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B Manju Bhargavi
Department of Agronomy, Agriculture College, Jagtial, Prof. Jayashankar Telangana State Agricultural University, Telangana, India

Dr. B Mukundam
Agricultural Research Station, Nathanaipally, PJTSAU, Telangana, India

M Malla Reddy
Department of Agronomy, Agriculture College, Jagtial, Prof. Jayashankar Telangana State Agricultural University, Telangana, India

Ch Aruna Kumari
Department of Crop Physiology, Agriculture College, Jagtial, Prof. Jayashankar Telangana State Agricultural University, Telangana-505529.

Correspondence
B Manju Bhargavi
Department of Agronomy, Agriculture College, Jagtial, Prof. Jayashankar Telangana State Agricultural University, Telangana, India

Different detopping levels effect on yield and nutrient uptake of maize (*Zea mays* L.)

B Manju Bhargavi, Dr. B Mukundam, M Malla Reddy and Ch Aruna Kumari

Abstract
In order to examine the different stages and different heights of detopping effects on yield and nutrient uptake of maize (DHM-117), a field experiment was conducted at College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Hyderabad, India, in 2014-15. The experiment was laid out in a randomized block design comprising of a factorial combination of three stages of detopping and three heights of leaves detopping. The three stages are (D_1-10 days after silking, D_2 -20 days after silking and D_3-30 days after silking) were tested with three heights of leaves *viz*., L_1- detopping up to two leaves, L_2- detopping up to four leaves, L_3 -detopping up to six leaves with a control and replicated thrice. It was found that, more grain yield and nutrient uptake were recorded in control (no-detopping). Higher yield and nutrient uptake were observed with D_3 and lowest in D_1. Among different heights of detopping more yield and nutrient uptake were observed in L_1 and lowest in L_3. It was concluded that nutrient uptake was related to production of grain and stover yield. As the number of leaf loss causes reduction in grain and stover yield, hence lower nutrient uptake by plant.

Keywords: nutrient uptake, detopping, maize, factorial, yield

Introduction
Maize (*Zea mays* L.) is an annual short day cross pollinated crop belongs to the family Poaceae (Gramineae) and the tribe Maydeae. It has been credited as "Queen of the Cereals" because of its inherently higher yielding potential. Maize (*Zea mays* L.) is the 3rd most important cereal, next to wheat and rice in the world in respect to area and productivity. During 2013-14 the worldwide area of maize about 177 million hectares and production of 989 million tonnes with a productivity of 5.5 t ha^{-1}. Being a C_4-plant it has best physiological efficiency and highest productivity potential among the cereals. This crop is known to be very responsive to inputs (fertilizer, seed, water and macro or micro-nutrients etc.) and better crop management.

Detopping refers to nipping or the removal of terminal portion from the uppermost node to improve the yield through greater functioning of remaining leaves by arresting unnecessary growth, decreasing mutual shading of leaves, enhancing light interception, increasing nutrient uptake, decreasing competition between the tassel and cob for available plant nutrients, diverting plant nutrients to the reproductive part which aids in better source-sink relationship and better cob development (Esechie and Al-Alawi, 2002) [4]. Maize tassel removal may affect light penetration in the canopy, especially if the crop is a C_4 plant needs high light requirement. Tassel removal may increase the seed yield and seed quality. Interaction of defoliation and tassel removal may also affect assimilate distribution between reproductive and vegetative organs. The objective of this investigation was to study the effect of detopping on yield and nutrient uptake by maize.

Materials and Methods
The present investigation was carried out at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during *rabi*, 2014-15. The farm is geographically situated at an altitude of 542.3 m above mean sea level at $17^0$19' N latitude and $78^0$28' E longitude and falls under the Southern Telangana Agro-Climatic Zone of Telangana state.

The experiment was laid out in randomized block design with factorial concept in three replications. Treatments comprised of three stages of detopping at different days after silking

and three heights of leaves detopping with single control (no detopping). The details of treatments are furnished below. Factor I: Days after Silking: D_1- 10 days after silking, D_2- 20 days after silking, D_3- 30 days after silking. Factor II: Detopping: L_1- detopping up to two leaves, L_2- detopping up to four leaves, L_3- detopping up to six leaves and Control (No- detopping). Maize seeds were planted in the field with plot size of 5.4 m x 4.8 m with spacing 60 cm x 20 cm on ridges at 19th Oct, 2014. The soil texture was sandy loamy with pH 7.5, EC 0.163 dSm^{-1} and organic carbon 0.40%. The maize cultivar was DHM-117. The soil was low in available nitrogen (175 kg ha^{-1}), medium in available phosphorus (36 kg ha^{-1}) and high in available potassium (342 kg ha^{-1}). For all treatments fertilizer was applied on the basis of recommended dose of N:P:K was 200:80:80 kg ha^{-1}. Crop has come to silking at 60 DAS and treatments were implemented 10 days interval. Herbicide and pesticide were used to control the weeds and pests. Every 10-12 days interval irrigation has given based on soil moisture content. Crop was harvested at 15th Feb 2015. Yield taken from net plot converted into kg ha^{-1}. Nutrient content such as N, P and K was determined by micro kjeldahl method, Vanado - molybdo phosphoric acid yellow colour method and ELICO flame photometer method respectively. And uptake of nutrient was calculated as fallows.

$$\text{Uptake of nutrient (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)}}{100} \text{ x grain yield (kg ha}^{-1})$$

Result and Discussion

Grain yield (kg ha^{-1})

Experimental data on grain yield was presented in Table 1. The difference in grain yield of maize was conspicuous with different stages and different heights of detopping. There is a direct relationship between grain yield and the number of leaves removed (Tilahun, 1993) [11]. In any crop, the degree of yield reduction is directly proportional to the percentage of leaf area destroyed. The loss of functional leaf area results in loss of photosynthetic area of plant and reduce the assimilate availability (Walpole and Morgan, 1970) [12]. The superior effect of top leaves on the yield depends on their extent of sunlight absorption. It was reported that apex leaves of ear could transfer about 23-91% of photosynthetic matters to the cobs. (Anderew and Peterson, 1984) [1].

The grain stores photosynthates via three main resources including current photosynthesis in the leaves, photosynthesis in green parts of plants excluding leaves and transferring from the storing parts (Hashemi and Maraashi, 1993) [5]. The findings are in accordance with those of Barimavandi *et al*. (2010) [2], Jalilian and Delkhoshi (2014) [6], Esechie and AL-Alawi (2002) [4], safari *et al*. (2013) [8], Wilhelm *et al*. (1995) [13].

Interaction effect of different stages and heights of detopping showed that significantly higher grain yield (7218 kg ha^{-1}) was recorded in 30 days after silking (D_3) and detopping up to 2 to leaves (L_1) and was on par with detopping up to 4 (L_2), 6 (L_3) top leaves and detopping at 20 days after silking (D_2) with detopping up to 2 and 4 top leaves. On the other hand D_1 (detopping at 10 days after silking) with 2, 4 and 6 top leaves removal recorded lowest grain yield (5288 kg ha^{-1}, 5238 kg ha^{-1} and 4168 kg ha^{-1}, respectively). In early stages of detopping up to 2, 4 and 6 top leaves grain yield reduced, but in later stages detopping up to 2, 4 top leaves did not altered the grain yield. However, when plants were detopped above the cob (L_3) drastically reduced the grain yield. These results were in conformity with Emam *et al*. (2013) [3]. Mimbar and Susylowati (1995) [7] and Subedi (1996).

Similarly, when compared with control vs. treatments, higher grain yield (7226 kg ha^{-1}) was recorded in control (no detopping), as compared to less grain yield noticed in detopping at 10 days after silking (D_1) with detopping up to 2, 4 and 6 top leaves and reduction of yield in percentages were 26.8%, 27.5% and 42.3% respectively. On other hand control produced significantly comparable grain yield with detopping at 30 days after silking with 2, 4 and 6 top leaves removal (reduction of yield in percentages were 0.1%, 0.3% and 0.4% respectively) and detopping at 20 days after silking with 2 and 4 top leaves removal (reduction yield in percentages were 0.4% and 0.42% respectively).

Nitrogen uptake

The data on nitrogen uptake in plant at harvest as influenced by different heights and different stages of detopping was presented in Table 1. Significantly higher nitrogen uptake by plant was observed in D_3 (detopping at 30 days after silking) and which was significantly superior over D_1 (detopping at 10 days after silking). However, D_3 (detopping at 20 days after silking) and D_2 (detopping at 20 days after silking) were found to be statistically comparable to each other. In turn, D_1 recorded the lowest nitrogen uptake.

Among different heights of detopping the highest nitrogen uptake was observed with L_1 (detopping up to 2 top leaves) and which was followed by L_2 (detopping up to 4 top leaves) but uptake in both treatments were significantly superior over L_3 (detopping up to 6 top leaves), on other hand L_3 recorded the lowest nitrogen uptake. Grain received highest portion of nitrogen uptake by plant compared to stover at harvest. The total N uptake of grain related to grain yield and not grain N content, and declined 17% with removal of 6 top leaves when compared to control (no detopping). The results were in conformity with the findings of Wilhelm *et al*. (1995) [13] who reported N removed from the canopy during detasseling increased linearly with number of leaves removed. The decline in N content of grain and stover was associated with a decline in dry matter production, not a change in grain and stover N concentration. Loss of photosynthetic tissue, the ability to intercept light and plant N contributed to the change in crop productive capacity.

Interaction effect of different stages and heights of detopping showed significantly higher nitrogen uptake recorded in detopping at 30 days after silking (D_3) and detopping up to 2 to leaves (L_1) and which was on par with detopping up to 6 (L_3) top leaves and also similar with detopping at 20 days after silking (D_2) with detopping up to 2 leaves. Whereas, D_1 (detopping at 10 days after silking) with 2, 4 and 6 top leaves removal recorded lowest nitrogen uptake. Further, when comparison with control vs. treatments, higher nitrogen uptake was recorded in control (no detopping), compared to low nitrogen uptake in detopping at 10 days after silking with detopping up to 2, 4 and 6 top leaves. On the other hand, control was found to be statistically comparable with detopping at 30 days after silking with 2, 4 and 6 top leaves removal and detopping at 20 days after silking with 2 and 4 top leaves removal.

The results were in line with Srisailam (2010) [9] who concluded that at early stages of detopping with 2, 4, 6 and 8 leaves lesser nitrogen content in straw at harvest. Further, lower nitrogen content was recorded when detopping was

done at early stages than the later stages of crop growth period.

Phosphorus uptake

Data obtained on phosphorus uptake was presented in Table 2. Different stages of Detopping showed that significantly maximum phosphorus uptake by plant was observed in D_3 (detopping at 30 days after silking) and which was significantly superior over D_1 (detopping at 10 days after silking). However, D_3 and D_2 (detopping at 20 days after silking) were significantly comparable. On other hand, D_1 recorded the lowest phosphorus uptake.

Among different heights of detopping significantly higher phosphorus uptake was observed with L_1 (detopping up to 2 top leaves) and which was followed by L_2 (detopping up to 4 top leaves). However, both L_1& L_2 significantly superior over L_3 (detopping up to 6 top leaves). On the other hand L_3 recorded the lowest phosphorus uptake.

Interaction effects showed that significantly higher phosphorus uptake was recorded in 30 days after silking (D_3) and detopping up to 2 to leaves (L_1) and which was on par with detopping up to 4 (L_2), 6 (L_3) top leaves and detopping at 20 days after silking (D_2) with detopping up to 2, 4 and 6 top leaves. On other hand, D_1 (detopping at 10 days after silking) with 2, 4 and 6 top leaves removal recorded lowest phosphorus uptake. When comparison with control vs. treatments, higher phosphorus uptake noticed in control (no detopping) and lesser uptake was noticed in detopping at 10 days after silking with detopping up to 2, 4 and 6 top leaves. However control comparable with detopping at 30 days after silking with 2, 4 and 6 top leaves removal and also similar with detopping at 20 days after silking with 2 and 4 top leaves removal.

Potassium uptake

Data obtained on potassium uptake was presented in Table 2. Different stages of detopping showed that, significantly higher potassium uptake by plant was observed in D_3 (detopping at 30 days after silking) and which was significantly superior over D_1 (detopping at 10 days after silking). However, D_3 and D_2 (detopping at 20 days after silking) were statistically comparable to each other at harvest. In turn D_1 recorded the lowest potassium uptake.

Incase of different heights of detopping significantly higher potassium uptake was observed with L_1 (detopping up to 2 top leaves) and which was followed by L_2 (detopping up to 4 top leaves) but both were significantly superior over L_3 (detopping up to 6 top leaves), in turn L_3 recorded the lowest potassium uptake.

Interaction effect showed that significantly higher potassium uptake was recorded in 30 days after silking (D_3) with detopping up to 2 to leaves (L_1). It was also observed that, detopping at 20 days after silking (D_2) with up to 4 top leaves (L_2) was on par with detopping up to 4 (L_2), 6 (L_3) top leaves at D_3 and detopping at 20 days after silking (D_2) with detopping up to 2, 4 and 6 top leaves. However, D_1 (detopping at 10 days after silking) with 2, 4 and 6 top leaves removal recorded lowest potassium uptake. Further, when compared with control vs. treatments, higher potassium uptake noticed in control (no detopping), as compared to lower uptake was observed in detopping at 10 days after silking with detopping up to 2, 4 and 6 top leaves. On the other hand, control was statistically comparable with detopping at 30 days after silking with 2, 4 and 6 top leaves removal and detopping at 20 days after silking with 2 and 4 and 6 top leaves removal.

Number of leaves removal above the cob at early stages of silking has causes decrease in grain yield. Nutrient uptake was related to production of grain and stover yield. As the number of leaf loss causes reduction in grain and stover yield, hence lower nutrient uptake by plant. Delay in detopping reduced the negative effect on yield and nutrient uptake.

Table 1: Grain yield and Nitrogen uptake (kg ha^{-1}) of maize as influenced by different stages and heights of detopping

Treatment	Grain yield kg (ha^{-1})				Nitrogen uptake							
					Stover				Grain			
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
D_1	5288	5238	4168	4898	43.7	41.2	34.8	39.9	68.6	65.9	53.8	62.8
D_2	7197	7195	6872	7088	43.6	41.5	34.4	39.8	91.9	91.9	87.5	90.4
D_3	7218	7198	7196	7204	40.0	40.9	37.4	39.4	93.8	93.1	93.1	93.3
Mean	6568	6544	6078		42.4	41.2	35.5		84.8	83.6	78.1	
Control	7226				57.61				93.5			
	SEm±	CD (P=0.05)			SEm±	CD (P=0.05)			SEm±	CD (P=0.05)		
Factor (I)	55.9	117.6			1.32	NS			0.91	1.91		
Factor (II)	48.4	101.8			1.14	2.39			0.79	1.66		
Interaction	96.9	203.7			2.28	NS			1.58	3.32		
Control vs. Treatment	118.7	352.9			2.79	8.29			1.93	5.74		

Factor (I): Different stages of detopping : D_1- 10 days after silking, D_2- 20 days after silking and D_3- 30 days after silking

Factor (II): Different heights of detopping: L_1- Detopping up to 2 top leaves, L_2- Detopping up to 4 top leaves, L_3- Detopping up to 6 top leaves

Control- No detopping

Table 2: Phosphorus and potassium uptake (kg ha^{-1}) of maize as influenced by different stages and heights of detopping

Treatment	Phosphorus uptake (kg ha^{-1})								Potassium uptake (kg ha^{-1})							
	Stover				Grain				Stover				Grain			
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
D_1	14.0	11.8	9.0	11.6	19.5	19.3	14.9	17.9	91.5	87.1	74.1	84.2	30.9	29.5	23.3	27.9
D_2	14.2	11.3	10.1	11.9	25.9	26.6	24.5	25.7	94.0	81.7	72.3	82.7	42.2	43.7	39.2	41.7
D_3	11.3	11.7	11.4	11.5	26.0	25.9	26.9	26.3	85.6	81.6	74.4	80.6	42.6	42.0	42.0	42.2
Mean	13.2	11.6	10.2		23.8	23.9	22.1		90.4	83.5	73.6		38.6	38.4	34.8	
Control	15.7				27.9				122.7				42.2			
	SEm±	CD (P=0.05)			SEm±	CD (P=0.05)			SEm±	CD (P=0.05)			SEm±	CD (P=0.05)		

Factor (I)	0.473	NS	0.53	1.12	2.41	NS	0.55	1.15
Factor (II)	0.410	0.861	0.46	0.97	2.09	4.39	0.47	0.99
Interaction	0.819	NS	0.92	1.93	4.17	NS	0.95	1.99
Control vs. Treatment	1.004	2.982	1.13	3.35	5.11	15.19	1.16	3.44

Factor (I): Different stages of detopping : D_1- 10 days after silking, D_2- 20 days after silking and D_3- 30 days after silking
Factor (II): Different heights of detopping: L_1- Detopping up to 2 top leaves, L_2- Detopping up to 4 top leaves, L_3- Detopping up to 6 top leaves
Control- No detopping

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