



Field Evaluation of Agronomic Traits of Some Promising Maize Lines Developed by the Topcross Method in the Northeast Areas of Vietnam

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Abstract Maize (*Zea mays* L.) is one of the most widely grown crops in the world. In Vietnam, maize is the second biggest annual crop after rice in terms of the harvested areas and is often consumed for animal feed as the livestock and poultry production industry. In this study, the agronomic traits including plant growth duration, height of insertion ear, height of ear/plant height, number of leaf, grains per ear, ear length and diameter as well as evaluating the ability resistance of pests/insects and disease as lodging of root and stalk of 29 maize lines which were generated by topcross breeding were evaluated in field condition at three different provinces in the northeast areas of Vietnam. We have identified and selected three promising maize lines (ĐB1, ĐB23 and ĐB24) with short growth duration, (105 to 109 days), good resistance to some major pests and disease, high yield and stability (96.3 to 100.4 quintals/ha), respectively. These lines are conformed to the structural crop conversion in the northeast areas of Vietnam. However, they should be promptly undergone for national testing and developed as new maize varieties.

Keywords Maize, agronomic traits, field evaluation, promising lines

Introduction

Maize (*Zea mays* L.) is one of the most widely grown crops in the world. Maize is being cultivated in over 165 countries in the world under complex-different agro-climatic conditions [1]. In Vietnam, maize is the second biggest annual crop after rice in terms of the harvested areas [2] and is often consumed for animal feed as the livestock and poultry production industry. This crop is cultivated in the diverse environment and mainly found both upland rainfed and irrigated lowland areas in the northeast, northwest, central highlands and the southeast regions in this country [3]. Both maize production and maize harvested areas were sharply increased from 1990 to 2014. Specifically, increased 2.73 times from 0.43 million ha in 1990 to 1.18 million ha in 2014 which was equivalent to 4.36% per year. Simultaneously, maize production was remarkably enhanced from 1.55 tons/ha to over 4.0 tons/ha in 1990-2014 [4]. However, maize yield in Vietnam is still lower to compare with world average level and other maize producing countries due to both abiotic and biotic stresses from climate change. Moreover, a set of maize varieties are not diverse.

In the previous our study, we have evaluated the agronomical traits of 31 inbred maize lines for their drought tolerance and combining ability of the promising inbred maize lines which selected from National Maize Institute, Hanoi, Vietnam [5]. We have identified 04 maize lines (C127, C127, C175 and C649) with high yield and short growth duration were recorded. 3 lines, including C188, C175 and C182 with high drought tolerance and 3 top- crossing hybrid combinations (THL C649 x CNL4097-1, C252 x CNL4097-1 và C175 x CNL4097-



1) with a higher yield than that of the control varieties [5]. Hence, the objectives of this study were to assess some agronomic traits of maize lines developed by topcross method in a field trial in the northeast areas of Vietnam.

Materials and Methods

Materials collection

In the previous this study, a total of 66 maize lines developed by the topcross methods were evaluated for their yield and abiotic and biotic stresses in Autumn season, 2014, in Dan Phuong, Hanoi, Vietnam. Twenty-eight maize lines (ĐB1 to ĐB28) with high yield potential, drought tolerance and short growth duration were selected for further evaluating their agronomic traits in the northeast areas of Vietnam (Table 1). Two maize varieties were DK9901 and DK8868 were used as the control.

Table 1: The list of promising crossed maize lines used in this study

No	Name of crossed lines	Code	No	Name of crossed lines	Code
1	C175 x CNL4097-1	ĐB1	16	C575 x CNL4097-1	ĐB16
2	C104x CNL4097-1	ĐB2	17	C760 x CNL4097-1	ĐB17
3	C112 x CNL4097-1	ĐB3	18	C604 x CNL4097-1	ĐB18
4	C118 x CNL4097-1	ĐB4	19	C614 x HNC1	ĐB19
5	C127 x CNL4097-1	ĐB5	20	C362 x HNC1	ĐB20
6	C140 x CNL4097-1	ĐB6	21	C766 x B67	ĐB21
7	C157 x CNL4097-1	ĐB7	22	C760 x HNC1	ĐB22
8	C174 x CNL4097-1	ĐB8	23	C252 x CNL4097-1	ĐB23
9	C91 x CNL4097-1	ĐB9	24	C649 x CNL4097-1	ĐB24
10	C762 x CNL4097-1	ĐB10	25	C112 x HNC1	ĐB25
11	C766 x CNL4097-1	ĐB11	26	C649 x B67	ĐB26
12	C194 x B67	ĐB12	27	C781 x HNC1	ĐB27
13	C194 x CNL4097-1	ĐB13	28	C766 X HCN1	ĐB28
14	C362 x B67	ĐB14	29	DK9901 (ĐB28)	ĐB29
15	C362 x CNL4097-1	ĐB15	30	DK8868 (ĐB28)	ĐB30

Methods

Evaluation of some agronomic traits of the maize lines

The abiotic and biotic stresses of maize lines were assessed following the report of Thu et al [5]. For the duration of growth including the sowing day, germinating day that were observed with over 50% of the seed emergence. The number of days was sowing to flowering and physiological ripening period were measure following the report of Thu et al [5].

Experimental design

Three experimental sites belonging to Bac Kan, Bac Giang and Tuyen Quang provinces of the northeast areas were selected for this study (Figure 1). All maize lines were grown following the conventional maize cultivation method. The experiments were conducted in a randomize blocks with at least three replications. Each experimental plot was 12.6 m² (4 rows x 0.7m x 4.25 m/row). The data were collected at the middle 2 rows of each experimental plot. The testing methods were performed following the standard of the method of Vietnam QCVN 01-56:2011/BNNPTNT. Also, data collections and measurement were conducted according to the CIMMYT [6, 7].

Phenotyping agronomic traits

The phenotyping was conducted following the report of Thu [8] (unpublished data). Briefly, plant height (cm): The 10 individual plants in each row were measured after 20-25 days after anthesis time (except for the first plant in a row). Measurement was calculated from the brace roots on the ground to the first branch of the tassel. The height of ear insertion (cm) was recorded from the bottom of the brace root on the ground to the node that bearing effective ear on the top. Stem diameter (cm) was determined at a point 10 cm above the ground by use of



the panme calliper. The number of basal leaves (leaf) was calculated by observation of full sheath, collar leaf and leaf blade.



Figure 1: The map of Vietnam and the experimental site (red words)

For leaf toughness measurement of maize was taken at after 25-30 days of tasseling and be upto each cropping season. According to CIMMYT (2007), it was identified at the time of differential number of green leaves between the formulas based on the score (1 -10) as correspondence of percentage of dead leaves by 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100%, respectively.

Regarding the plant growth status (1-5 rating score), then turning yellow of husk, green of plant and fulfilled ear of each plot was assessed based on the standard criteria as the uniformity of plant height, length of ear insertion, tolerant ability to pests/insects and diseases etc, of which the score 1 is the highest and score 5 is the lowest. For ear status evaluation (score 1-5), it was taken when harvesting based on some factors including kernel size uniformity, kernel tightness (ratio of filled grain), scatter kernel per row or compact row, ear color and level infestation of pests/insects and disease etc, among them, the score 1 is the highest and score 4 is the lowest, respectively.

For both ear length and ear diameter (cm), the measurement was taken from the bottom to the top of the first ear. Diameter of the middle ear was a measure of at least 30 individual plants with thrice.

Visual scoring for pests/insects and diseases (%): It was taken by visual estimation of pests/insects and diseases severity on a 1-5 rating score, where 1 implies no pests/insects and disease infestation, while 5 indicated severe disease symptoms. The average lines with a score of $0 < 2.5$ were considered as resistant, the score between $2.5 < 3.0$ as moderate resistance, and ranged scores of $3 < 4.0$ as moderately susceptible, and $4.0 - 5.0$ is susceptible [10].

Ratio of root lodging (%) was calculated based on the sloping angle $> 30^\circ$ to compare with the vertical side of the direction of maize stump. Ratio of stalk lodging (%) was recorded when the plant was racked under the effective ear. The ratio of husk coverage (1-5 score). It was evaluated before harvesting from 1-2 weeks. The



score 1 is highest husk coverage, score 2 is rather good, and 5 score is the weakest husk cover (husk cover tightness), 3 is husk cover looseness at top of ear; 4 is husk cover openness, and 5 is husk uncover gain and ear. Stalk rot and ear and grain rots were visually made from 1-5 rating score; 1 is equally 0% of the stalk and ear rots; 2 is approximately 10% number of the stalk and ear rots; 3, 4 and 5 scores are implied 20%, 30% and 40% of rots, respectively. Yield and yield component determination was performed following the previous method of Thu et al [5].

Statistical analyses

All data of agronomic traits were analysed by IRRISTAT 5.0 version and Excel ver 2010

Results and Discussion

Growth duration of the maize lines grown in autumn cropping seasons, 2015 in the northeast areas

As the results obtained, a total of 28 lines of maize and two controlled maize varieties were shown average early growth duration. Days to anthesis of the lines were ranged by 55 to 59 days at three different areas (Bac Kan, Bac Giang and Tuyen Quang provinces), while, average days to silking have fluctuated from 57-61 days which were negligible shorter than the control varieties (DK9901 and DK8868).

Generally, there have been 5 maize lines namely ĐB1, ĐB23, ĐB14, ĐB24 and ĐB28 which showed the shortest growth duration (105 to 109 days) to compare with other lines and the controlled varieties. Most of the growth duration of the remaining lines were similar as shown in Table 2.

Table 2. Growth duration of maize lines grown at different areas in the northeast in Autumn cropping season in 2015

No	Lines	Duration from sowing (days)								
		Anthesis			Silking			Physical ripening		
		Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang
1	ĐB1	57	56	58	58	57	59	106	107	105
2	ĐB2	57	56	55	60	58	57	109	112	110
3	ĐB3	58	57	56	59	58	58	109	112	110
4	ĐB4	58	58	58	60	59	60	110	113	111
5	ĐB5	56	55	59	58	56	61	110	113	111
6	ĐB6	58	57	56	59	58	58	110	113	111
7	ĐB7	57	56	57	59	58	58	107	110	108
8	ĐB8	57	56	56	58	57	58	110	113	111
9	ĐB9	58	55	56	59	58	58	106	109	107
10	ĐB10	56	56	58	58	57	59	110	113	111
11	ĐB11	57	56	58	58	57	60	111	114	112
12	ĐB12	59	57	57	60	59	59	109	112	110
13	ĐB13	59	55	57	61	56	59	111	114	112
14	ĐB14	56	55	58	58	56	60	105	108	106
15	ĐB15	56	57	58	58	58	60	111	114	112
16	ĐB16	58	56	57	59	57	59	110	113	111
17	ĐB17	56	55	58	58	57	60	109	112	110
18	ĐB18	58	56	58	60	57	59	109	112	110
19	ĐB19	59	57	55	61	58	57	108	111	109
20	ĐB20	57	56	56	59	57	58	113	116	114
21	ĐB21	57	56	58	60	57	60	109	112	110
22	ĐB22	56	59	58	58	60	61	109	112	110
23	ĐB23	58	55	56	59	55	57	106	109	107
24	ĐB24	58	55	57	60	55	57	107	107	105
25	ĐB25	56	58	59	58	59	59	110	113	111
26	ĐB26	59	56	58	60	56	59	111	114	112
27	ĐB27	59	56	58	61	59	61	110	113	111
28	ĐB28	55	58	57	57	59	60	105	108	106
29	DK9901	58	60	59	59	61	60	108	111	109
30	DK8868	60	59	60	61	61	61	110	113	111



Evaluation some agronomic traits of the lines grown at 3 provinces in northeast areas

Height of plant and ear insertion

The plant height and height of ear insertion are the important morphological traits of maize, are tightly associated to the growth and development, as well as lodging tolerance which is controlled by the QTLs/genes. However, these traits are also influenced by environmental conditions and farming techniques. In this study, there was a significant difference between the plant height and ear insertion height at the experimental sites. The lowest plant height was the ĐB28 line (180.7 cm), while, the highest line was ĐB19 (215.7 cm). Generally, most plant height of maize was either a higher nor similar height to compare with the controlled varieties at 3 experimental areas. Comparably, the average ear insertion height of all lines was almost identical as comparing with the control plants. The CV% variation revealed the stability and uniformity of the plant height and ear insertion height characteristic of all lines grown at 3 experimental sites (Table 3).

The ratio of ear insertion height per plant height of the lines was varied from 47.7% to 60.8%, of which the ĐB7 line was the highest by 56.2%, on average among three experimental sites, meanwhile, the lowest line was ĐB27 (49.9%) which was similar with the control variety (DK9901). The results demonstrated that the ratio of ear insertion height per plant height was generally appropriate for growing at 3 provincial sites, where was favourable for pollination and be caused by negligible root and stalk lodging effects. It has lead to increase in maize yield. Our results were consists of with some previous reports, which showed the most suitable ratio of ear insertion height per plant height ranging from 40.0% to 60% respectively.

Table 3: Plant height, height of insertion of ear and ratio of ear height per plant length in autumn cropping season in 2015 in northeast areas

TT	THL	Plant height (cm)			Height of insertion ear (cm)			Height of ear/ Plant length (%)		
		Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang
1	ĐB1	198.0	214	187.4	99.2	115.3	106	50.1	53.9	56.6
2	ĐB2	195.7	211.4	207.8	98.2	117.8	114.8	50.2	55.7	55.2
3	ĐB3	186.8	219.1	188.0	101.2	114.8	100.4	54.2	52.4	53.4
4	ĐB4	199.9	176.3	187.8	111.2	89.5	105.4	55.6	50.8	56.1
5	ĐB5	195.1	215.0	201.2	109.4	118.7	107.0	56.1	55.2	53.2
6	ĐB6	193.4	194.4	211.2	104.7	107.4	117.6	54.1	55.2	55.7
7	ĐB7	185.3	198.7	189.6	110.1	110.4	101.4	59.4	55.6	53.5
8	ĐB8	204.8	210.0	189.2	110.1	116.9	102.2	53.8	55.7	54.0
9	ĐB9	197.4	213.7	212.0	102.6	119.2	101.4	52.0	55.8	47.8
10	ĐB10	198.1	220.9	219.8	109.4	114.2	114.4	55.2	51.7	52.0
11	ĐB11	200.6	215.2	190.0	111.5	115.6	104.0	55.6	53.7	54.7
12	ĐB12	197.3	211.3	190.0	110.3	116.4	97.4	55.9	55.1	51.3
13	ĐB13	198.7	223.4	221.2	111.5	115.9	111.2	56.1	51.9	50.3
14	ĐB14	203.6	195.9	209.2	100.1	100.1	115.8	49.2	51.1	55.4
15	ĐB15	202.2	210.5	205.8	104.8	111.3	113.0	51.8	52.9	54.9
16	ĐB16	200.9	212.2	194.4	101.3	122	115.5	50.4	57.5	59.4
17	ĐB17	197.7	214.1	194.8	96.3	120.3	118.4	48.7	56.2	60.8
18	ĐB18	197.6	217.4	187.7	105.6	120.6	107.8	53.4	55.5	57.4
19	ĐB19	200.5	217.0	214.4	102.7	116.1	112.0	51.2	53.5	52.2
20	ĐB20	203.2	212.9	197.0	109.1	114.2	99.6	53.7	53.6	50.6
21	ĐB21	207.3	210.9	201.6	109.8	114.6	107.0	53.0	54.3	53.1
22	ĐB22	185.8	208.2	199.8	100.5	116.8	104	54.1	56.1	52.1
23	ĐB23	205.1	208.7	190.0	110.5	118.6	115.2	53.9	56.8	60.6
24	ĐB24	203.2	211.3	202	108.8	111.4	102.8	53.5	52.7	50.9
25	ĐB25	175.7	188.1	194.0	89.6	90.9	102.6	51.0	48.3	52.9
26	ĐB26	195.2	213.5	199.2	98.0	112.9	103.8	50.2	52.9	52.1



27	ĐB27	172.2	195.8	192.7	87.8	98.1	93.6	51.0	50.1	48.6
28	ĐB28	183.4	171.7	189.7	95.8	90.1	104.7	52.2	52.5	55.2
29	DK9901	192.4	215.8	194.4	98.0	106.1	92.8	50.9	49.2	47.7
30	DK8868	202.5	205.2	196.4	110.6	112.3	107.2	54.6	54.7	54.6
CV(%)		7.70	7.25	7.24	7.03	5.80	6.32	-	-	-
LSD0.05		24.66	24.60	23.47	11.94	10.57	11.01	-	-	-

In maize, the leaves are the key photosynthetic organ which taken part in determining the yield components and quality of maize kernels. A large number of leaves and leaf area index are led to high photosynthetic efficiency, improved dry matter accumulation and increase yield. According to some studies, approximately 90.0% to 95.9% of the dry matter which is accumulated in the plant is due to its grouping activity of leaves. Moreover, the number of leaves trait, number of nodes and growth duration of maize are controlled by the complexed genes, which are less affected by environmental conditions and cultivating techniques.

The results showed that the average total number of the final leaves of all maize line grown at 3 sites were ranged from 18.3 to 19.7 leaves which were similar to the two controlled varieties, DK9901 (18.6 leaves) and DK8868 (19.2 leaves), respectively. The ĐB1 line has had the highest average number of leaves (19.7 leaves) (Table 4).

Table 4: Number of final leaf and ratio gains/ear of maize lines in the autumn cropping season, 2015 in northeast areas

No	Lines	Number of leaves			Ratio grain/ ear (%)		
		Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang
1	ĐB1	20.2	19.5	19.5	79.81	64.5	82.1
2	ĐB2	20.1	18.9	19.3	76.52	60.8	76.1
3	ĐB3	20.2	19.2	18.3	79.58	59.3	78.0
4	ĐB4	19.9	18.3	17.9	78.63	61.7	75.1
5	ĐB5	19.2	18.7	18.2	77.15	62.8	78.9
6	ĐB6	19.9	18.8	18.8	79.20	64.6	77.3
7	ĐB7	19.0	18.3	18.3	74.88	57.6	78.8
8	ĐB8	19.7	18.5	19.3	74.24	58.8	79.3
9	ĐB9	20.0	19.5	18.8	77.31	59.4	72.4
10	ĐB10	19.4	18.9	18.5	78.75	62.0	81.5
11	ĐB11	20.3	19.0	18.8	79.28	60.7	72.2
12	ĐB12	20.2	19.8	18.6	79.39	59.3	74.4
13	ĐB13	19.5	19.3	19.3	74.72	60.7	72.0
14	ĐB14	19.9	18.7	19.0	74.88	65.0	80.3
15	ĐB15	17.9	19.0	19.7	76.13	62.7	75.4
16	ĐB16	18.1	19.4	19.3	73.48	63.3	71.2
17	ĐB17	18.0	19.3	19.0	77.06	65.8	78.5
18	ĐB18	18.6	18.3	19.6	75.86	62.0	72.5
19	ĐB19	18.6	19.5	18.7	75.51	60.5	80.8
20	ĐB20	18.3	18.8	18.5	76.35	62.0	72.2
21	ĐB21	17.8	19.3	19.3	79.67	64.8	73.2
22	ĐB22	18.2	18.5	18.8	77.03	58.0	74.9
23	ĐB23	17.8	19.3	17.7	79.91	62.9	81.9
24	ĐB24	17.7	18.5	18.9	79.55	58.8	80.8
25	ĐB25	17.8	18.3	19.2	77.46	51.25	72.9
26	ĐB26	17.9	19.2	19.3	77.60	63.8	73.2
27	ĐB27	18.8	18.7	19.6	77.42	54.77	70.1
28	ĐB28	18.9	19.7	19.7	76.36	53.77	69.4
29	DK9901	18.9	18.8	18.0	78.26	56.3	75.1
30	DK8868	19.5	19.2	18.8	79.27	62.9	76.4



Evaluating of pests/insects, diseases and lodging resistance of the maize lines

Pests/insects and disease resistance

The promising maize lines and varieties are not only high yield but also resist against both abiotic and biotic stresses (pests, insects, disease, drought, heat, lodging resistance etc...). Therefore, it is essential to evaluate the stability of maize lines grown under unfavourable conditions and different ecological conditions.

In this study, our initial assessment showed that all maize lines have not much affected with some major pests and diseases including stem borer, rust and sheath blight. Specifically, for stem borer of 3 experimental sites, all maize lines were rated at 1 to 2 (score) which were equivalent to the control varieties. They have slightly affected by rust disease, the grown plants at Bac Kan province were observed to less than score 2. For sheath blight resistance, the affection was less than 4.0% in all growing sites (Table 5). Similarly, leaf blight was slightly affected at 1 to 2 score, except for some lines, ĐB15, ĐB18, and ĐB25 lines which were rated over 3.0 score at Bac Giang and Tuyen Quang provinces, respectively (Figure 6).

Table 5: Evaluation of pest/insects and diseases resistance of the maize lines in the cropping season, 2015 in the northeast areas

No	Lines	Stem borer (score)			Rust (score)			Sheath blight (%)		
		Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang
1	ĐB1	1.0	1.0	1.0	0.0	2.3	2.6	2.0	2.8	0.0
2	ĐB2	1.0	1.0	1.0	0.0	2.0	2.1	2.0	2.1	0.0
3	ĐB3	1.0	1.0	1.0	0.0	2.6	3.1	0.0	3.5	0.0
4	ĐB4	2.0	1.0	1.0	0.0	2.3	2.6	2.9	2.8	0.0
5	ĐB5	1.0	1.0	1.0	0.0	2.4	1.8	1.0	1.4	0.0
6	ĐB6	2.0	1.0	2.0	0.0	1.7	2.4	2.0	2.8	3.5
7	ĐB7	2.0	1.0	1.0	0.0	2.8	3.7	2.0	4.2	0.0
8	ĐB8	1.0	1.0	1.0	0.0	1.4	1.8	2.0	2.1	2.5
9	ĐB9	1.0	1.0	1.0	0.0	1.4	1.8	1.0	2.1	0.0
10	ĐB10	2.0	1.0	1.0	0.0	2.7	2.3	1.0	2.1	0.0
11	ĐB11	1.0	1.0	1.0	0.0	2.3	2.6	1.0	2.8	2.1
12	ĐB12	1.0	1.0	2.0	0.0	2.2	3.4	2.0	4.2	2.6
13	ĐB13	1.0	1.0	1.0	0.0	3.7	4.4	0.0	4.9	0.0
14	ĐB14	2.0	1.0	1.0	0.0	2.0	2.1	0.0	2.1	0.0
15	ĐB15	1.0	1.0	2.0	0.0	2.0	2.1	1.0	2.1	3.2
16	ĐB16	1.0	1.0	2.0	0.0	2.0	2.1	2.0	2.1	5.6
17	ĐB17	1.0	1.0	2.0	0.0	2.3	2.6	3.9	2.8	3.4
18	ĐB18	2.0	1.0	1.0	0.0	1.8	1.6	2.9	1.4	2.9
19	ĐB19	1.0	1.0	1.0	0.0	1.8	1.6	3.9	1.4	0.0
20	ĐB20	2.0	1.0	1.0	0.0	3.2	3.4	3.9	3.5	2.2
21	ĐB21	1.0	1.0	1.0	0.0	2.8	3.7	1.0	4.2	0.0
22	ĐB22	1.0	1.0	1.0	0.0	2.6	3.1	0.0	3.5	0.0
23	ĐB23	1.0	1.0	1.0	0.0	2.6	3.1	0.0	3.5	0.0
24	ĐB24	1.0	1.0	1.0	0.0	1.8	1.6	0.0	1.4	1.5
25	ĐB25	1.0	2.0	1.0	0.0	1.3	0.5	2.0	0.0	1.7
26	ĐB26	1.0	1.0	1.0	3.9	2.7	2.3	0.0	2.1	0.0
27	ĐB27	2.0	2.0	1.0	0.0	1.3	0.5	1.0	0.0	4.2
28	ĐB28	1.0	2.0	2.0	0.0	2.5	1.0	1.0	0.0	3.2
29	DK9901	1.0	1.0	2.0	2.0	3.1	4.2	1.0	4.9	0.0
30	DK8868	1.0	1.0	1.0	0.0	2.8	3.7	0.0	4.2	0.0

Evaluation of root and stalk lodging tolerance

In general, the climatic conditions in the cropping season in autumn, 2015 in three provinces in the northeast areas were relatively stable. There was no heavy rain and storms occurred. Hence, most of the maize lines were grown well without root and stalk lodging. However, the ratio of root lodging at Tuyen Quang – experimental site of some lines was virtually scored at 2.5 to 6.0% such as ĐB6, ĐB15, ĐB16 and ĐB28, respectively. Overall, most of the lines have been able to resist some major pests and diseases in maize (Table 6).



Yield components and actual yield obtained

The ear length is a trait which is controlled by genetic factor but significantly affected by environmental conditions. In this study, the average of ear length of all lines were fluctuated based on the growing areas, among them, 4 out of 28 maize lines (4/28) grown at the experimental site of Bac Kan province, 5/28 lines at Bac Giang province, and 2/28 lines planted at Tuyen Quang province which showed ear length to be significantly higher than 17 cm to compare with other lines, also were greater than the control varieties DK9901 (16.5cm) and DK8868 (16.7cm). The ear length of other lines was similar to the ear length of the controlled varieties. For ear diameter, the diameters of the ear of maize lines were ranged from 4.2 to 4.7 cm at Bac Kan province, Bac Giang (4.4 to 5.1 cm) and Tuyen Quang (3.8 to 4.9 cm), which were similar to the ear diameter of control varieties.

Regarding the number of gains row per ear, it was generally shown that the average number of grain row per maize ear was ranged from 13.3 to 14.3-grain rows in the 3 experimental sites that were a higher than the control varieties, DK9901 (12.2-13.5 rows) and DK8868 (12.3-14.3 gain rows), respectively. Note worthily that the highest average number of grain rows in all three growing areas was ĐB24, followed by ĐB3, ĐB1, ĐB23 and ĐB26, while the lowest was ĐB16 line (Table 7).

Table 6: Evaluation of leaf blight resistance, the ratio of root lodging and stalk lodging in autumn cropping season, 2015 in northeast areas

TT	THL	Leaf blight (score)			Root lodging (%)			Stalk lodging (%)		
		Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang
1	ĐB1	1.0	2.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
2	ĐB2	1.0	2.0	1.0	0.0	1.0	0	0.0	1.0	0.0
3	ĐB3	2.0	1.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
4	ĐB4	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
5	ĐB5	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
6	ĐB6	1.0	2.0	3.0	0.0	2.0	2.5	0.0	1.0	2.5
7	ĐB7	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
8	ĐB8	1.0	2.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
9	ĐB9	1.0	1.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
10	ĐB10	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
11	ĐB11	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
12	ĐB12	1.0	1.0	2.0	0.0	1.0	4.5	0.0	1.0	4.6
13	ĐB13	1.0	2.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
14	ĐB14	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
15	ĐB15	1.0	1.0	3.0	0.0	1.0	6.1	0.0	1.0	6.2
16	ĐB16	1.0	2.0	2.0	0.0	1.0	4.2	0.0	1.0	4.1
17	ĐB17	1.0	1.0	2.0	0.0	1.0	3.5	0.0	1.0	3.5
18	ĐB18	1.0	1.0	3.0	0.0	2.0	3.0	0.0	1.0	2.9
19	ĐB19	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
20	ĐB20	2.0	2.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
21	ĐB21	1.0	2.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
22	ĐB22	2.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
23	ĐB23	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
24	ĐB24	1.0	1.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
25	ĐB25	1.0	3.5	1.0	0.0	1.0	0.0	0.0	1.0	0.0
26	ĐB26	1.0	2.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0
27	ĐB27	2.0	2.5	2.0	0.0	1.0	4.8	0.0	1.0	4.7
28	ĐB28	1.0	3.0	2.0	0.0	1.0	6.0	0.0	1.0	5.9
29	DK9901	1.0	2.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
30	DK8868	2.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0



In the 3 growing areas, there was a difference of the grains per row which was from 30.1 to 36.4 grains/row at Bac Kan, Bac Giang (29.1 to 39.6 grains/row), and Tuyen Quang (24.3 to 26.4 grains/row), respectively. The highest average grains/row at the 3 experimental sites was found in Correspondingly, the ratio of grains per ear of all maize lines has differed among the growing site, in which the highest average of the score was 3 that found in ĐB1, following to ĐB14 and ĐB23 lines, respectively.

Table 7: Yield and yield components of the maize lines in autumn cropping season in northeast areas

No	Lines	Ear length (cm)			Ear diameter (cm)			Number of grain row/ear (row)		
		Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang
1	ĐB1	17.0	16.2	18.7	4.5	4.8	4.9	12.8	14.5	14.6
2	ĐB2	16.1	17.2	15.6	4.5	4.5	4.0	12.8	14.3	13.5
3	ĐB3	15.6	14.2	16.4	4.2	5.1	4.2	14.1	15.7	13.7
4	ĐB4	16.0	13.9	14.6	4.3	4.5	4.0	14.4	14.3	13.5
5	ĐB5	16.8	17.6	16.6	4.5	4.4	4.0	14.7	13.0	13.8
6	ĐB6	16.8	16.3	15.7	4.5	4.3	4.1	14.7	14.6	13.7
7	ĐB7	16.0	15.4	13.7	4.4	4.6	4.0	14.3	14.7	13.6
8	ĐB8	16.6	14.7	16.8	4.5	4.9	4.0	14.5	15.4	13.4
9	ĐB9	15.9	17.1	13.4	4.4	4.5	3.8	14.6	14.4	12.4
10	ĐB10	16.7	16.4	16.3	4.6	4.6	4.5	14.6	14.1	14.3
11	ĐB11	16.5	15.3	13.9	4.5	4.4	3.8	14.6	14.2	12.6
12	ĐB12	16.3	17.2	14.6	4.6	4.4	3.9	12.6	14.2	12.8
13	ĐB13	16.7	15.3	13.8	4.6	4.9	3.8	12.2	16	12.6
14	ĐB14	16.6	15.2	16.2	4.5	4.4	4.4	12.5	12.6	13.9
15	ĐB15	16.8	15.8	15.4	4.6	4.6	4.2	12.6	14.8	13.5
16	ĐB16	16.5	16.4	13.2	4.4	4.4	3.9	12.5	13.7	12.7
17	ĐB17	17.1	16.0	14.9	4.7	4.5	3.8	12.5	13.5	13.5
18	ĐB18	16.5	15.2	13.8	4.6	4.4	3.9	12.6	13.8	13.6
19	ĐB19	16.8	15.2	15.8	4.6	4.8	4.2	12.6	12.9	13.8
20	ĐB20	16.5	16.3	13.6	4.4	4.5	3.8	12.5	14.6	12.4
21	ĐB21	16.7	16.4	16.2	4.5	4.4	4.0	12.5	14.7	13.3
22	ĐB22	16.9	16.4	15.5	4.5	4.5	4.0	12.6	14.0	13.5
23	ĐB23	17.2	16.8	17.1	4.4	4.6	4.8	12.7	14.7	14.5
24	ĐB24	17.1	17.2	16.8	4.5	4.8	4.4	12.5	16.6	14.2
25	ĐB25	16.7	13.8	14.9	4.5	4.7	4.2	12.7	12.9	13.8
26	ĐB26	16.3	15.4	14.7	4.5	4.7	4.3	14.2	14.9	14.3
27	ĐB27	16.7	13.8	13.5	4.6	4.5	3.9	14.3	14.1	13.3
28	ĐB28	15.6	14.9	13.2	4.2	4.9	3.9	14.1	14.5	12.3
29	DK9901	16.5	15.3	14.9	4.5	4.4	4.0	12.2	13.5	13.4
30	DK8868	16.7	16.7	15.0	4.5	4.3	3.9	12.3	14.3	13.6
TB		16.5	15.8	15.2	4.5	4.9	4.2	13.3	14.3	13.5
CV(%)		3.74	3.60	3.88	4.38	5.50	5.88	2.69	2.95	2.82
LSD		1.01	0.93	0.96	0.32	0.41	0.40	0.59	0.69	0.62

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For P.1000 grains weight, the average weight of grains in the 3 growing areas was 13 out of 28 maize lines was a higher 320g, of which the highest of P 1000 was ĐB1 and ĐB23 lines. It also found that the average P 1000 grains weight of all maize lines grown at Bac Kan and Bac Giang areas were similarly ranged from 284.3 g to 285.4 g, respectively. The highest average P 1000 grain weight of lines was found in Tuyen Quang province with the value 342.7 g as shown in Table 8.

For the actual yield gained: there was a difference in dry grain yield among the maize lines. The most productivity obtained was in ĐB11 (58.3 quintals /ha), ĐB24 (100.8 quintals/ha) in Bac Kan. In Bac Giang site, it was ranging from 61.3 quintals/ha (ĐB27) to 96.7 quintals/ha (ĐB1); and was 62.7 quintals/ha to 96.3 quintals/ha (ĐB1) in Tuyen Quang, respectively.

The highest average of actual yield of all 3 experimental sites was found in ĐB1 line (100.4; 96.7 and 96.3 quintals/ha), followed by the ĐB23 and ĐB24 lines (Table 8). Overall, three maize lines (ĐB1, ĐB23 and ĐB24) have shown to be yield stability in whole the experimental sites which were higher than other remaining maize lines and the control varieties. It noted that among the 3 growing sites, the highest average yield obtained was found in Bac Kan (average 82.85 quintals/ha), two other growing Bac Giang and Tuyen Quang has gained the similar average yield by 75.61 quintals/ha and 75.15 quintals/ha, respectively. In Vietnam, great attempts have been made to develop new maize varieties with high yield and disease resistance [9]

Table 8: Yield and yield components of the maize lines growing in different areas in the north of Vietnam

No	Line	Number of grain/ row (grain)			P1000 (g)			Yield (100kg/ha)		
		Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang	Bac Kan	Bac Giang	Tuyen Quang
1	ĐB1	35.3	37.8	37.9	313.9	300.1	395	100.4	96.7	96.3
2	ĐB2	32.6	35.0	32.0	250.8	283.2	350	66.9	74.9	73.9
3	ĐB3	30.1	29.7	34.6	285.8	285.1	360.5	83.3	72.0	76.9
4	ĐB4	31.6	32.3	30.7	264.7	304.8	330	91.2	65.7	68.5
5	ĐB5	34.0	39.7	34.9	281.1	275.1	370.7	92.3	81.3	85.8
6	ĐB6	33.4	33.9	32.6	295.6	310.3	372	82.9	69.4	77.4
7	ĐB7	32.9	32.2	28.2	308.9	298.8	325.0	87.5	75.6	72.5
8	ĐB8	34.3	29.6	35.6	297.5	316.6	350.0	75.2	78.8	85.3
9	ĐB9	32.5	39.6	26.4	254.7	250.1	340.6	89.7	80.7	67.2
10	ĐB10	31.3	33.5	35.6	285.8	304.1	375.0	92.9	80.9	85.5
11	ĐB11	34.7	32.5	25.7	265.8	281	335.0	58.3	74.7	66.1
12	ĐB12	34.0	37.5	30.3	278.8	251.1	345.8	77.8	77.2	73.9
13	ĐB13	33.8	33.8	24.8	316.2	261.8	300	68.6	77.6	62.7
14	ĐB14	34.3	38.7	34.6	251.3	275.1	370.4	75.5	72.4	80.3
15	ĐB15	35.3	35.5	31.7	269.1	286.2	330.0	77.1	79.2	77.2
16	ĐB16	34.4	35.1	24.3	286.2	267.3	305.8	83.6	72.1	67.5
17	ĐB17	36.4	31.5	30.2	279.8	327.2	330	71.5	72.6	77.3
18	ĐB18	34.3	32.7	26.3	269.3	275.9	328.6	77.7	69.3	70.2
19	ĐB19	35.3	29.8	32.8	274.8	351.7	354.7	90.4	78.3	80.0
20	ĐB20	34.4	33.1	26.2	291.5	292.3	355	87.6	77.2	69.3
21	ĐB21	35.7	34.5	30.2	296.9	269.9	340.0	72.8	80.8	73.3
22	ĐB22	34.9	34.2	32.8	291.1	247.2	340.9	77.3	76.0	76.4
23	ĐB23	35.1	33.1	37.1	290.1	304.3	382.4	99.7	84.9	90.3
24	ĐB24	34.6	39.0	35.7	292.1	246.1	372.0	100.8	84.9	86.7
25	ĐB25	36.8	28.1	32.0	288.9	310.9	330.0	73.8	64.0	73.6
26	ĐB26	32.9	31.8	31.2	288.7	316.5	340.0	95.1	82.8	78.4
27	ĐB27	34.6	30.7	25.6	294.9	281.4	300.6	77.4	61.3	68.5
28	ĐB28	30.1	30.8	24.8	305.1	279.0	310.0	85.2	64.7	65.7
29	DK9901	34.1	33.5	29.6	280.0	252.1	310.0	80.6	70.5	77.0
30	DK8868	35.0	37.5	31.9	277.3	260.9	330.0	92.8	78.0	78.8
Average		34.0	33.9	30.9	284.3	285.4	342.7	82.85	75.61	75.15
CV(%)		8.19	8.79	9.02	4.95	6.34	5.60	7.2	8.7	9.1
LSD _{0.05}		4.54	4.86	4.55	22.96	29.56	31.33	9.7	10.8	11.3



In summary, among the 28 maize lines experimented in the northeast areas, we have selected three promising lines included: ĐB1, ĐB23 and ĐB24 which showed good agronomic traits, stable yield and tolerance of abiotic and biotic stresses such as stem borer, sheath blight, rust etc... as well as root and stalk lodging. Moreover, they have had a short growth duration which is shorter than that of the control varieties. Noteworthy, the ĐB1 line was generated by crossing the parental C436A and C497 lines which were the most promising line, well-grown and developed, short growth duration, and good resistance to both abiotic and biotic stresses. Therefore, these lines should be promptly developed as new maize varieties and grown in the northeast areas.

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