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Effect of Graded Nutrient Levels and Timing Nitrogen Application on Yield and Quality of Sweet Corn (*Zea mays* L.)

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A field experiment was conducted during the *rabi* seasons of 2005 and 2006 at S.V.Agricultural college farm, Tirupati to study the effect of four graded levels of NPK and split application of N at different times on yield and quality of sweet corn. The experiment was laid out in split plot design with three replications. Four graded NPK levels *viz*.,- NPK @ 90:50:40; 120:60:45; 150:70:50 and 180:80:55 kg ha^{-1} were assigned to main plots and split application of N at different times *viz*.,- 1/2 basal + 1/2 at knee high stage, 1/2 basal + 1/4th knee high + 1/4 th tasseling; 1/ 3 rd basal + 1/3 rd knee high + 1/3 rd tasseling and 1/4th basal +1/2 at knee high + 1/4th tasseling were alloted to sub plots. The results revealed that increasing the nutrients level of NPK from 90:50:40 to 150-70-50 kg ha^{-1} significantly increased the yield attributes, green cob yield with husk, green fodder yield and benefit : cost ratio during both the years. It also brought significant improvement in the quality of kernels (higher content of protein, reducing and non-reducing sugars) and of green fodder (higher crude protein and lower crude fibre contents).The yield attributes, yield and quality of sweet corn obtained with NPK @ 150-70-50 kg ha^{-1} were on par with the highest level of NPK @ 180-80-55 kg ha^{-1}. Application of nitrogen in three splits-1/4th basal + 1/2 at knee high + 1/4th tasseling had substantially increased the green cob weight, kernel number cob^{-1}, green cob and fodder yield of sweet corn as compared to the application of nitrogen in two splits-1/2 basal + 1/2 at knee high stage. Time of nitrogen application did not exert any significant effect on the quality of sweet corn.

Key words: Nutrient levels, split application of nitrogen, green cob yield, kernel quality, sweet corn

Maize is a miracle crop emerging as the third most important cereal in the world agriculture to provide food, feed and source of numerous industrial products. Out of various speciality corns, sweet corn is a mutant type, with one or more recessive alleles in homozygous condition, that enables the endosperm to accumulate twice the sugar content as that of seed corn (Creech, 1965). Recently, it is gaining popularity among nutritive and health conscious urban mass in India with an immense potential in domestic and international market. It is highly prized by the corn fanciers for its succulent, tender kernels with sweet flavour. Commercial production of this diversified corn in conjunction with assured markets and agro-processing industries have recognized it as a crop of great agro-economic value. Sweet corn is of short duration, harvested at milky stage to provide green cobs. Therefore, inclusion of sweet corn in the intense cropping systems is being widely accepted by the farmers in the southern agro-climatic zone of Andhra Pradesh. Balanced and judicious use of nutrients is imperative to maintain positive nutrient balance, sustain crop productivity and improve the quality of produce. As nitrogen is taken up throughout the crop growth and liable for leaching, split application of nitrogen, synchronizing with the peak demand period is a promising agro-technique to enhance its use efficiency and crop productivity. However, no systematic research has been conducted to develop suitable site and situation specific production technology for sweet corn. Keeping these points in view, the present investigation was under taken to assess the optimum level of nutrients and suitable time of nitrogen application for higher productivity and quality of sweet corn.

Materials and Methods

The experiment was conducted during *rabi* seasons of 2005 and 2006 at S.V.Agricultural college farm, Tirupati located in the southern agro-climatic zone of Andhra Pradesh. The soil was well drained, sandy loam in texture, with a pH of 6.5, low in organic carbon (0.25%), and nitrogen (204 kg ha^{-1}), medium in available phosphorus (32 kg ha^{-1}) and potassium (199 kg ha^{-1}). The experiment was laid out in split plot design with three replications. Four graded nutrient levels *viz*., - 90:50:40; 120:60:45; 150:70:50 and 180:80:55 NPK kg ha^{-1} were assigned to main plots and split application of nitrogen at different times viz.,- 1/2 basal + 1/2 at knee high stage, 1/2 basal + 1/4th knee high + 1/4 th tasseling; 1/3 rd basal

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+1/3 rd knee high + 1/3 rd tasseling and 1/4th basal +1/2 at knee high + 1/4thtasseling , were allotted to sub plots. The test variety "Madhuri" was sown on 15th November, 2005 and 7th November, 2006. In all the treatments, entire quantity of phosphorus in the form of single super phosphate and potassium in the form of muriate of potash were applied as basal, at the time of sowing. The nitrogen in the form of urea was applied in splits at different stages, as per the treatments. The green cobs were harvested after attaining full size with tight green husk, dry brown silk and exuded milky liquid, when punctured with thumb nail. Green fodder was immediately harvested after picking of cobs. Nitrogen, phosphorus and potassium contents were analysed with standard procedures outlined and uptake of NPK in kg ha^{-1} was calculated. Quality analysis of kernels (*viz.,* protein content, reducing and non-reducing sugars) and of fodder (*viz.*, crude protein and crude fibre) were done with standard methods (AOAC, 1995). Benefit cost ratio was worked out considering the current market price for inputs and outputs.

Results and Discussion

Nutrient levels

The successive increase in nutrient levels significantly increased the number of kernels cob^{-1} and green cob weight (with husk) up to NPK @ 150:70:50 kg ha^{-1}, which were however comparable with the application of the highest nutrient level of NPK @180:80:55 kg ha^{-1} (Table 1). The increased value of yield attributes might be presumably due to the synergistic effect of concomitant supply of primary nutrients (NPK), higher level of biomass accrual coupled with increased sink capacity. The lowest number of kernels/cob with 90:50:40 was due to the transient deficiency of nutrients at silking stage, which resulted in lesser cob weight as reported earlier by Chapin(1988).

The highest green cob and fodder yield were produced with NPK @ 180:80:55 kg ha^{-1}, which were also on par with NPK @ 150:70:50 kg ha^{-1}. As per the pooled mean of 2005 and 2006 , the highest

Table 1. Effect of graded nutrient levels and time of nitrogen application on yield attributes, yield and economics of sweet corn

Treatment	No. of kernels cob^{-1}			Weight green cob^{-1} (g)			Green cob yield (with husk)(t ha^{-1})			Green fodder yield (t ha^{-1})			Benefit-Cost ratio		
	2005	2006	Pooled Mean	2005	2006	Pooled Mean	2005	2006	Pooled Mean	2005	2006	Pooled Mean	2005	2006	Pooled Mean
Nutrient levels (NPK kg ha^{-1})															
90:50:40	351	342	347	178.0	170.0	174.0	10.11	9.65	9.88	13.65	12.02	12.83	2.47	2.33	2.40
120:60:45	428	409	419	200.0	194.3	197.2	14.03	13.34	13.68	17.96	16.75	17.35	3.22	3.04	3.13
150:70:50	483	458	471	215.1	210.7	212.9	16.45	15.38	15.91	21.17	19.52	20.34	3.55	3.32	3.43
180:80:55	515	484	500	218.9	218.3	218.6	17.16	16.18	16.67	22.68	20.97	21.82	3.52	3.30	3.41
SEd	15	15	13	5.1	5.9	5.5	0.32	0.33	0.32	066	0.61	0.62	0.06	0.07	0.06
C.D (P=0.05)	37	38	34	12.6	14.3	13.5	0.79	0.82	0.80	1.62	1.51	1.54	0.16	0.18	0.17
Time of nitrogen application															
1/2 basal +1/2 at knee high	397	377	387	188.0	181.6	184.8	12.98	12.45	12.71	16.49	15.54	16.01	2.95	2.80	2.87
1/2 basal + 1/4th knee high + 1/4 th tasseling	443	422	432	204.8	201.8	203.3	14.48	13.70	14.09	19.07	17.41	18.24	3.16	3.00	3.08
1/3 rd basal +1/3 rd kneehigh + 1/3rd tasseling	465	450	458	207.4	203.4	205.4	15.02	14.11	14.56	19.68	17.99	18.83	3.28	3.09	3.18
1/4th basal+1/2 at knee high + 1/4thtasseling	472	453	463	211.7	206.5	209.1	15.37	14.30	14.83	20.21	18.33	19.27	3.37	3.14	3.25
SEd	21	20	20	7.4	7.0	7.0	0.61	0.41	0.59	0.72	0.75	0.73	0.13	0.09	0.12
C.D(P=0.05)	43	41	43	15.1	14.4	14.6	1.27	0.91	1.23	1.50	1.56	1.52	0.28	0.20	0.25

level of NPK @ 180:80:55 kg ha^{-1} recorded 61 per cent higher green cob yield and 70 per cent higher green fodder yield over the lowest nutrient level of NPK @ 90:50:40 kg ha^{-1}. This might be due to the favourable influence of consistent and adequate availability of nutrients throughout the crop growth period, favouring the production of photosynthates and their efficient translocation to the sink. These results are in conformity with those of Sahoo and Mahapatra (2005).

Nitrogen, phosphorus and potassium uptake of sweet corn at 60 days after sowing, during the peak demand period for nutrients was found to be significantly increased with each successive increase in the nutrient level up to NPK @ 150:70:50 kg ha^{-1} (Table.2). The higher level of nutrient supply might be conducive for extensive root proliferation, to explore a greater volume of soil and absorb larger quantities of nutrients.

The best quality of sweet corn kernels (the highest protein, reducing and non-reducing sugar contents) and green fodder (the highest crude protein and lowest crude fibre content) were obtained with NPK @ 180:80:55 kg ha^{-1}, and 150:70:50 kg ha^{-1} (Table 3). Nitrogen, being the principal constituent of proteins, might have substantially increased the protein content of kernels and fodder, with increased uptake of nitrogen under higher nutrient levels as reported by Raja (2001).Potassium, a miracle nutrient might have directly involved in enhancing

Table 2. Effect of graded nutrient levels and time of nitrogen application on nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by sweet corn at 60 days after sowing.

Treatment	Nitrogen uptake			Phosphorus uptake			Potassium uptake		
	2005	2006	Pooled Mean	2005	2006	Pooled Mean	2005	2006	Pooled Mean
Nutrient levels (NPK kg ha^{-1})									
90:50:40	55.3	53.7	54.5	24.1	24.5	24.3	91.8	88.9	90.4
120:60:45	80.7	79.4	80.1	29.2	28.9	29.1	110.7	107.0	108.8
150:70:50	93.3	91.8	92.6	32.2	31.7	31.2	122.4	120.2	120.2
180:80:55	94.9	93.4	94.1	33.4	33.1	33.2	125.9	122.6	122.6
SEd	2.5	2.0	2.2	0.9	0.8	0.7	2.9	2.3	2.7
CD (P=0.05)	6.3	5.1	5.4	2.2	2.1	1.9	7.2	5.7	6.8
Time of nitrogen application									
1/4th basal + 1/2 at knee high + 1/4th tasseling	71.3	69.4	70.4	26.7	26.4	26.6	102.4	99.3	100.8
1/3 rd basal +1/3 rd knee high+ 1/3rd tasseling	82.8	81.4	82.1	29.9	29.3	29.6	113.6	110.1	111.8
1/2 basal +1/4th knee high +1/4th tasseling	84.4	82.8	83.6	30.6	31.5	31.1	115.8	113.8	114.8
1/2 basal +1/2 at knee high	85.6	84.7	85.1	31.7	31.9	31.8	118.5	115.4	117.0
SEd	3.8	3.3	3.4	1.4	1.3	1.3	4.6	3.7	4.0
CD (P=0.05)	7.9	6.9	7.2	2.9	2.7	2.7	9.5	7.6	8.3

the translocation of sugars to the kernels (Estes *et al*.,1973).Thus, better physiological and biochemical activity under comfortable nutrition would have enhanced the sugar content of kernels. Sweet corn supplied with higher nitrogen contains relatively high proportion of water, low proportion of drymatter, more succulent and therefore, low in crude fibre content. The inverse relationship between crude fibre in fodder and nitrogen noticed in the present investigation was also reported by Verma *et al.* (1997).

The highest benefit cost ratio was obtained with NPK@ 150:70:50 kg ha^{-1} and was on par with NPK @ 180:80:55 kg ha^{-1}, but was significantly higher than that with NPK @ 90:50:40 kg ha^{-1}(Table 1).

Time of nitrogen application

Split application of nitrogen at different times significantly influenced the yield attributes and yield, whereas it did not exert any significant effect on the quality of kernels and green fodder.

Table 3. Effect of graded nutrient levels and time of nitrogen application on the quality of kernels and green fodder of sweet corn

Treatment	Kernels									Green Fodder					
	Protein(%)			Reducing sugars(%)			Non reducing sugars (%)			Crude protein(%)			Crude fibre(%)		
	2005	2006	Pooled Mean	2005	2006	Pooled Mean	2005	2006	Pooled Mean	2005	2006	Pooled Mean	2005	2006	Pooled Mean
Nutrient levels (NPK kg ha^{-1})															
90:50:40	9.67	8.42	9.04	0.021	0.022	0.022	0.213	0.200	0.206	7.86	6.75	7.30	27.4	26.7	27.1
120:60:45	12.28	10.65	11.46	0.026	0.025	0.025	0.267	0.257	0.262	8.82	8.03	8.42	26.0	25.3	25.7
150:70:50	14.13	12.32	13.22	0.029	0.028	0.028	0.315	0.299	0.307	9.32	8.98	9.15	25.2	24.4	24.8
180:80:55	14.94	12.80	13.87	0.031	0.029	0.029	0.342	0.033	0.033	9.34	9.14	9.24	24.6	23.8	23.8
SEd	0.22	0.41	0.24	0.001	0.001	0.0001	0.014	0.011	0.012	0.19	0.12	0.15	0.27	0.28	0.26
C.D (P=0.05)	0.55	0.62	0.59	0.002	0.001	0.002	0.034	0.028	0.030	0.49	0.29	0.37	0.6	0.70	0.60
Time of nitrogen application															
1/2 basal +1/2 at knee high	11.44	10.73	11.08	0.025	0.023	0.024	0.281	0.267	0.274	8.58	8.05	8.32	27.2	25.9	26.5
1/2 basal + 1/4th knee high + 1/4 th tasseling	11.70	11.00	11.35	0.027	0.024	0.025	0.284	0.272	0.278	8.77	8.22	8.49	26.7	25.4	26.1
1/3 rd basal + 1/3 rd kneehigh + 1/3rd tasseling	11.87	11.16	11.51	0.027	0.025	0.026	0.285	0.271	0.278	8.86	8.27	8.56	25.9	24.6	25.2
1/4th basal+1/2 at knee high + 1/4thtasseling	12.38	11.29	11.29	0.028	0.025	0.026	0.286	0.273	0.279	8.93	8.35	8.64	25.9	24.3	25.1
SEd	0.41	0.37	0.38	0.001	0.001	0.001	0.012	0.014	0.013	0.23	0.19	0.21	0.86	080	0.82
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS – Non significant

Yield attributes (number of kernels cob^{-1} and green cob weight), green cob and fodder yield were the highest with application of nitrogen in three splits - 1/4th basal +1/2 knee high + 1/4thtasseling, which was also on par with those under 1/3rd basal +1/3rd knee highs+ 1/3rd tasseling and 1/2 basal + 1/4th knee high + 1/4th tasseling (Table 1). The increased values of yield attributes could be ascribed to the availability of sufficient quantity of nitrogen, during the period of flowering (from 15 days before silking to 15 days after silking) which is the most critical period in determining sink size as reported by Hawkins and Cooper (1981). Nitrogen starvation at tasseling and silking stages might have enhanced the kernel abortion, ultimately resulted in the lowest number of kernels cob^{-1} and green cob weight with nitrogen application in two splits-1/2 basal + 1/2 at knee high stage, as also confirmed by Lemcoff and Lumis(1986).

Application of nitrogen in three splits -1/4th basal +1/2 at knee high + 1/4th tasseling increased the green cob yield to a magnitude of 17 per cent and green fodder yield to the extent of 21 per cent over two splits as 1/2 basal + ½ at knee high stage (according to the pooled mean of 2005 and 2006). Top dressing of adequate nitrogen at tasseling stage improved the stature of yield attributes and translocation of photosynthates to the sink, resulted in higher green cob yield (Table 1). Continuous supply of nitrogen synchronizing with its requirement at different stages of crop growth, contributed for higher green fodder yield. These results are in conformity with the findings of Hari Krishna *et al*.(2005).The highest uptake of nitrogen, phosphorus and potassium at 60 days after sowing of sweet corn, registered with nitrogen application - 1/4th basal +1/2 at knee high + 1/4thtasseling might be due to the consistent and adequate supply of nitrogen during the flowering period, which is the peak demand period with regard to mineral nutrition (Hanway, 1962).

The present study revealed that the highest green cob and fodder yield of sweet corn with good quality of produce could be realized with the supply of NPK @ 150:70:50 kg ha^{-1} and application of nitrogen in three splits- 1/4th basal +1/2 at knee high + 1/4th tasseling stages.

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