

DEVELOPMENT OF HIGH YIELD, DROUGHT TOLERANT MAIZE HYBRIDS FOR CENTRAL HIGHLAND PROVINCES

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Abstract

The Central Highlands is one of three main maize regions in Vietnam. Drought could be considered as the greatest reason of reduction in maize grain yield and production, therefore it is necessary to develop drought tolerant maize hybrids with high yield potential. Through testing and demonstration trials, it was found that three maize hybrids named LVN66, LVN092, LVN146 were of well drought tolerance, yield of 9-11 tons.ha⁻¹, 6-30% higher than of popular local hybrids and an increase in economic efficiency by 3-8 million VND.ha⁻¹, accepted by farmers for production development in the Central Highlands and should be developed in the next years.

Key words: Drought tolerance, maize hybrids, Central Highlands

INTRODUCTION

After more than 20 years of developing maize hybrids in Vietnam, maize production agro-ecological zones have been formed, including Red River Delta, North Upland and Mountainous regions, North Central Coast, South Central Coast, South East, the Central Highlands and the Mekong River Delta. According to General Statistics Office of Vietnam, maize area, grain yield and production in the Central Highlands in 2012 was 235,000 ha, were equivalent to 20.6% maize area of Vietnam, 5.1 tons.ha⁻¹ and 1.2 million tons, respectively. It was 5.03 times in maize area and 13.0 times in production as much as in 2005.

As one of the main maize regions in Vietnam but maize production in the Central Highlands is facing so many challenges such as drought, diseases, low investment, obsolete processing and storage and so on, in which drought and diseases should be two factors that are most responsible for limiting maize yield, production and area expansion in Autumn-Winter and Winter-Spring crop seasons. In order to develop maize production in these seasons for the Central Highland provinces, it is essential to develop high yield hybrids quite well tolerant to drought.

MATERIALS AND METHODS

Materials

Materials used in the study included LVN66, LVN092, LVN146, VN595, CP888.

Methods

- VCU testing method: in compliance with the Value of Cultivation and Use testing on maize (QCVN 01-56:2011/BNN-PTNT), issued by the Ministry of Agriculture and Rural Development and conducted by Center for Plant Testing of South Region.

- The demonstrations were carried out at different ecological locals with 1-5 ha for each and cultivated by the procedures of National Maize Research Institute.
- Identifying hybrid varieties based on demonstrations, farming conferences/workshops and the feedback of experts, scientists, managers, farmers and enterprises.
- Transferring new hybrid varieties into practice based on demand, investment and development capacity of farmers and companies.

RESULTS AND DISCUSSION

The yield of some promising maize hybrids on basic testing and production testing in Central Highland provinces

From the most promising varieties, Maize Research Institute selected some best varieties for basic testing, conducted at official testing system in the Central Highlands. Results are presented in Table 1.

Through basic testing in 4 crop seasons, it showed that average grain yield of LVN66 was 9.0 tons.ha⁻¹ which was higher than that of C919 (11.1%) and CP888 (11.3%) while both LVN092 and VN595 up to 9.5 tons. ha⁻¹) increased by 17.2% over C919 and by 20.2% compared with CP888. Especially, Hybrid LVN146 produced superior yield (10 tons.ha⁻¹) to C919 and CP888 by 28.3% and 31.6%, respectively.

The production testing results (Table 2.) also indicated that the grain yield of LVN66 was 9.3 tons.ha⁻¹, 5.6% higher than C919 and 6.8% higher than CP888 and of VN595 was 9.4 tons.ha⁻¹, increased by 6.8% and 8.0% compared with C919 and CP888, respectively; and the highest average yield obtained on production testing was 10.7 tons.ha⁻¹ for Hybrid LVN146, superior to C919 (21.5%) and CP888 (22.9%) but for LVN092, it was not significantly different in yield to these checks.

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Table 1. The average yield on the basic testing of LVN66; LVN146; LVN092 and VN595 in the Central Highlands (tons.ha⁻¹) in 4 crop seasons

| No. | Hybrids | Grain yield at testing locations (tons.ha ⁻¹) | | Mean yield (tons.ha ⁻¹) | Advantage over the checks (%) | |
|-----|---------|---|---------|-------------------------------------|-------------------------------|-------|
| | | Lam Dong | Dak Lak | | C919 | CP888 |
| 1 | LVN66 | 9.2 | 8.8 | 9.0 | 11.1 | 11.3 |
| 2 | LVN146 | 10.8 | 10.6 | 10.4 | 28.3 | 31.6 |
| 3 | LVN092 | 9.8 | 9.2 | 9.5 | 17.2 | 20.2 |
| 4 | VN595 | 9.4 | 9.6 | 9.5 | 17.2 | 20.2 |
| 5 | C919 | 9.1 | 7.2 | 8.1 | - | - |
| 6 | CP888 | 8.5 | 7.4 | 7.9 | - | - |

(Sources: Center for Plant testing of South Region)

Table 2. The average yield of LVN66; LVN146; LVN092 and VN595 on production testing in the Central Highlands

| No. | Hybrids | Yield in the tested locations (tons.ha ⁻¹) | | Average yield (tons.ha ⁻¹) | Increased (%) | |
|-----|---------|--|---------|--|---------------|-------|
| | | Lam Dong | Dak Lak | | C919 | CP888 |
| 1 | LVN66 | 9.6 | 9.1 | 9.3 | 5.6 | 6.8 |
| 2 | LVN146 | 10.8 | 10.6 | 10.7 | 21.5 | 22.9 |
| 3 | LVN092 | 9.2 | 8.9 | 9.0 | 2.2 | 3.4 |
| 4 | VN595 | 8.9 | 10.0 | 9.4 | 6.8 | 8.0 |
| 5 | C919 | 8.9 | 8.7 | 8.8 | - | - |
| 6 | CP888 | 8.9 | 8.6 | 8.7 | - | - |

(Sources: Center for Plant testing of South Region)

In short, through basic testing and production testing, Hybrid LVN146 showed the best in the average yield (10.0 tons.ha⁻¹), increased by 17-30% over C919 and CP888 while the others were of the average yield equivalent to C919 and higher than CP888.

The drought tolerant ability of LVN66, LVN146, LVN092, VN595 maize hybrids in Winter and Winter-Spring crop seasons

During 4 crop seasons (Autumn-Winter in 2011 and 2012, Winter-Spring in 2011- 2012 and 2012-2013), Maize Hybrids LVN146, LVN66, LVN092 and VN595 were evaluated for drought tolerance. The results are available in table 3.

The results showed that the drought ability of LVN146 was the best (score 1), followed by LVN092 (score 2) which was similar to C919 and better than CP888 while drought tolerance ability of LVN66 and VN595 was as same as of two checks (score 2.5).

The development of maize varieties in the Central Highlands

The results of demonstration trials

Demonstration trials of selected hybrids with high yield potential and good tolerance to drought were implemented, on the scale of 200-1,000 m² for each, at ecological regions in three provinces (Dak Lak, Dak Nong and Gia Lai) during crop seasons of 2011 and 2012 Autumn-Winter, 2011-2012 Winter-Spring and 2012-2013 Winter-spring. The data of results would be described in table 4.

Table 3. The drought tolerant ability of LVN66, LVN146, LVN092 and VN595 hybrids (Score: 1-5)

| No | Hybrids | Crop Seasons | | Average score |
|----|---------|---------------|---------------|---------------|
| | | Autumn-Winter | Winter-Spring | |
| 1 | LVN66 | 2 | 3 | 2.5 |
| 2 | LVN146 | 1 | 1 | 1.0 |
| 3 | LVN092 | 2 | 2 | 2.0 |
| 4 | VN595 | 2 | 3 | 2.5 |
| 5 | C919 | 2 | 2 | 2.0 |
| 6 | CP888 | 2 | 3 | 2.5 |

(Sources: Center for Plant testing of South Region; Score: 1- good; 5- bad).

Table 4. Grain yield of hybrids in demonstration trials

| No. | Hybrids | Dak Nong | | Dak Lak | | Gia Lai | | Mean | |
|-----|---------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | | No. of trials | Average Yield | No. of trials | Average Yield | No. of trials | Average Yield | No. of trials | Average Yield |
| 1 | LVN66 | 3 | 10.6 | 12 | 9.7 | 5 | 8.7 | 20 | 9.6 |
| 2 | LVN146 | 5 | 11.3 | 16 | 11.9 | 5 | 9.2 | 26 | 10.8 |
| 3 | LVN092 | 4 | 10.8 | 9 | 9.6 | 5 | 9.0 | 18 | 9.8 |
| 4 | VN595 | - | - | 7 | 9.4 | - | - | 7 | 9.4 |
| 5 | C919 | 12 | 9.1 | 28 | 8.8 | 15 | 8.0 | 43 | 8.6 |
| 6 | CP888 | 12 | 8.7 | 28 | 8.3 | 15 | 8.5 | 43 | 8.5 |

Through demonstration trials including 20 ones for LVN66, 26 for LVN146, 18 for LVN092 and 7 for VN595, it showed that the average yield of maize hybrids LVN66, LVN146, LVN092 and VN595 reached 9.6 tons.ha⁻¹; 10.8 tons.ha⁻¹; 9.8 tons. ha⁻¹ and 9.4 tons. ha⁻¹, respectively while that was 8.6 tons. ha⁻¹ for C919 and 8.5 tons.ha⁻¹ for CP888. In addition, these new varieties were evaluated by local leaders, experts and farmers about drought tolerance and

other agronomic traits. The results are presented in table 5, through which it may be recognized that: 63.9% households of farmers were in agreement with planting LVN66; 75.6% households of farmers agreed to plant LVN146; 68.5% households of farmers accepted to plant LVN092; 90% households of farmers accepted to plant VN595.

In general, all maize hybrids have been accepted by farmers in three provinces of the Central Highlands.

Table 5. The feedbacks on four maize hybrids from the results of demonstration trials

| No. | Hybrids | Feedback of local organizations | Percentage of farming households accepting these hybrids (%) | | | |
|-----|---------|---|--|---------|----------|---------|
| | | | Gia Lai | Dak Lak | Dac Nong | Average |
| 1 | LVN66 | Short plant, good tolerance to stalk lodging and intensive cultivation, 14-16 seed rows, yellow flint kernels, high grain yield, quite good tolerance to drought. | 73.7 | 56.4 | 61.7 | 63.9 |
| 2 | LVN146 | High plant, fair tolerance to stalk lodging, good resistance to diseases, 14-16 seed rows, long ears, high grain yield, good tolerance to drought. | 88.7 | 74.8 | 63.3 | 75.6 |
| 3 | LVN092 | Medium plant height, good tolerance to stalk lodging, high uniform, good resistance to diseases, 12-14 seed rows, long ears, semi-flint kernels, quite high grain yield, fair drought to tolerance. | 71.4 | 52.7 | 81.6 | 68.5 |
| 4 | VN595 | High plant, quite good tolerance to stalk lodging and drought, good resistance to diseases, 14-16 seed rows, yellow-flint kernels, quite high grain yield. | - | 90.0 | - | 90.0 |

The ability of seed marketing development

Based on the cooperation with enterprises and distributors, after 5 crop seasons (2011-2012 Winter-Spring, 2012 Spring-Summer; 2012 Autumn-Winter; 2012-2013 Winter-Spring; 2013 Summer-Autumn), the growth rate of area for these hybrids (in Table

6) was relatively fast with more than 11,000 ha, in which three hybrids (LVN66, LVN146, LVN092) were planted on over 3,000 ha for each. Especially, the growth rate of area in 2013 was twice more than that in 2012 and seed marketing increased from 1.46% in 2012 to 3.37% in 2013.

Table 6. The growth rate of area for new maize hybrids in Central Highland provinces (ha)

| No. | Hybrids | Crop seasons | | | | | Total |
|----------------------------|---------|-------------------------|--------------------|--------------------|-------------------------|--------------------|--------|
| | | Winter-Spring 2011-2012 | Summer-Autumn 2012 | Autumn-Winter 2012 | Winter-Spring 2012-2013 | Summer-Autumn 2013 | |
| 1 | LVN66 | 17 | 850 | 150 | 410 | 1,700 | 3,127 |
| 2 | LVN146 | 35 | 1050 | 460 | 620 | 1,900 | 4,065 |
| 3 | LVN092 | 10 | 400 | 350 | 650 | 2,500 | 3,910 |
| 4 | VN595 | - | - | - | 5 | 150 | 155 |
| <i>Total</i> | | 62 | 2,300 | 960 | 1,685 | 6,250 | 11,257 |
| <i>The seed market (%)</i> | | 1.46 | | | 3.37 | | - |

Moreover, in order to evaluate the roles of these maize hybrids (LVN146, LVN66, LVN092) in production,

it would be important to determine their economic efficiency showed in table 7.

Table 7. The economic efficiency of new maize hybrids compared with C919 in Central Highland provinces

| No. | Hybrids | Area (ha) | Increased value | | Savings due to low price of seeds (Million VND) | Increased profit per ha (Million VND) |
|-------------------|---------|-----------|------------------|----------------------|---|---------------------------------------|
| | | | Production (ton) | Profit (Million VND) | | |
| 1 | LVN66 | 3,127 | 156.3 | 1,015 | 187.6 | 3.84 |
| 2 | LVN146 | 4,065 | 487.8 | 3,170 | 243.9 | 8.39 |
| 3 | LVN092 | 3,910 | 234.6 | 1,524 | 186.0 | 4.37 |
| <i>Total/Mean</i> | | 11,257 | 878.7 | 5,709 | 617.5 | 5.53 |

- The average yield of LVN66, LVN146 and LVN092 was 9.3 tons.ha⁻¹; 10 tons.ha⁻¹; and 9.4 tons.ha⁻¹ respectively, while the C919 was only 8.8 ton.ha⁻¹. With the low price of maize seeds (only 65,000 VND/kg) compared with foreign maize seeds, there would be the savings of 30,000 VND per kilogram.

- The average profit of 3 maize hybrids increased by 5.5 million VND.ha⁻¹ compared to C919 and that was highest for LVN146 with 8.39 million VND.ha⁻¹.

From the testing results, demonstration trials and production development, these new maize hybrids brought high economic efficiency for farmers in the Central Highlands, who accepted to use them. Therefore, it should be to develop these new maize hybrids in the following years.

CONCLUSION

Through the testing, demonstration trials and production development, it was identified that three maize hybrids (LVN66, LVN092 and LVN146) were of high yield of 9-11 tons.ha⁻¹, 6 - 30% higher than that of local popular hybrids, economic efficiency of 3 - 8 million.ha⁻¹, quite good tolerance to drought and

accepted by the farmers for production in the Central Highlands. It would be suggested that these new maize hybrids should be developed in the next years.

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Date received: 21/10/2016

Date reviewed: 19/11/2016

Reviewer: Dr. Nguyen Xuan Thang

Date approved for publication: 20/12/2016

EVALUATION OF SALT TOLERANCE IN MAIZE HYBRIDS AT SEEDLING STAGE

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Abstract

Twenty four maize hybrids named as STM1 to STM24 were studied at five different salt concentrations of 0; 50; 100; 150; 200 mM NaCl at the National Maize Research Institute. After 7 days germination in room temperature, seedlings were transplanted to nutrient solutions salinized with salt. 17 day old seedlings were harvested for calculating of growth parameters such as root and shoot length, seedling dry matter production, ion Na⁺ and K⁺ content. As the results of the study, salt stress reduced plant growth of all hybrids but the STM10 and STM21 showed better salt tolerance while STM17 and STM18 presented salt-sensitive. The results of analysis for Na⁺ and K⁺ showed that among the hybrids, STM21 presented the lowest ion Na⁺ (2.057) and the highest ion K⁺ (2.763) in the seedlings.

Keywords: Maize hybrid, salt tolerance, seedling

INTRODUCTION

Salinization is the accumulation of salts in the soil, that is strong impact on agricultural production, the environment and economy of the countries (Rengasamy, 2006). According to Wild (2003) about 15% of the land in the world has been eroded, the physical and chemical characteristics of the soil has been modified, including soil salinization.

In Vietnam, saline soils are primarily formed by salt or saltwater from the sea or underground movement to the soil surface. Another reason is the using of saline water from the canals to the fields due to lack of fresh water. Evaporation during crop farming also causes of soil surface salinity. There is about three million hectares of land salinization and acidification, distributed mainly in the provinces of the Mekong Delta as Bac Lieu, Ca Mau, Kien Giang, Tra Vinh, Ben Tre, and the provinces in the Red River Delta as: Quang Ninh, Hai Phong, Thai Binh, Nam Dinh, Ninh Binh, Thanh Hoa (Soils and Fertilizers Institute, 2010).

Most crops tolerate salinity to a threshold level and above which will decrease in productivity (Khan *et al.*, 2006). Maize is pollinated crop which is able to tolerate to salinity (Paterniani, 1990). Research in maize genotypes is necessary to determine the materials for maize breeding programs with high yield and salt tolerance. The studies on salt tolerance in maize have been published by some national institutions and international organizations, which have given some scientific basis for salinity tolerance in maize. In Vietnam, salt tolerance in maize has not been studied yet. Facing of adverse climate change and the increasing salinization of agricultural land, the research on breeding salt-tolerant crops in general

and maize in particular is urgent for development of agriculture. Studies on salinity tolerance of maize on the field is very difficult, because the heterogeneity of soil physical and chemical properties and fluctuations in seasonal rainfall. Therefore, we conducted "Evaluation of salt tolerance in maize hybrid at seedling stage" with the objective assessment of maize hybrids for salt tolerance.

MATERIALS AND METHODS

Materials

The research was conducted at Maize Research Institute, Dan Phuong, Hanoi with 24 test crosses named as STM1, STM2, STM3, ..., STM24.

Methods

The seeds were soaked in distilled water and germinated at individual line for 5 to 7 days after transplant to Yoshida nutrition solution (Yoshida, 1976), which salinized with NaCl at 4 different salt (S) concentrations: S1 (50 mM); S2 (100 mM); S3 (150 mM); S4 (200 mM); and control 0 mM (S0). Salt was added in small amounts, 50 mM at 5 days after transplanting, the remain salt was provided after 7 days. The nutrition solution was changed twice a week. The experiment was arranged in randomized complete block design (RCBD) with 3 replications. After 17 days the plants were harvested separately in line and treatment. Harvested plants were washed in tap water and twice in distilled water and the following observation parameters were recorded:

- Survival date and salt tolerance ability: Number of dead plants after transplanting to solution culture.

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