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Yield, nutrient uptake and quality of sweet corn as influenced by transplanting dates and nitrogen levels

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Abstract
A field experiment on "Yield, nutrient uptake and quality of sweet corn as influenced by transplanting dates and nitrogen levels" was conducted at research farm of Faculty of Agriculture (SKUAST-K) during 2016. The soil of the experimental field was silty clay loam in texture, low in soil available N and P and medium in available K and neutral in reaction. The treatments comprised of two transplanting dates *viz* 1st of May and 1st of June and five levels of N *viz* 0, 30, 60, 90 and 120 kg/ha. Although latter date of sowing resulted in better quality of seedlings but 1st May transplanting was superior in all growth and yield attributes. 1st May transplanting resulted 35.4% and 19.8% higher cob yield and green fodder yield over 1st June transplanting, respectively. Nitrogen application resulted in a significant increase in growth and yield parameters. The green cob yield increased by 34%, 44%, 52%, and 54% respectively at 30, 60, 90 and 120 kg/ha N over control. The corresponding figures for the green fodder yield were 39%, 70%, 91% and 108%, respectively. Highest net profit and benefit cost ratio was realised in 1st May transplanting applied with 120 kg N/ha. There was a significant increase in grain and stover N concentration and total N uptake. Although, transplanting dates and N levels did not affect plant P and K concentration, but their uptake was significantly increased in the earlier planting date and at higher N levels. Earlier planting date had higher protein content in both grain and stover. Higher N levels also resulted in a significant increase in protein content upto 120 kg N ha^{-1}. Although 1st June transplanting had slightly lower TSS but N levels resulted in a incarese in TSS upto 90 kg N/ha.

Keywords: Nutrient uptake, sweet corn, influenced, transplanting dates, nitrogen levels

Introduction
Sweet corn (*Zea mays var. saccharata*) has gained popularity across the world owing to its sweet, creamy, tender, crispy and almost shell-less kernels. Sweet corn is one of the most popular vegetables in the USA, Canada and Australia. It is gaining popularity in India and other Asian countries. The green cobs are harvested at dough stage at which out of 18-20% carbohydrates the kernels contain 5-6% free sugar, 2.1–4.5% of proteins and 70% water. The sweetness of sweet corn is due to a spontaneous mutation in the *su* (''sugary'') gene of the field corn, which controls conversion of sugar to starch inside the endosperm of the corn kernel. In Kashmir valley frozen sweet corn imported from outside state as its popularity is gradually increasing. Earlier studies have demonstrated that abundant sunshine, moderate temperature and nearly pest free environment of Kashmir valley is suited for high quality and yield of sweet corn. Dates of sowing/ transplanting are the most important non monetary inputs that affect the yield and quality of sweet corn. Further staggered sowing can help in prolonging the supply of fresh sweet and prevent the spoilage of otherwise perishable commodity. In addition to other factors such as soil fertility, temperature regimes and irrigation planting date are major factors affecting the sweet corn production (Ramankutty *et al.*, 2002; Anapalli *et al.*, 2005) [13, 1]. During the months of March and April the crop is exposed to cold and excess moisture due to high rainfall during these months. Early sowing of sweet corn also exposes the crop to cold and cut worm damage. For early sowing, raising of the seedlings under protected conditions and then transplanting them in the main filed can be the alternative strategy to avoid the risk of crop failure. Earlier planting of corn is preferable because of utilization of the entire growing season, achieving physiological maturity before frost, thereby increasing profit (Lauer *et al.*, 1997) [8] while delays in sowing date reduced individual kernel weight (Cirilo and Andrade1996) [3]. Among the nutrients nitrogen is most critical due to is profound impact on vegetative and reproductive growth yield quality and nutrient uptake of the sweet corn. Nitrogen is an integral part of proteins, enzymes and chlorophyll (Havlin *et al.*, 2005) [4].

Therefore a field investigation was conducted to evaluate the effect of transplanting dates and nitrogen levels on yield, nutrient uptake and quality of sweet corn under temperate conditions of Kashmir valley.

Materials and Methods

A field experiment was conducted at Faculty of Agriculture, Wadura, Sopore to investigate the response of sweet corn to dates of transplanting and nitrogen levels on the yield and quality of sweet corn. It is located at latitude of 34° 34´ N, longitude 74°40´ E and altitude of 1590 m amsl. The soil of the experimental field was silty clay loam in texture, neutral in reaction, low in available N (210 kg/ha) and P (12.3 kg/ha) and medium in available K (183.5kg/ha). Treatments comprised of two transplanting dates (1st May and 1st June) and five nitrogen levels (0, 30, 60, 90, 120 kg/ha) laid out in RCBD with three replications. The P_2O_5 and K_2O were applied basally @ 60 and 30 kg/ha. Sweet corn variety Sugar-75 of Syngenta was used as the test variety. The seeds were sown in greenhouse on 10th April and 10th May respectively and transplanted at an age of 20 days. Seedlings were raised under protected in poly bags using poting mixture of 400 g of soil: sand: manure in the ratio of 2:1:1. The poly bags were teared at the time of transplanting without disturbing the soil. The crop was irrigated four times each at critical stage of the crop. A spacing of 60 cm x 20 cm was used *i.e* a population of 83000 plants /ha. Recommended of dose 60 kg/ha P_2O_5 and 40 kg/ha K_2O was applied as basal application. Grain samples from the well developed cobs and stover samples were taken at the time of harvest. The samples were shade dried and then transferred to oven and dried at 65^0C. The N analysis was done after triple acid digestion and Kjesdhal distillation. A di-acid digestion procedure was followed in P and K estimation (Prasad *et al*., 2011) [12]. The nutrient concentration and uptake was calculated on dry weight basis. The hand refractometer of range (0-32) °Brix (Erma Make Japan) was used to determine total soluble solids of fresh sweet corn samples. The values were corrected at 20°C (Ranganna, 1986) [14].

Results and Discussion

Yield attributes and yield

Yield attributes *viz.* number of number of grains/cob, cobs/plant and weight/ cob were significantly higher in 1st May transplanting the 1st June transplanting (Table 1). In earlier planting date the crop experienced favourable growing weather conditions commensurate to each phenological stage. The same was reflected in better vegetative growth, yield attributes. Similarly green cob yield, green fodder yield were observed to be significantly higher in 1st May transplanting. An increase of 35.4% and 19.8% was recorded in 1st may transplanting over 1st June transplanting in respect of green cob yield and green fodder yield over 1st June transplanting, respectively (Table 1). Superior growth and yield attributes in 1st May transplanting was manifested in higher cob and fodder yield. This might be due to reduction in growth period, in the latter planting date, higher temperature which increased the respiration rate of plant resulted in reduced net photosynthates, decreased translocation rate of photosynthates from source to sink. Williams, (2008) [22] and Namakka *et al*., (2008) [10] have reported similar results. On the other hand the earlier sown crop was exposed to better growing conditions that resulted in higher biomass production and yield.

There was a significant effect of N levels on yield attributes, cob yield and green fodder yield of sweet corn (Table 1). The green cob yield increased by 34%, 44%, 52%, and 54% respectively at 30, 60, 90 and 120 kg/ha N over control (Table 1). A significant interaction between dates of transplanting and N levels with regard to green cob yield was significant (Table 2). Green cob yield increased significantly with increase in N levels up to 120 kg N/ha in 1st May transplanting whereas the yield increased significantly only up to 90 kg Nha^{-1} in 1st June transplanting. A yield of 17.98 t/ha was obtained at 120 kg N/ha in 1st May transplanting whereas, the yield obtained with 120 N kg ha^{-1} in 1st June transplanting was only 12.91 t/ha which was at par with 90 kg N/ha (12.66 t/ha). Delayed transplanting of sweet corn resulted in a significant decline in the yield contributing components *i.e*. grains/cob, number of cobs/plant, weight/cob girth per plant and number of grains per cob etc. The results indicated that application of higher N doses significantly increased number grains/cob, cobs/plant. The increased availability of photosynthates might have enhanced number of flowers and their fertilization resulting in higher number of grains/cob and cobs/plant. The existence of favourable N doses had a positive influence on both the phases of crop which ultimately led to realization of greater yield attributes. These results are in conformity with the earlier findings of Kar *et al*. (2006) [7], Panwar (2008) [11] and Sahoo and Mahapatra (2007) [15].

Nutrient concentration and uptake

From the perusal of the data it is evident that nitrogen concentration of grain and stover transplanted on 1st May was significant higher over the 1st June transplanted sweet corn. Highest N concentration of 1.52% and 0.81% in grain and stover respectively was recorded in 1st May stock which was significantly higher over the 1st June transplanted stock (Table 3). Similarly he nitrogen content of grain and stover varied significantly amongst treatments of nitrogen levels. Nitrogen content increased significantly with the increasing N levels from 0 to 120 kg ha^{-1}. Highest nitrogen concentration of grain (1.68%) and stover (0.96%) was recorded with 120 kg N ha^{-1} which was significant higher over all other levels of nitrogen. N uptake was significantly superior in 1stMay transplanting over 1st June transplanting. Higher N uptake of 72.07 kg ha^{-1} (grain), 64.79 kg ha^{-1} (stover) and 136.86 kg ha^{-1} (total) was recorded with 1st date of transplanting due to more biomass and efficient utilization of available resources (Fig 1). Obviously N uptake increased significantly with increase in levels of N levels from 0 to 120 kg ha^{-1}. Highest N uptake was observed in 120 kg N ha^{-1} application with 87.47 kg ha^{-1} uptake in grain, 87.65 kg ha^{-1} in stover) and a total uptake of 175.11 kg ha^{-1} which was significantly superior over all the other levels of nitrogen. This improvement in nutrient concentration and uptake seems to be on account higher available N and enhanced translocation in plant system. Moreover, increase in shoot growth was noticed as evident from higher dry matter accumulation which lead to high N concentration and uptake in grain and stover. In general, total uptake of a nutrient by plant depends is directly related to nutrient concentration and dry matter production. Increased uptake of nitrogen at higher doses might have resulted in initial vigour of plant growth and high photosynthetic rate which resulted better uptake throughout the crop growth period. When a considerable amount of N is applied at or near anthesis, there is greater possibility of its accumulation in sink rather than other vegetative parts. These findings are in close conformity with the observations made by Shivay *et al.* (2002) [16] and Jadhav and Shelke (2012) [5].

From the perusal of the data it is evident that the dates of transplanting and nitrogen levels had a non-significant effect on phosphorus concentration of grain and stover. A P concentration of 0.61% and 0.39% in grain and stover respectively was recorded in 1st May transplanting which was at par with 1st June transplanted stock. Similarly, highest phosphorus concentration of 0.61% and 0.40% in grain and stover respectively was recorded with 120 kg N ha^{-1} and 90 kg N ha^{-1} which was at par with all other levels of nitrogen. Application of recommended dose of P might have maintained optimum P supply and plant P concentration. The P uptake was significantly superior in 1st May transplanting over 1st June transplanting. Higher P uptake of 25.61 kg ha^{-1} (grain), 27.97 kg ha^{-1} (stover) and 53.58 kg ha^{-1} (total) was recorded with 1st May transplanting (Fig 1.). Similarly, P uptake increased significantly with increase in levels of nitrogen. Highest N uptake was observed in 120 kg N ha^{-1} application 28.92 kg ha^{-1} (grain), 33.75 kg ha^{-1} (stover) and 62.68 kg ha^{-1} (total) but uptake of phosphorus at 90 kg N ha^{-1} application was also at par with 120 kg N ha^{-1} application. However, higher values of these parameters were recorded by early transplanting of sweet corn which might be due to improved growth and yield in earlier transplanting date. Similarly higher P uptake was recorded in 1st May transplanting over 1st June. The increase in P uptake could also be attributed to synergistic effect of nitrogen with phosphorus. When water soluble nitrogen and phosphorus compounds are applied together, plant roots proliferate extensively in that area of treated soil resulting in more uptake of the nutrients. The present findings are in close agreement with the results obtained by Backiyavathy and Vijayakumar (2006) [2] and Sujatha *et al.* (2008) [17].

From the perusal of the data it is evident that the dates of transplanting and nitrogen levels had a non significant effect on K concentration of grain and stover. Numerically higher K concentration of 0.92% (grain) and 1.62% (stover) was recorded in 1st May transplanting which was at par with 1st June transplanting. Similarly, highest K concentration of 0.92% and 0.63% in grain and stover respectively was recorded with 120 kg N ha^{-1} which was at par with all lowe levels of nitrogen. The results indicate that the K uptake was significantly superior in 1st May transplanting over 1st June transplanting. Higher K uptake of 40.89 kg ha^{-1} (grain), 119.54 kg ha^{-1} (stover) and 160.44 kg ha^{-1} (total) was recorded in 1st May transplanting. Similarly, uptake of K increased significantly with increase in levels of nitrogen (Fig 1). Highest K uptake was observed in 120 kg N ha^{-1} application *i.e.*, 46.09 kg ha^{-1} (grain), 142.65 kg ha^{-1} (stover) and 188.74 kg ha^{-1} (total) but uptake of potassium at 90 kg ha^{-1} nitrogen application was also at par with 120 kg N ha^{-1} application. A synergistic relationship between N and P and K uptake has been widely reported (Sumner *et al.* 1986; Terman *et al.*, 1977) [18, 22].

Quality of sweet corn

Crude protein (%) in grain and stover

Perusal of the data (Table 3) that the transplanting dates had a significant effect on protein content of grain and fodder. Higher protein content of cob (9.54%) and fodder (5.07%) was recorded with1st May transplanting which was significant over the 1st June transplanting. Similarly the protein content of grain and fodder varied significantly amongst treatments of nitrogen levels. Protein content increased significantly with the increasing N levels from 0 to 120 kg ha^{-1}. Highest protein content of grain (9.54%) and fodder (5.07%) was recorded with 120 kg N ha^{-1} which was significantly higher over all other levels of nitrogen. Higher values of protein content in grain and straw were recorded by early transplanting of sweet corn which might be due to enhanced growth and higher temperature with delayed sowing which resulted in less assimilation of synthates. These results are in confirmation with Darby and Laver (2002) and Mokhtarpour *et al*. (2013) [9] reported that delayed sowing resulted in lower protein of sweet corn. Thus, better physiological and biochemical activity of sweet corn under adequate and balanced nutrient supply of N might have enhanced the protein content of kernel as reported by Kar *et al*. (2006) [7] and Sunitha and Reddey (2012) [19].

TSS in cob (ºBrix)

Data presented in (Table 4) showed transplanting dates and nitrogen levels had a significant effect on TSS of cob. Highest TSS (16.58ºBrix) was recorded with 1st June transplanting which was significantly higher over 1st May transplanting. Whereas, 60 kg N ha^{-1} application recorded highest TSS content (16.56ºBrix) which was at par with 90 and 120 kg N ha^{-1}. The results of the present experiment revealed that quality parameters viz. protein content and total soluble sugars of sweet corn were influenced by transplanting dates. However TSS recorded in 1st June transplanting was significantly higher, which might be probably due to low temperature available during later stages of growth in 2nd date of transplanting which is conducive for development of sugars. Similar results have been reported by Ugur and Maden (2015) [21]. The protein content varied widely among the treatments of nitrogen (Table 4). It was lowest (8.05%) in unfertilized control which increased significantly to (10.51%) at 120 kg N ha^{-1}. This might be due to increased availability of nitrogen and its uptake and storage in grain. Nitrogen, being the principle constituent of protein might have substantially increased the protein content of kernel due to increased uptake of nitrogen. Thus, better physiological and biochemical activity of sweet corn under adequate and balanced nutrient supply of N might have enhanced the protein content of kernel as reported by Kalibhavi *et al.* (2001) [6], Kar *et al*. (2006) [7] and Sunitha and Reddey (2012) [19].

Table 1: Effect of dates of transplanting and nitrogen levels on yield attributes yield of sweet corn

Treatments	No of grains/cob	No of cobs /plant	Weight/ cob (g)	Green cob yield (t/ha)	Green fodder yield (t/ha)
Transplanting dates					
Ist May	568	1.30	261.8	13.97	23.30
Ist June	497	1.21	245.0	10.32	19.44
SEM±	10.48	0.006	4.33	0.09	0.07
CD ($p \leq 0.05$)	31.37	0.017	12.97	0.30	0.22
Nitrogen levels (kg/ha)					
0	324	1.01	178.3	7.07	13.22
30	477	1.15	216.5	10.73	18.39
60	578	1.28	251.9	12.64	22.43

90	617	1.36	303.0	14.83	25.26
120	664	1.48	317.6	15.44	27.53
SEM+	16.57	0.009	6.85	0.15	0.11
CD (p≤0.05)	49.61	0.026	20.50	0.47	0.35

Table 2: Effect of dates of transplanting and nitrogen levels on green cob yield t/ha (without husk) of sweet corn

	N_0	N_{30}	N_{60}	N_{90}	N_{120}	Mean
1st May	8.19	12.04	14.61	17.01	17.98	13.97
1st June	5.95	9.42	10.67	12.66	12.91	10.32
Mean	7.07	10.73	12.64	14.83	15.44	
	Dates of transplanting	Nitrogen levels				C.D N x D
C.D(p≤0.05)	0.30	0.47				0.66

Table 3: Effect of dates of transplanting and nitrogen levels on N, P and K concentration (%) of sweet corn

Treatment	N		P		K	
	Grain	Stover	Grain	Stover	Grain	Stover
Transplanting dates						
Ist May	1.52	0.81	0.61	0.39	0.92	1.61
Ist June	1.49	0.79	0.59	0.38	0.88	1.62
SEm+	0.004	0.005	0.027	0.013	0.035	0.029
CD (p≤0.05)	0.013	0.015	NS	NS	NS	NS
Nitrogen levels (kg ha^{-1})						
0	1.28	0.56	0.59	0.37	0.89	1.60
30	1.41	0.71	0.59	0.38	0.89	1.61
60	1.51	0.81	0.60	0.39	0.91	1.62
90	1.65	0.93	0.61	0.40	0.91	1.63
120	1.68	0.96	0.61	0.40	0.92	1.63
SEm+	0.007	0.008	0.043	0.021	0.055	0.046
CD (p≤0.05)	0.020	0.024	NS	NS	NS	NS

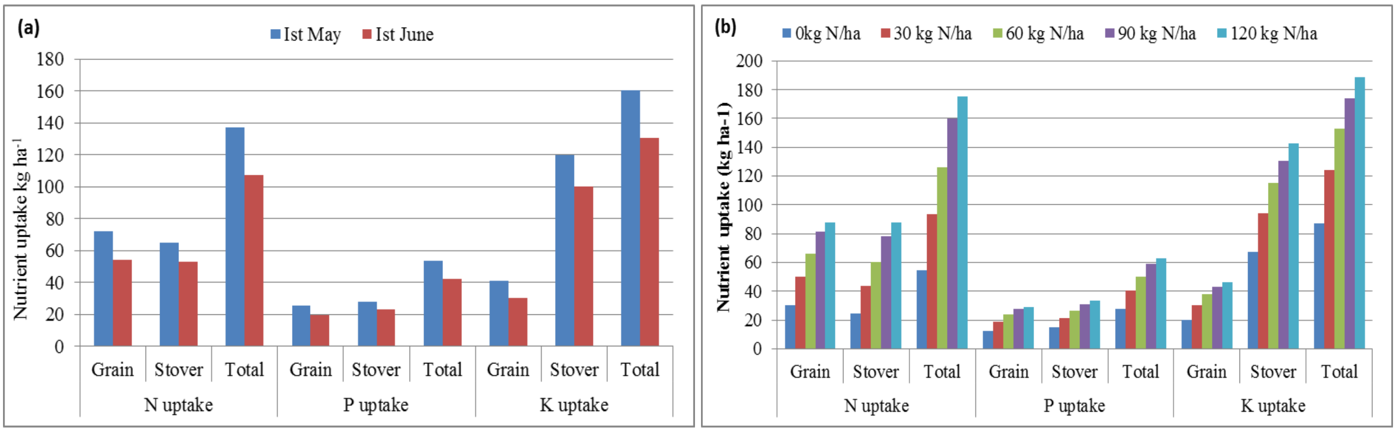

Fig 1: Effect of transplanting dates (a) and N levels (b) N on N, P and K uptake in sweet corn

Table 4: Effect of dates of transplanting and nitrogen levels on crude protein (%) and TSS in sweet corn

Treatments	Protein (%)		TSS in cob
Transplanting dates	Grain	Stover	
1st May	9.54	5.07	15.31
1st June	9.33	4.94	16.58
SEM+	0.03	0.03	0.02
CD (p≤0.05)	0.08	0.10	0.05
Nitrogen levels (kg ha^{-1})			
0	8.05	3.54	14.31
30	8.82	4.49	15.21
60	9.47	5.10	16.56
90	10.31	5.85	16.19
120	10.51	6.02	16.13
SEM+	0.04	0.05	0.13
CD (p≤0.05)	0.13	0.15	0.43

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