul *et al* (2012) [21].

Yield attributing characters

Data on Cob length, Cob girth, Grain weight $cob^{-1}$and test weight (g) affected by different fertilizers level applied with FYM levels are presented in Table 2 and 4.

It was evident from the data presented in table 2, 3 that having recorded maximum cob length of 14.96 cm, girth 13.99 cm, number of grains per line of cob 29.1, number of line per cob 13.9 and number of grains per cob 288.7 due to L_3 fertilizer level as compare to L_1 and L_2. Similarly the maximum cob length (14.01 cm) and girth (13.03 cm), number of grains per line of cob (21.1), number of line per cob (12.9) and number of grains per cob (272.6) recorded in F_2 FYM levels was applied over the rest of FYM levels.

The effect of interaction between fertilizer levels with FYM levels on cob length and cob girth was recorded significant over control. The maximum cob length and girth recorded (15.71 and 14.45 cm) in treatment combination L_3F_2 followed by L_3F_1 as compare to control (L_1F_0). But overall average performance of treatment combinations was encouraging over control and it was 28.70 and 35.01% respectively. The treatment combination L_3F_2 was recorded maximum number

of grains per line of cob, number of lines per cob number of grains per con and grain weight per cob (22.15, 13.71, 272.61 and 64.18 (g) respectively followed by L_3F_1 as compare to other treatment combinations. Average response of treatment combination was 16%, 20.13%, 33.53% and 50.95% respectively higher over control (L_1F_0). Highest Test weight was recorded in treatment combination L_3F_2 followed by L_3F_1 While lowest test weight was recorded in control (L_1F_0). Similar finding was reported by Panwar (2008) [17], Ravi *et al* (2012) [19], Gul *et al* (2015) [7], Singh *et al* (2010) [22], Kannan *et al* (2013) [10] and Khidrapure *et al* (2015) [11].

Grain and stover yields and harvest index

The data on grain and stover yields of maize are presented in Table 5. The highest grain yield of 3232 kg ha^{-1} and stover yields 10873 kg ha^{-1} was recorded with L_3 (240:160:120; N:P_2O_5:K_2O kg ha^{-1}) fertility which was statistically at par to L_2 and both were significantly superior to L_0 (control). Similarly highest grain yield of 3070 kg ha^{-1} and stover yields 10496 kg ha^{-1} with 10 t FYM ha^{-1} level was obtained as compare to other FYM levels.

The different treatment combinations have affected the crop yield significantly. Minimum grain yield was recorded with treatment combination L_1F_0 (control) 2167 kg ha^{-1}. While maximum grain yield was recorded with treatment combination L_3F_2; (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) 3387 kg ha^{-1}. This was containing higher dose of fertilizer with FYM. Minimum stover yield was recorded with (L_1F_0) 1863 kg ha^{-1} While maximum stover yield was recorded with treatment combination L_3F_2 11317 kg ha^{-1}. All treatment combinations yielded numerically better grain and stover yields as compare to control except L_1F_1 L_1F_2 and L_2F_0. Average increase in grain and stover yield due to higher dose of fertilizer with FYM (L_3F_2) was 36.02 and 30.52% respectively higher over control. Harvest index was non-significant. Not a single treatment combination was able to contribute statistically significant result over control. The highest harvest index was recorded in treatment combination L_3F_2 (23.11%) followed by L_3F_1 as compare to control. Similar finding was reported that Chandrasheker *et al* (2000) [3], Brar *et al* (2001) [2], Wagh *et al* (2002) [23], Gour and Kumawat (2004) [5] Kannan *et al* (2013) [10], Gul *et al* (2015) [7].

Protein and starch contain in grain

The data presented in table 6. On perusal of the data it revealed that application of fertilizer at higher level with L_3 (240:160:120; N:P_2O_5:K_2O kg ha^{-1}) was recorded maximum value of protein and starch content over control (L_0). Similarly the highest protein and starch content was recorded with F_2 (10 t FYM ha^{-1}) over to F_0.

Protein and starch is the major constituent contributing to the quality of any crop. The supply of balance nutrient to the growing plant influenced the protein and starch metabolism. Protein and starch in grain (10.94 and 66.73%) was higher recorded under treatment combination L_3F_2 which was containing higher dose of fertilizers with FYM. While minimum (9.75 and 61.77%) was recorded with control (L_1F_0). Similar finding reported that Singh *et al* (2010), Jat *et al*. (2013) [9], Wagh *et al* (2002) [23] and Kumar (2014) [13].

Economic

As regards economic viability with different treatment combinations of fertilizer levels with FYM levels significantly affected the maximum cost of cultivation and GMR (58735, 55360 Rs ha^{-1} respectively) having recorded in treatment combination L_3F_2,; (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) but highest value of NMR (12100 Rs ha^{-1}) was found in treatment combination L_3F_0 followed by L_2F_0 and highest B:C ratio was recorded in same treatment combination L_3F_0; (240:160:120; N:P_2O_5:K_2O kg ha^{-1}) (1.30). Similar finding was reported that by Kalhapure *et al* (2013) [11], Singh *et al* (2010) [22], Ravi *et al* (2012) [19] and Chandrashekhar *et al* (2000) [3].

Table 1: Response of fertility gradients with FYM levels on yield attributes of maize

FYM Levels (Factor B)	Days to 50% tasseling				Days to 50% silking			
	Fertility gradients (Factor A)							
	L_1	**L_2**	**L_3**	**Mean**	**L_1**	**L_2**	**L_3**	**Mean**
F_0	53	52	51	52	65	62	60	62
F_1	52	51	48	50	63	60	55	59
F_2	51	49	47	49	61	58	53	57
Mean	52	51	48		63	60	56	
Factor	A	B	AXB		A	B	AXB	
SE m±	2.0	2.0	3.5		0.8	0.8	1.4	
CD *(p = 0.05)*	NS	NS	NS		2.5	2.5	4.3	

Table 2: Response of fertility gradients with FYM levels on cob length, cob girth of maize

FYM levels (factor B)	Cob length (cm)				Cob girth (cm)			
	Fertility gradients (factor A)							
	L_1	**L_2**	**L_3**	**Mean**	**L_1**	**L_2**	**L_3**	**Mean**
F_0	11.20	12.05	14.33	12.53	9.39	11.37	13.35	11.37
F_1	11.66	12.61	14.85	13.04	10.41	11.95	14.17	12.18
F_2	11.85	14.47	15.71	14.01	11.13	13.51	14.45	13.03
Mean	11.57	13.04	14.96		10.31	12.28	13.99	
Factor	A	B	AXB		A	B	AXB	
SE m±	0.65	0.65	1.12		0.65	0.65	1.12	
CD (p = 0.05)	1.93	1.93	3.35		1.93	1.93	3.35	

Table 3: Response of fertility gradients with FYM levels on Number of grains line^{-1}, Number of lines cob^{-1}, of cob of maize and Number of grains cob^{-1}of maize

FYM Levels (Factor B)	Number of grains line^{-1} of cob				Number of lines cob^{-1}				Number of grains cob^{-1}			
	Fertility gradients (Factor A)											
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
F_0	18.4	19.7	20.8	19.7	10.9	11.7	12.9	11.9	201.8	236.2	269.4	235.8
F_1	19.8	20.7	21.8	20.8	11.6	12.8	13.4	12.6	235.4	265.3	293.6	264.8
F_2	20.2	20.9	22.2	21.1	11.7	13.2	13.7	12.9	237.9	276.2	303.7	272.6
Mean	19.5	20.6	21.9		11.4	12.6	13.3		225.1	259.2	288.7	
Factor	A	B	AXB		A	B	AXB		A	B	AXB	
SE m±	0.49	0.49	0.86		0.32	0.32	0.56		11.3	11.3	19.5	
CD *(p = 0.05)*	1.48	1.48	2.56		0.97	0.97	1.69		33.8	33.8	58.5	

Table 4: Response of fertility gradients with FYM levels on Grain weight cob^{-1} and Test weight of maize

FYM levels (factor B)	Grain weight cob^{-1} (g)				Test weight (g)			
	Fertility gradients (factor A)							
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
F_0	31.48	40.97	51.65	41.36	155.95	173.45	191.73	173.71
F_1	38.24	49.18	59.80	49.07	167.17	185.37	203.67	185.40
F_2	41.72	53.93	64.18	53.28	175.33	195.25	211.35	193.98
Mean	37.14	48.03	58.54		166.15	184.69	202.25	
Factor	A	B	AXB		A	B	AXB	
SE m±	1.93	1.93	3.34		6.79	6.79	11.76	
CD (p = 0.05)	5.78	5.78	10.00		20.35	20.35	35.24	

Table 5: Response of fertility gradients with FYM levels on grain and stover yield and Harvest index of maize

FYM levels (factor B)	Grain yield (kg ha^{-1})				Stover yield (kg ha^{-1})				Harvest Index (%)			
	Fertility gradients (factor A)											
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
F_0	2167	2713	3053	2644	7863	9377	10357	9199	21.61	22.44	22.77	22.27
F_1	2581	2935	3255	2924	9185	10125	10945	10085	21.94	22.47	22.92	22.44
F_2	2745	3077	3387	3070	9633	10538	11317	10496	22.18	22.59	23.11	22.63
Mean	2497	2908	3231		8894	10013	10873		21.91	22.50	22.93	
Factor	A	B	AXB		A	B	AXB		A	B	AXB	
SE m±	120.6	120.6	208.9		365.7	365.7	633.4		1.14	1.16	2.00	
CD (p = 0.05)	361.7	361.7	626.4		1096.4	1096.4	1899.1		NS	NS	NS	

Table 6: Response of fertility gradients with FYM levels on protein and starch content in grain of maize

FYM levels (factor B)	Protein (%)				Starch (g/100g)			
	Fertility gradients (factor A)							
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
F_0	9.75	10.25	10.51	10.17	61.77	63.91	65.23	63.64
F_1	10.13	10.44	10.75	10.44	63.13	64.56	66.15	64.61
F_2	10.31	10.56	10.94	10.60	63.65	64.88	66.73	65.09
Mean	10.06	10.42	10.73		62.85	64.45	66.04	
Factor	A	B	AXB		A	B	AXB	
SE m±	0.14	0.14	0.23		0.47	0.47	0.82	
CD *(p = 0.05)*	0.40	0.40	0.69		1.42	1.42	2.47	

Table 7: Economic of maize production under different treatment combinations

Treatment combinations	Cost of cultivation (Rs ha^{-1})	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C Ratio
L_1 F_0	38201	33440	4761	1.14
L_1 F_1	45319	40746	4573	1.11
L_1 F_2	48063	47800	263	1.01
L_2 F_0	47359	37220	10139	1.27
L_2 F_1	51215	44525	6690	1.15
L_2 F_2	53617	51580	2037	1.04
L_3 F_0	53099	40999	12100	1.30
L_3 F_1	56515	48305	8210	1.17
L_3 F_2	58735	55360	3375	1.06

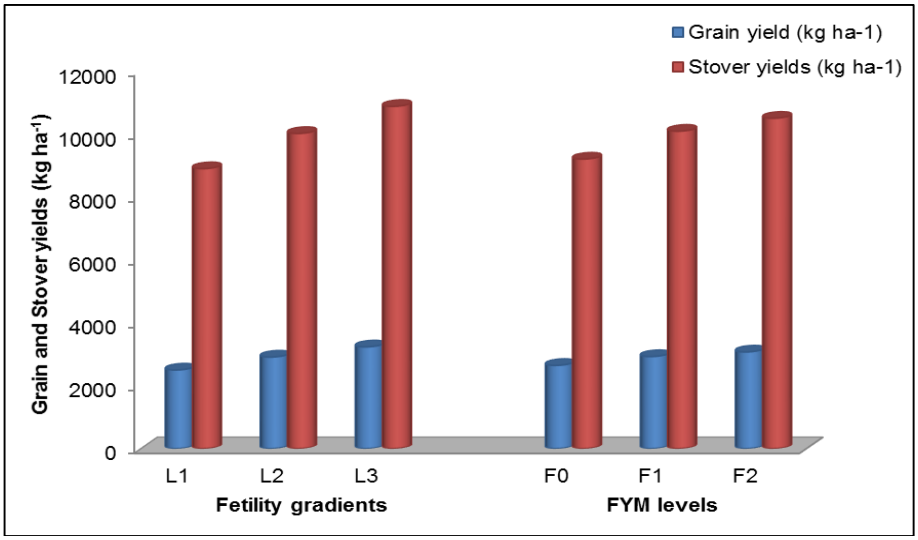

Fig 1: Response of fertility gradients with FYM levels on grain and stover yield (kg ha^{-1}) of maize

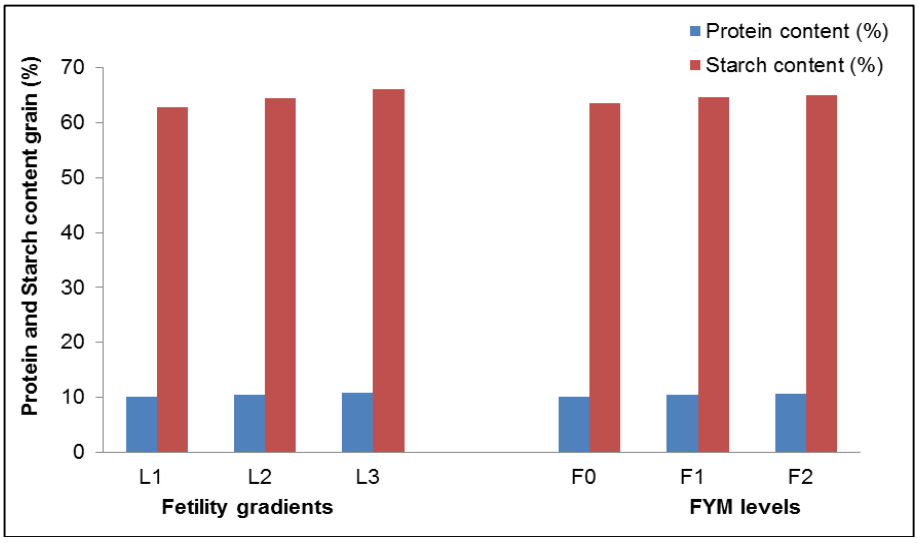

Fig 2: Response of fertility gradients with FYM levels on protein and starch content in grain

Conclusions

- It is concluded that the higher dose of fertilizers applied with FYM (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) was significantly superior in respect of yield attributes (cob length and girth, number of grains line^{-1} of cob, number of lines cob^{-1}, numbers of grain cob^{-1}, grain weight cob-1, test weight and harvest index), of maize crop quality as well as Grain and straw yield by maize crop
- It is concluded that the maximum cost of cultivation and GMR (58735, 55360 Rs ha^{-1} respectively) having recorded in treatment combination L_3F_2, (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) but highest value of NMR (12100 Rs ha^{-1}) was found in treatment combination L_3F_0 followed by L_2F_0 and highest B:C ratio was recorded in same treatment combination L_3F_0 (240:160:120; N:P_2O_5:K_2O kg ha^{-1} + 0 t FYM ha^{-1}) (1.30).

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