however, the terminal tassels were entirely modified into small single ears in place of tassels. The ears were small with few seeds (Fig. 5).

Figure 5. Terminal ears in place of tassels.

Compact sterile tassels with swollen glumes. Some of the plants showed compact tassels with bulky glumes and few stigmas emerging. Such types of tassels do not have viable pollen grains. Some of the glumes of the tassel also induced silk in place of anthers, and of these, few were able to pollinate and set individual grain (Fig. 6).

Figure 6. Tassels with bulky sterile glumes.

The unusual expressions in ear and tassel are suspected to be due to environmental factors. The monsoon season of 2008 was peculiar in terms of rainfall at regular intervals starting from the 2nd fortnight of June to mid-September 2008. Due to excess soil moisture, it became difficult to perform inter-cultural operations properly. The plants received less sunlight and also experienced low temperatures due to cloudy weather and frequent rainfall during the cropping season. Richey and Sprague (1932) reported the role of environment, i.e., shorter daylight periods and lower temperatures, and heredity in the development of silks in the tassels. Heslop-Harrison (2008) also shared the viewpoint that low temperatures, particularly when experienced through the dark period of the daily photoperiodic cycle, promote female sexual expression and depress male. The frequencies of the unusual expressions described above were extremely low. In case of widespread occurrence of these kinds of characteristics, the quality as well as the quantity of the maize grain or green cob will certainly suffer.

Influence of low nitrogen and excess soil moisture stress on yield of maize inbreds and their hybrids

--Massey, P; Warsi, MZK

Nitrogen fertilization in agriculture has emerged as a serious matter of world concern. Recent statistics on N fertilizer consumption patterns show the average application of N in developed countries is 250 kg ha^{-1}, while in developing countries it is82 kg ha^{-1}, and in sub-Saharan African it is as low as 5.0 kg ha^{-1} (Sasakawa Africa Assoc. Newsl. 18:4-5, 2002). Indian soils are characteristically low in organic matter and N. In India, water logging is also an important constraint for crop production. Out of a total of 6.55 million hectares of maize, about 2.5 million hectares are affected by an excess soil moisture (ESM) problem that causes an average 25-30 percent loss in national maize production every year (Directorate of Maize, Annual Maize Workshop, Kanpur, India, April 5-9, 2001; Bhan, Indian J. Agric. Res. 11:147-150, 1977; Howell and Hiler, Trans. ASAE 17(2):286-288, 1974). Carter et al. (Trans. ASAE 33(4):1203-1207, 1990) reported that yield reductions from 9 days of ESM during the vegetative and tasseling/silking stages can be as high as 77 and 61 percent, respectively. For June plantings, ESM may coincide with flowering, which may interfere with normal pollination behavior and seed setting (Savita et al., J. Plant Biol. 31(1):29-36, 2004). Therefore, it would be desirable to develop maize cultivars with increased resistance to ESM conditions and with improved N-use efficiency. For purposes of this report, a yield reduction of 25 percent or more is categorized as undesirable. Our results indicate we have ESM tolerant genotypes.

The materials consisted of 12 lines, 4 testers and their 48 crosses and were evaluated under low-N, excess soil moisture and normal conditions in Randomized Block Design during the monsoon season of 2007 at the Crop Research Centre of the University. The experimental plot consisted of 5-meter rows, with between row and within row spacing of 75 cm and 25 cm, respectively. For the low-N trials, 40 kg N ha^{-1} was applied. For the ESM trials, water-logging treatment was given at the knee-high growth stage for 6 days, with continuous submergence to about 5 cm. After 6 days of flooding, water was drained out of the plots.

Analysis of variance for yield under normal, low-N and ESM conditions revealed that mean squares for all genotypes studied were highly significant, clearly indicating the existence of genetic variability in the genotypes.

Estimation of yield loss in low-N conditions. The percent yield reduction varied from 0.37 per cent in L_8T_1 to 83.25 per cent in L_7T_1. While most of the hybrids showed relatively more susceptibility to low-N stress than inbred lines, this is likely due to reduced N-requirements associated with the short plant stature and lower yield potential of the inbreds. Among the lines, the highest reduction was recorded in L_{11} (56.36 percent) with the lowest reduction in L_2 (9.31 percent). Among testers, the highest reduction of 16.26 percent was reported in T_1 and the lowest reduction of 4.3 percent was observed in T_3. The crosses with low yield reduction in comparison to normal were L_1T_4 (0.7 percent), L_4T_2 (1 percent), L_6T_3 (3.8 percent) and L_9T_2 (4 percent). Six lines and 5 single cross hybrids showed yield reduction more than 25%, whereas the remaining test materials exhibited less than 25% yield reduction under low N conditions (Table 1).

Table 1. Yield reduction in genotypes under low-N and ESM conditions.

Genotype	% yield reduction	Response	% yield reduction	Response	Genotype	% yield reduction	Response	% yield reduction	Response
	Low-N	Low-N	ESM	ESM		Low-N	Low-N	ESM	ESM
POB. 33 C_3-12-2-1-1-2-2 (L_1)	39.58	S	59.02	S	L_5T_1	2.55	T	32.71	S
POB. 33 C_3-12-2-1-2-2-5 (L_2)	9.31	T	20.35	T	L_5T_2	3.02	T	30.09	S
POB. 33 C_3-142-1-6-1-1-4 (L_3)	12.16	T	58.29	S	L_5T_3	7.86	T	30.05	S
POB. 45 C_8-86-1-3-7-6-4 (L_4)	13.74	T	22.48	T	L_5T_4	32.39	S	70.63	S
POB. 45 C_8-45-2-6-1-2-7 (L_5)	23.16	T	42.22	S	L_6T_1	15.87	T	27.84	S
POB. 45 C_8-269-2-4-6-3-3 (L_6)	11.64	T	23.08	T	L_6T_2	9.69	T	25.92	S
POB. 45 C_8-86-1-1-7-5-1 (L_7)	20.89	T	44.41	S	L_6T_3	3.8	T	22.16	T
CLG 1708-1-1-9 (L_8)	40.27	S	37.19	S	L_6T_4	6.62	T	3.32	T
POB. 45 C_8-45-2-6-1-1-1 (L_9)	68.57	S	85.88	S	L_7T_1	83.25	S	50.34	S
POB. 45 C_8-86-1-3-4-5-2 (L_{10})	27.18	S	30.88	S	L_7T_2	3.23	T	19.40	T
POB. 45 C_8-86-1-3-2-2-5 (L_{11})	56.36	S	65.98	S	L_7T_3	19.97	T	44.57	S
POB. 45 C_8-269-2-4-6-6-1 (L_{12})	33.11	S	58.63	S	L_7T_4	18.34	T	29.49	S
POB. 445 ⊗ 58-6-3-B-B-B (T_1)	16.26	T	16.22	T	L_8T_1	0.37	T	33.03	S
POB. 446-74-2-B-B-B (T_2)	9.68	T	19.18	T	L_8T_2	17.21	T	19.11	T
CML-421(T_3)	4.3	T	3.87	T	L_8T_3	26.69	S	53.25	S
CML-423(T_4)	7.26	T	80.46	S	L_8T_4	6.05	T	35.52	S
L_1T_1	8.82	T	28.25	S	L_9T_1	27.57	S	27.71	S
L_1T_2	13	T	37.12	S	L_9T_2	4	T	22.88	T
L_1T_3	17.41	T	45.22	S	L_9T_3	8.1	T	43.40	S
L_1T_4	0.70	T	26.52	S	L_9T_4	8.89	T	38.26	S
L_2T_1	6.03	T	45.52	S	$L_{10}T_1$	4.01	T	19.17	T
L_2T_2	23.96	T	55.3	S	$L_{10}T_2$	5.58	T	51.02	S
L_2T_3	8.72	T	52.67	S	$L_{10}T_3$	5.42	T	41.35	S
L_2T_4	5.1	T	39.17	S	$L_{10}T_4$	18.08	T	31.13	S
L_3T_1	7.34	T	41.53	S	$L_{11}T_1$	22.04	T	26.50	S
L_3T_2	6.13	T	20.30	T	$L_{11}T_2$	18.68	T	49.89	S
L_3T_3	20.02	T	55.40	S	$L_{11}T_3$	9.64	T	41.94	S
L_3T_4	5.41	T	45.44	S	$L_{11}T_4$	16.52	T	33.02	S
L_4T_1	12.90	T	17.70	T	$L_{12}T_1$	6.12	T	39.27	S
L_4T_2	1.0	T	50.33	S	$L_{12}T_2$	28.53	S	84.73	S
L_4T_3	20.72	T	48.79	S	$L_{12}T_3$	17.79	T	45.41	S
L_4T_4	4.39	T	42.12	S	$L_{12}T_4$	11.18	T	21.18	T

Note: S = susceptible (greater than 25% yield reduction), T = tolerant (less than 25% yield reduction).

Estimation of yield losses in ESM conditions. The percent yield reduction among the crosses varied from 3.32 percent in L_6T_4 to 84.73 percent in $L_{12}T_2$. Crosses with moderate reductions in yield were L_8T_2 (19.11 percent), $L_{10}T_1$ (19.17 percent) and L_7T_2 (19.40 percent). Among the lines, the lowest reduction in yield was found in L_2 (20.35 percent) and the highest reduction in yield was found in L_9 (85.88 per cent). Among the testers, T_3 showed the least reduction in yield (3.87 percent) and T_4 showed maximum yield reduction (80.46 percent). Excess soil moisture conditions reduced the yield of nine lines, 1 tester and 39 hybrids by more than 25%, whereas the remaining test materials showed less than 25% yield reduction (Table 1).

Kernel carotenoids in 37 maize lines

--Mishra, P; Singh, NK

Vitamin A deficiency is a global problem. Among the three major cereals, only maize grain contains coloured carotenoid compounds that can be converted into vitamin A in humans and other animals. Maize exhibits considerable natural variability for kernel carotenoids, with some lines accumulating as much as 66 μg/g of dry weight (Brunson and Quackenbush, Crop Sci. 2:344-347, 1962; Buckner et al., Plant Cell 2:867-876, 1990; Harjes et al., *Science* 319:330-333, 2008). The present investigation was undertaken to characterize a set of potential inbred lines and populations for carotenoid content for further analysis and use in development of hybrid with enhanced level of carotenoids.

Thirty inbred lines and 7 improved populations of maize were characterized for kernel carotenoid content using the extraction protocol developed by Torbert Rocheford's Lab (http://www.crop-sci.uiuc.edu/faculty/rocheford/quick_carotenoid_analysis_protocol.pdf) and optical density measurement. The total carotenoid content was found to vary from a minimum of 3.54 μg/g dry weight to a maximum of 29.27 μg/g dry weight (Table).

Table. Carotenoid content of different maize lines.

S. No.	**Pedigree**	**Carotenoids (μg/g)**	**S. No.**	**Pedigree**	**Carotenoids (μg/g)**
1.	Hyd07R-104-6	18.29	20.	Hyd07R-456-2	20.41
2.	Hyd07R-300-6	12.75	21.	Hyd07R-419-2	24.52
3.	Hyd07R-325-3	17.72	22.	Hyd07R-421-2	17.26
4.	Hyd07R-301-3	22.35	23.	Hyd07R-451-1	27.21
5.	Hyd07R-456-1	18.15	24.	Hyd07R-419-1	27.84
6.	Hyd07R-301-2	23.35	25.	Hyd07R-438-4	19.21
7.	Hyd07R-441-1	21.41	26.	Hyd07R-445-4	29.21
8.	Hyd07R-302-1	21.55	27.	Hyd07R-418-2	22.92
9.	Hyd07R-325-6	23.07	28.	Hyd07R-418-4	22.21
10.	Hyd07R-437-2	19.26	29.	Hyd07R-443-4	27.87
11.	Hyd07R-325-2	22.58	30.	D-131	22.78
12.	Hyd07R-408-2	29.27	31.	D-765	16.55
13.	Hyd07R-438-1	22.29	32.	Kanchan	12.41
14.	Hyd07R-302-5	26.24	33.	Tarun	12.24
15.	Hyd07R-300-4	27.47	34.	Surya	21.24
16.	Hyd07R-407-5	29.10	35.	Amar	24.89
17.	Hyd07R-445-5	26.10	36.	Pragati	14.15
18.	Hyd07R-437-5	25.72	37.	CM-300	3.54
19.	Hyd07R-444-3	26.98			
C.D. (5%)		2.454			2.454