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Influence of Nutrient Supply Levels on Yield, Nutrient Uptake, Grain Quality and Economics of Corn (*Zea mays* L.) in *Alfisols* of Karnataka

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ABSTRACT: A field experiment was conducted at Dryland Agriculture Project, Bangalore during *kharif* seasons of 2006 and 2007 to evaluate the influence of fertilizer levels on corn (*Zea mays* L.) yield, quality, nutrient uptake and economic returns. The treatments consist of corn genotypes NAH-2049 and NAC 6004. Fertilizer level treatment consists of N (0, 100, 150 and 200 kg/ha), P_2O_5 (0, 50, 75 and 100 kg/ha) and K_2O (0, 25, 50 and 75 kg/ha) along with or without elemental Sulphur (0 and 10 kg/ha) and $ZnSO_4$ (0 and 12.5 kg/ha) compared to site specific nutrient management (SSNM target 8 t/ha), soil test crop response (STCR target 8 t/ha) and state recommended dose of fertilizers (RDF).The results of the study indicated that hybrid NAH-2049 (5129 kg/ha) was out yielded over NAC-6004 (4811 kg/ha) in both the years. However, nutritional qualities were non-significant except grain oil content between genotypes. Targeted yield based fertilizer application either by SSNM or STCR approach recorded significantly higher grain yield, oil and crude protein yield, starch and phenol content over state recommendation. Significant improvement in N, P, K, S and Zn uptake was recorded under SSNM and STCR approaches. SSNM approach fared well and gave higher net returns (₹ 28.94 x 10^3/ha) and B: C ratio (2.06). Application of fertilizer based on target can enhance the yield, nutrient uptake and economic returns from the production of corn in *Alfisols* of Karnataka.

Key words: SSNM, STCR, corn oil, crude protein, NPK uptake

Precision nutrient management system offers improved land stewardship, optimizes resource usage, since every part of a field receives precise amount of fertilizer required to maximize crop yields (Patil, 2009). Among several fertilizer recommendation techniques, targeted yield approaches can be employed based on available farm resources. The yield target reflects the total amount of nutrients that must be taken up by the crop to produce a unit quantity of economic produce. The SSNM is a site based approach for managing the nutrient needs of crop in intensive production systems. This approach was developed to increase mineral fertilizer use efficiency and achieve balanced plant nutrition (Witt and Dobermann, 2002).

The *Alfisols* of southern Karnataka are very poor in water holding capacity, native fertility status and prone to nutrient losses. Appropriate efficient location-specific nutrient management strategies are needed to develop to sustain corn production. The potential of corn production can only be exploited with adequate and balanced fertilizers. Present state fertilizer recommendation for corn is a general application and fails to consider native soil fertility and optimized fertilizer prescription based on available resources. Nutrient recommendations for corn production should be based on soil test and a realistic crop yield goal. The present study was undertaken with a hypothesis of targeted yield approaches that can optimize fertilizers and improve yield, quality and economic returns. For such precision management of nutrient application as per the variations within the field, soil testing provides the strategy for nutrient management. The objectives of the experiment is to compare nutrient management practices to enhance yield, nutrient uptake by crop parts, grain quality and economic returns in maize production in *Alfisols* of Karnataka.

Materials and Methods

A Field experiment was conducted in Dryland Agriculture Project (77^{0}35' E, 12^0 58' N, 930 m amsl), Bangalore, Karnataka. According to Koppen's classification, the experiment location falls under a tropical savanna climate. During the period of the experiment, the mean annual maximum and minimum air temperatures were 27.8 and 19.3^{0}C, respectively, the mean annual temperature was 23.6^{0}C. The annual rainfall of the station is 927 mm distributed in 62 rainy days. The total recorded rainfall in 2007 and 2008 was 704.2 and 889 mm constituting 24 and 5% lower than normal rainfall distributed in 41 and 59 rainy days, respectively. Seasonal rainfall during the experimental

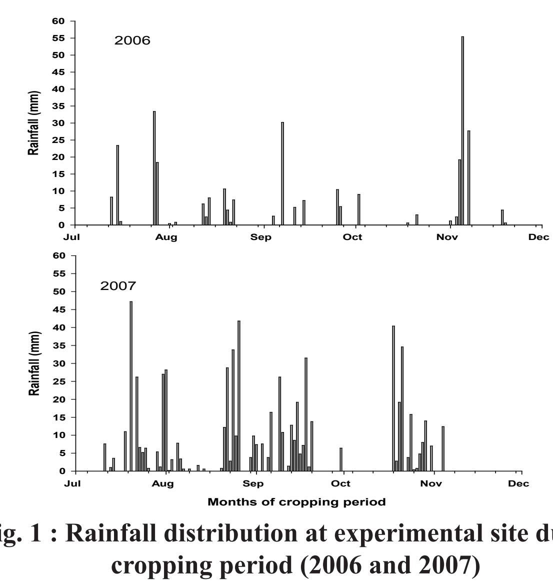

Fig. 1 : Rainfall distribution at experimental site during cropping period (2006 and 2007)

period is depicted in Figure 1. The experimental soil is sandy loam texture and soil reaction 6.3- 6.7. Soil is classified as fine, Kaolinite, *Isohyperthermic, Typic Kandiustalfs*. The details of experimental site soil and its nutrient status are provided in Table 1. The general nutrient status of soil was used for fertilizer prescription to SSNM and STCR treatments during 2006 and respective treatment wise values in 2007. State recommended fertilizers for maize in Bangalore region is 100-50-25 kg N-P-K/ha.

Table 1 : Soil physico-chemical properties of experimental site before experiment in 2006 and 2007 (depth 01-5 cm) and prices of inputs and outputs

Soil characteristics	2006	2007
pH (1: 2.5)	6.3	6.7
EC (1:2.5)	0.17	0.19
Organic Carbon (%)	0.69	0.65
N (kg/ha)	220	262
P (kg/ha)	30.0	43.8
K (kg/ha)	285	315
S (kg/ha)	13.8	14.2
DTPA-Zn (ppm)	0.53	0.49
Bulk density	1.3	1.4
Total pore space (%)	37	39
Maximum WHC (%)	41.6	45.3
Textural class	Sandy clay loam	-
Prices of inputs and outputs	**Prices (₹/kg)**	
Maize seed	30.0	36.0
Maize grain	5.6	6.5
Maize stover	0.75	0.75
Urea	5.0	4.85
Diammonium Phosphate	7.0	9.72
Muriate of Potash	4.5	4.46
Zinc Sulphate	30.0	30.0
Elemental Sulphur	16.0	18.0

The experiment was conducted in separate plots and pigeonpea was previous crop for both the years. Both the genotypes of corn were planted at 55, 555 plants/ha in 0.6 m row spacing on 15 August 2006 and 30 July 2007 and harvested at 121 and 112 days after planting, respectively. The experiment was laid out in factorial randomized complete block design with three replications. The first factor consists of two corn genotypes (NAH-2049 and NAC- 6004) and second factor with fertility levels *viz.,* $N_0P_{75}K_{50}$, $N_{100}P_{75}K_{50}$, $N_{150}P_{75}K_{50}$, $N_{200}P_{75}K_{50}$, $N_{150}P_0K_{50}$, $N_{150}P_{50}K_{50}$, $N_{150}P_{100}K_{50}$, $N_{150}P_{75}K_0$, $N_{150}P_{75}K_{25}$, $N_{150}P_{75}K_{75}$, $N_{200}P_{100}K_{75}$, $N_{150}P_{75}K_{50}Zn_0$, $N_{150}P_{75}K_{50}S_0$, $N_{100}P_{50}K_{25}$, $N_{100}P_{50}K_{25}S_0Zn_0$, $N_{100}P_{50}K_{25}$ (RDF). In addition, STCR and SSNM approaches each for a target yield 8t/ha treatments and RDF considered as control (Table 2). Elemental sulphur @ 10 kg/ha and Zinc sulphate @ 12.5 kg/ha were applied at the time of planting to all the treatments except in treatment mentioned as S_0. The straight fertilizers were applied according to treatments including STCR and SSNM. Zero levels of NPKS and Zn were included to measure indigenous native supply and compare with higher levels.

The equations used to recommend fertilizers for maize in STCR approach developed by AICRP on STCR, Bangalore were used in the study and are as follows:

FN = 3.41 T- 0.08 SN ($KMnO_4$-N)

FP = 1.94 T- 0.9389 SP (Bray's method)

FK = 2.28T-0.0864 SK (Ammonium Acetate method)

Where, T= 80 q/ha,

SN, SP and SK are initial soil available nitrogen, phosphorus and potassium, respectively (kg/ha)

FN, FP and FK are the quantity of nitrogen, phosphorous and potassium to be supplied through fertilizers.

To work out SSNM based fertilizer recommendation, the data on quantity of NPK uptake/tonne considered was 26.3, 13.9 and 35.8 kg, respectively based on several years of field studies. Further, the quantity of fertilizers required for a target yield of 8 t/ha was worked out. If soil has lower, médium and higher in native nutrient supply status, need to apply 30% higher, same and 30% lower than the estimated required quantity, respectively. Lower application rates in high fertile soil introduced to ensure that removal from the field by crop products was replenished. Whereas in low fertile soil, Soil N less than 280 kg/ha supplied through fertilizers to supply crop nutrient requirement and consequently fertilizers applied for SSNM treatment was 252-111-200 and 252-78-200 kg N-P-K/ha during 2006 and 2007, respectively. For STCR approach fertilizers applied at 210-142-155 and 239-136-152 kg N-P-K/ha during 2006 and 2007, respectively.

Soil test ratings for major nutrients considered for fertilizer prescription in SSNM

Nutrient	Soil test ratings (kg/ha)		
	Low	Medium	High
Available N	< 280	280-560	>560
Available P_2O_5	< 10	10-25	>25
Available K_2O	< 120	120-280	>280

The recommended nitrogen was applied in two splits (basal and 45 days after planting) and remaining PKS and Zn were applied at basal. Elemental Sulphur @ 10 kg/ha and zinc sulphate @ 12.5 kg/ha were applied to all the treatments except wherever it mentioned as S_0 and Zn_0. Agronomic data on cobs/plant, seeds/cob, 1000 seed weight and seed yield/plant collected at final harvest of the crop. Oven dried samples were ground in a Willey mill to pass through 2mm sieve. Duplícate sub samples and grain were analysed for N, P, K, S and Zn concentrations using standard procedures. Nutrient uptake per hectare was calculated by multiplying respective nutrient concentration in grain and stover and, respective yield/ha. The crude protein % was computed by multiplying grain N % with a factor 6.25 assuming that the plant protein contains on an average 16% N. The kernel oil content in % was estimated by nuclear magnetic resonance (NMR) spectrometer and oil yield/ha was worked out on the basis of seed oil content and grain yield/ha. Starch (Hedge

Table 2 : Grain and stover yield, harvest index and economics of corn genotypes under fertilizer application supply levels

Treatment	Grain yield (kg/ha)			Stover yield (kg/ha)			Harvest index	Cost of cultivation (x10³ ₹/ha)	Net returns (x10³ ₹/ha)	B:C ratio
	2006	2007	Mean	2006	2007	Mean				
Corn genotypes (V)			5129		7432					
NAH 2049	4961	5297	4811	6990	7229	7211	0.43	10.48	23.65	2.26
NAC 6004	4625	4996	91	6520	136	6875	0.41	10.48	21.62	2.06
SEm±	55	104	258	52	NS	238	0.01	-	-	-
CD (P=0.05)	155	295		146		672	NS	-	-	-
Nutrient levels (F)										
$N_0P_{75}K_{50}$	3934	3864	3899	6118	5849	5984	0.41	9.48	16.84	1.78
$N_{100}P_{75}K_{50}$	4710	4932	4821	6820	6967	6894	0.43	10.21	21.96	2.15
$N_{150}P_{75}K_{50}$	5178	5832	5505	7254	8272	7763	0.44	10.45	26.20	2.50
$N_{200}P_{75}K_{50}$	5610	6473	6042	7709	9068	8389	0.44	11.08	29.05	2.62
$N_{150}P_0K_{50}$	3962	4108	4035	6184	5949	6067	0.42	8.95	18.20	2.03
$N_{150}P_{50}K_{50}$	4447	5082	4765	6325	7208	6767	0.43	9.87	21.89	2.22
$N_{150}P_{100}K_{50}$	4914	5329	5122	6700	7527	7114	0.44	10.79	23.23	2.15
$N_{150}P_{75}K_0$	4112	4181	4147	6022	6036	6029	0.42	9.62	18.12	1.88
$N_{150}P_{75}K_{25}$	4630	5214	4922	6537	7244	6891	0.42	10.03	22.70	2.26
$N_{150}P_{75}K_{75}$	5100	5450	5275	6896	7731	7314	0.44	10.42	24.61	2.36
$N_{200}P_{100}K_{75}$	5680	6290	5985	7905	8686	8296	0.45	11.81	27.93	2.36
$N_{150}P_{75}K_{50}Zn_0$	4399	4637	4518	6670	6390	6530	0.43	10.66	19.54	1.83
$N_{150}P_{75}K_{50}S_0$	4487	4793	4640	6590	6770	6680	0.42	11.20	19.79	1.77
$N_{100}P_{50}K_{25}$	4155	4253	4204	5632	6590	5990	0.42	9.58	18.45	1.93
$N_{100}P_{50}K_{25}S_0Zn_0$	3877	3742	3810	5551	6391	5971	0.42	8.67	17.14	1.98
STCR (8 t/ha target)	5988	6379	6184	7881	8809	8345	0.43	13.29	27.60	2.08
SSNM (8 t/ha target)	6305	6677	6491	8272	9374	8823	0.45	14.03	28.94	2.06
S.Em ±	160	304	266	151	397	81.7	0.01	-	-	-
CD (P=0.05)	450	860	651	427	1121	230.7	0.03	-	-	-
Interaction (V x F)										
S.Em±	225.6	433.2	230	213.7	561.3	336.8	0.01			
CD (P=0.05)	676.7	1223.5	649	641.0	1683.8	951.0	0.03			

and Hofreiter, 1962) and phenol content (Malick and Singh, 1980) of corn grain was estimated by standard procedures.

Economic returns of the trial was worked out based on the prevailing market prices of inputs and outputs. The details of input cost and output market prices are provided (Table 1). Net returns (₹/ha) was calculated by deducting cost of cultivation from gross retuns in both the years. B:C ratio was worked out by cost of cultivation and net returns. The experimental data were analysed statistically by following Fischer's method of analysis of variance wherever 'F' test was significant at P=0.05. The results have been compared among treatments based on critical difference at same level of significance.

Results and Discussion

Grain and straw yield

Significantly higher grain (39.8%) and straw yield (48.4%) were obtained with the application of fertilizer based on SSNM for 8 t/ha target yield (6,491 kg/ha) over RDF (3,810 kg/ha). The stover yield was also responded lesser extent than did in grain yield. State fertilizer recommended dose for maize in Bangalore region was 100-50-25 kg N-P-K/ha. Significant contributions towards grain and stover yields were observed with the application of sulphur and zinc in addition to NPK fertilizers as compared to respective zero application. The target for SSNM was fixed at higher side for rainfed condition. The prime reason for lower yield than targeted was unfavorable rainfall distribution during cropping period (18 rainy days) and soil moisture stress in 2006 as compared with 2007 (39 rainy days) (Figure 1). Targeted yield was not achieved in both the years; the sustainable yield for a target can be achieved over years. There was no much difference in grain to total biomass yield (HI) of corn between genotypes (Table 2).

The SSNM practice under rainfed was found to be effective if sufficient soil moisture prevails throughout crop growth. The SSNM strategies may differ depending on climatic season, crop duration and water management or rainfall distribution. Biradhar *et al*. (2006) reported that SSNM practice for rice and wheat in Karnataka resulted additional 35 and 39% higher yield over RDF and farmers' practice, respectively. Yadhav and Hira Nand (2004) have shown that application of 125, 60 and 20 kg N, P_2O_5 and K_2O/ha, along with sulphur and micronutrients gave 26 and 17% higher grain yield over state recommendation (1.49 t/ha) and common farmers' practice (1.66 t/ha), respectively. Among fertilizer application levels, harvest index was decreased and found non-significant either without application of nitrogen or $N_{100}P_{50}K_{25}$ fertilizer levels.

Nutrient uptake by plant parts

Improvement in NPK uptake by corn plant parts was observed by SSNM based fertilizer application. It was 49, 57 and 40% higher over their respective without application of NPK levels (Table 3). The positive linear association with NPK uptake was observed by without application of fertilizer to 200, 75 and 50 kg/ha, respectively. Enhanced nutrient uptake might be due to higher rate of fertilizer application, enhanced soil fertility, nutrient accumulation in plant parts and ultimately due to higher biomass production. Khurana *et al*., (2004) tested SSNM approach in selected farmers' field and results indicated that improvement in N, P and K accumulation (12-20%) in plant parts over farmers' practice. Site specific management zones exhibited less spatial variability in N uptake and grain yield of corn within individual zones than on a whole field basis Inman *et al*., (2005).

Significant influence of sulphur application on grain yield and uptake (4 to 41%) was observed with combined application of NPKS and Zn (Table 4). Sulphur is known to be involved in production of protein, promotes activity and development of enzymes and helps in chlorophyll formation in crop plants. The increase in uptake of N at increased levels of sulphur and N:S and P:S ratios were more important in balanced fertilization. Higher levels of NPK application enhanced the S uptake when compared to lower levels of NPK (Dhananjaya and Basavaraj, 2002).

Application of 12.5 kg zinc sulphate has significant influence on corn grain yield and uptake of zinc (Table 3). The extent of increase in zinc uptake by plant parts was 11.1 to 54.9% as against to the without application of zinc. It is considered as vital micronutrient for corn involved in transformation and regulation of carbohydrates. Combined application of S and Zn along with NPK fertilizer enhances yield, nutrient uptake and protein content of corn than applied alone (Dwivedi *et al.,* 2002).

Corn grain oil content and protein yield

There was no significant difference among fertilizer application levels with respect to grain oil content (Table 4). However, oil yield per hectare was differed significantly due to differences in corn grain yield. There was a significant difference between genotypes in both the years and higher oil content was observed in 'NAC-6004' over 'NAH-2049'. The oil content in corn is subjected to genetic make up as well as agronomic practices on fatty acid composition. The high yielding varieties and hybrids of corn have poor grain oil content. Besides total oil content, some studies have also shown that the fatty acid content also be subjected to genetic control, as noticed by changes in linoleic acid content in corn oil. Grain quality of corn was further enhanced by higher and precise fertilization (Arun Kumar *et al.,* 2007).

The crude protein content of corn (12.3-14.9%) was differed significantly between genotypes and fertility levels (Table 4). Significantly higher crude protein content was observed in 'NAH-2049' (13.4-14.3%) over 'NAC-6004' (12.3-13.4%). The grain crude protein content is a nitrogen dependent quality parameter directly related to N content of corn grain. Obviously, an improvement in crude protein content of corn was observed with the increased levels of N from 0 to 200 kg/ha. Crude protein yield was higher with application of 200 kg N fertilizer and target yield approaches of SSNM and STCR. Lower crude protein content and yield were recorded without application of N (N_0). Miao *et al*. (2007) had endorsed that the genetic constitution of hybrid corn with higher N nutrition might be responsible for more crude protein in hybrid corn.Studies showed significant increase in corn yield and protein content but, decreased corn oil and starch content by N fertilization. Miao *et al*. (2007) was observed that increase in protein content by application of nitrogen from 143 to 303 kg/ha and 0 to 235 kg/ha. Hybrid-specific N application could have either negative or positive impacts on corn yield and protein content.

Table 3 : Uptake of NPKS and Zn by plant parts of corn genotypes under fertilizer application levels in *Alfisols* of Karnataka

Treatment	N (kg/ha)		P (kg/ha)		K (kg/ha)		S (kg/ha)		Zn (kg/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Corn Genotypes (V)										
NAH- 2049	183.4	210.4	34.7	32.8	106.3	98.9	9.4	9.3	0.53	0.49
NAC 6004	165.3	210.9	29.4	28.1	96.2	90.9	8.8	8.9	0.47	0.48
CD (P=0.05)	6.8	13.5	2.0	1.6	4.8	4.6	0.4	0.3	0.02	NS
Nutrient levels (F)										
$N_0P_{75}K_{50}$	127.6	133.2	20.0	19.2	80.0	77.3	6.6	6.6	0.35	0.38
$N_{100}P_{75}K_{50}$	170.4	194.5	28.0	24.8	92.6	92.3	8.4	8.3	0.48	0.51
$N_{150}P_{75}K_{50}$	196.3	236.7	36.0	29.7	114.8	99.2	11.4	11.4	0.6	0.56
$N_{200}P_{75}K_{50}$	223.9	258.4	44.2	36.4	130.7	111.6	11.9	11.9	0.74	0.68
$N_{150}P_0K_{50}$	142.0	159.6	17.0	18.4	76.2	81.2	7.3	7.3	0.46	0.50
$N_{150}P_{50}K_{50}$	159.6	204.7	31.4	27.1	97.0	86.7	8.7	8.8	0.5	0.48
$N_{150}P_{100}K_{50}$	180.4	218.8	38.5	34.0	84.9	85.2	9.7	9.8	0.43	0.43
$N_{150}P_{75}K_0$	143.6	162.7	28.2	26.9	70.8	71.5	7.8	7.9	0.47	0.44
$N_{150}P_{75}K_{25}$	164.6	203.6	32.1	26.7	101.0	90.6	9.5	9.3	0.51	0.49
$N_{150}P_{75}K_{75}$	185.7	223.5	34.8	29.5	108.1	100.2	10.4	10.5	0.52	0.52
$N_{200}P_{100}K_{75}$	225.1	251.5	43.1	41.2	132.4	120.6	11.0	10.9	0.68	0.67
$N_{150}P_{75}K_{50}Zn_0$	170.0	190.6	28.7	31.1	88.9	95.7	7.9	7.9	0.42	0.36
$N_{150}P_{75}K_{50}S_0$	160.5	185.4	28.3	30.6	95.1	91.9	7.2	6.9	0.45	0.47
$N_{100}P_{50}K_{25}$	137.9	152.6	22.6	24.4	83.2	76.5	7.9	8.3	0.35	0.36
$N_{100}P_{50}K_{25}S_0Zn_0$	124.8	145.5	21.5	23.1	81.0	72.9	6.9	7.1	0.35	0.29
STCR (8 t/ha target)	227.4	263.3	40.7	45.4	127.2	117.8	11.1	10.9	0.59	0.58
SSNM (8 t/ha target)	244.9	265.9	48.5	48.1	137.3	126.2	11.3	11.4	0.61	0.60
CD (P=0.05)	19.9	39.3	6.0	4.7	13.9	13.3	1.2	0.9	0.05	0.06

Starch and phenol content (%)

There was no significant difference in starch content between corn genotypes (Table 4). The starch content was increased from 1.02-1.29% with the application of $N_{200}P_{100}K_{75}$. The starch content of corn grain has tendency to decrease at higher NPK levels. Reduced corn starch due to N manuring was opined by Srivastava and Mehrotra (1991).

There was no significant difference in phenol content between genotypes. It was significantly influenced by fertilizer application levels. The phenol content was increased with higher levels of fertilizers application (0.09 to 0.22%).The phenol production is a specific attribute closely linked to disease resistance in crop plants. Srivastava and Mehrotra (1991) opined that fertilizer application levels to corn had significant influence on phenol content of grain.

Economic analysis

Economic returns is an important factor to assess feasibility of the practice in crop production. The increased yield under SSNM based nutrient application resulted in improvement of economic returns of corn production. The net income obtained from corn production under SSNM was 28.94 x 10^3 ₹/ha was much higher over RDF excepting $N_{200}P_{75}K_{50}$ level (Table 2). The improvement in soil fertility over years might reduce the input costs and in such circumstances corn production under SSNM approach might become profitable and sustainable. Rice and wheat production was profitable under SSNM practice in Karnataka was reported by Biradhar *et al.* (2006) compared with RDF and farmers' practice. Yadhav and Hira Nand (2004) reported SSNM practice increased net returns of 35 and 109% in pigeonpea and pearlmillet over state recommendations. Khurana *et al.* (2004) compared profitability of SSNM over farmers' practice in selected farmers' field in Punjab and obtained 13% higher net returns besides >0.8 t/ha increase in wheat grain yield.

Conclusion

The results of the study showed that corn hybrid 'NAH 2049' fertilized with SSNM approach under well soil moisture status was proved to be advantageous to improve grain yield, quality and economic returns. It is a profitable practice to improve upon recommended dose of fertilizers to enhance corn productivity in *Alfisols* of Karnataka.

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Table 4 : Oil yield, crude protein yield, starch and phenol content of corn grain under different fertilizer application levels

Treatment	Grain oil yield (kg/ha)		Crude protein yield (kg/ha)		Starch (%)		Phenol (%)	
	Corn genotypes (V)							
	NAH 2049	NAC 6004	NAH 2049	NAC 6004	NAH 2049	NAC 6004	NAH 2049	NAC 6004
Nutrient levels (F)								
$N_0P_{75}K_{50}$	236	223	510	378	0.98	0.99	0.09	0.09
$N_{100}P_{75}K_{50}$	305	294	675	543	1.08	1.11	0.12	0.13
$N_{150}P_{75}K_{50}$	335	307	830	698	1.16	1.19	0.13	0.14
$N_{200}P_{75}K_{50}$	378	342	901	769	1.24	1.26	0.17	0.18
$N_{150}P_0K_{50}$	240	232	565	433	1.09	1.14	0.13	0.16
$N_{150}P_{50}K_{50}$	308	278	679	547	1.23	1.25	0.12	0.14
$N_{150}P_{100}K_{50}$	329	299	738	606	1.23	1.29	0.11	0.14
$N_{150}P_{75}K_0$	269	267	591	459	1.14	1.16	0.13	0.17
$N_{150}P_{75}K_{25}$	282	262	690	558	1.16	1.19	0.10	0.13
$N_{150}P_{75}K_{75}$	326	304	758	626	1.43	1.44	0.12	0.14
$N_{200}P_{100}K_{75}$	322	300	908	776	1.22	1.26	0.16	0.19
$N_{150}P_{75}K_{50}Zn_0$	254	237	667	535	1.18	1.20	0.12	0.15
$N_{150}P_{75}K_{50}S_0$	253	237	652	520	1.19	1.20	0.13	0.15
$N_{100}P_{50}K_{25}$	262	247	580	448	1.07	1.10	0.10	0.13
$N_{100}P_{50}K_{25}S_0Zn_0$	240	227	530	398	1.07	1.10	0.10	0.12
STCR (8 t/ha target)	363	357	893	761	1.24	1.30	0.17	0.21
SSNM (8 t/ha target)	398	376	992	827	1.25	1.27	0.19	0.22
Mean	300	281	715	581	1.17	1.20	0.13	0.15
CD (P=0.05)	V 26, F 8.9	V x F 36.8	V 70.4, F 24.1	V x F 99.5	V 0.13, F NS	V x F 0.19	V 0.02, F NS	V x F 0.04

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