Maize Seed Production in Croatia

I. BRKIC, D. PARLOV and V. KOZUMPLIK

There is more than 3.1 million ha of agricultural land in Croatia, of which over 2 million ha are private farmholdings. Arable land and gardens are spread on 1.5 million ha. Every year 1 million ha of arable land is cultivated, of which 724000 ha are under cereals. In last five years, maize acreage varied from 350,000 to 450,000 ha and, maize seed production has been on 2,500 to 5,500 ha. All maize maturity groups from FAO 100 to FAO 700 are grown. Later maturity groups are grown in Eastern Croatia (longitude approx. 18°-19°E.) and earlier groups in Northern and Central Croatia (longitude approx. 16°-17°E.) and at higher altitudes. Seed production of maize hybrids FAO 400-700 is predominantly in Eastern Croatia, while of hybrids FAO 100-500 is in Central part of Croatia. Eastern Croatia (Slavonia) is settled on south-west border of Panonian plain having excellent conditions for breeding and producing later maize materials. However, both maize growing regions of Croatia belong to European Corn-Belt (BRANDOLINI, 1969).

Climate in maize growing region of Croatia

Climate of Eastern Croatia is semi-arid, temperate continental, with eastern European characters to semi-humid, temperate continental central European climate. Eastern areas are characterized by higher aridity, while humidity increases towards west areas. Characters of such climate are long and warm summers, cold winters, and little horizontal changes of temperature between different locations in north-eastern Croatia. Winters become more severe to north-eastern areas, while extreme summer temperatures rise towards east. According to annual precipitation distribution by months, Eastern Croatia has more precipitation in warm (April - September), than in cold (October - March) part of the year. There are two annual maximums (main - autumn, and secondary - end of spring and beginning of summer). Although the precipitation decreases from west to east, it considerably depends on topography. Despite of sufficient total quantity, the precipitation distribution can vary greatly during the growing period. Average annual precipitation for the period 1961 - 1990 in Osijek area was 650 mm (*Table 1*).

Influence of continental humid climate, which is affected by the mountain systems of Alps and Dinarides, dominates the area of Zagreb (Central Croatia). In the Central Croatian region there is very small horizontal temperature difference. Winter becomes more severe to the north-east and maximum summer temperatures increase from south-west to eastern areas. Climate of this area is very similar to the eastern Croatian region. However, increased humidity of Central Croatia and its relief diversity make a difference between those two regions. Precipitation of Central Croatia is not typically continental because of the sea vicinity. Main precipitation maximum is in autumn, and secondary is at the end of spring. Main precipitation minimum occurs during winter, and secondary is during summer. Annual precipitation distribution is very similar to the distribution in Eastern Croatia. The total annual precipitation is higher in Central Croatia. Average annual precipitation for the period 1961 - 1990 in Zagreb area was 852 mm.

At both locations there was a tendency of decreasing the precipitation level during the 1961-1990 period as compared to the 1931-1960 period. More frequent drought periods occurred during the growing seasons of later decades. During the vegetation period there is frequently a lack of water for maize production of about 100 mm. This quantity may vary in dry years depending on soil type and ground water from winter and early sp-

Table 1: **Mean air temperatures and precipitation, Osijek, Zagreb, 1931-1990.**

Month	Osijek				Zagreb			
	1931-1960		1961-1990		1931-1960		1961-1990	
	°C	mm	°C	mm	°C	mm	°C	mm
January	-1,0	47	-1,2	47	-1,2	55	-0,8	46
February	1,0	53	1,5	40	0,5	52	1,8	42
March	5,9	45	6,0	45	5,5	45	5,9	56
Apri	11,7	54	11,3	54	11,0	60	10,6	64
May	16,6	71	16,5	58	15,4	89	15,3	79
June	20,0	83	19,5	88	18,9	94	18,5	100
July	22,0	52	21,0	65	20,7	81	20,1	83
August	21,1	55	20,3	58	20,0	75	19,3	95
September	17,1	51	16,6	45	16,2	70	15,8	79
October	11,3	68	11,2	41	10,5	91	10,5	69
November	6,0	70	5,4	57	5,5	92	5,3	81
December	1,6	57	0,9	52	1,3	66	0,9	58
Total		706		650		870		852
Mean	11,1		10,8		10,4		10,3	

Autoren: Dr. Ivo BRKIC and Prof. Dr. Vinko KOZUMPLIK, Department of Plant Breeding, University of Zagreb, Svetosimunska 25, HR-10000 ZAGREB; Dr. sc. Dragomir PARLOV, Bc Institute for Breeding and Production of Field Crops, Marulicev Trg 5/I, HR-10000 ZAGREB

ring rains. In Croatia, there are good hydro-edaphic, topographic and hydro-geographical conditions for irrigation of 680,000 ha (TOMIC and MARUŠIC, 1994), particularly in Eastern Croatia (about 400,000 ha) where maize seed is mostly produced. The favorable growing season of 2002 has shown that it is possible to realize almost maximum yield potential in maize seed production. There was 502 mm of rainfall in period April - September that year combined with 120 mm of ground water in light soil types and about 180 mm in heavier soil types resulting in very good conditions for maize seed production. Considering these climatic and edaphic conditions of the region, an optimum for high yielding maize seed production could be about 400 mm of rainfall appropriately distributed during vegetation period.

Short history of maize seed production

Introduction of inbred line hybrids in maize production in Croatia began in 1950's. Till then, local populations (varieties) had been in production with 82 populations registered only in Eastern Croatia (RADIC, 1986). First series of the hybrids came from Wisconsin, USA (W692, W641AA, W646A, W355A, W270) to be grown in more humid areas of Croatia. The hybrids from Nebraska and Kansas (K1859, N301C, OHC92, US13 etc.) were grown in more arid areas. The local varieties such as Vukovarski zuban (Vukovar dent), Beljski zuban (Belje dent) and Novosadski zuban (Novi Sad dent) were at the same yield level as the first hybrids at the density of 30000 plants ha^{-1}. However, hybrids were yielding 20-25% more than the local varieties at 40000-45000 plants ha^{-1}. First hybrids between local varieties and the US-Corn Belt single crosses showed good combining abilities indicating a considerable divergence between the local and the Corn Belt germplasm (RADIC, 1986) (*Figure 1*). Some of the combinations outyielded considerably the American hybrids Wisconsin 641AA, Wisconsin 692 and US-13 denoted as American checks in *Figure 1*. These crosses were encouraging for deriving inbred lines from local varieties, particularly from Vukovar dent, Belje dent, and *Koricev brzak* (early variety). The derived lines were combined in hybrids with American lines WF9, N6, M14, Hy and so on.

At the beginning, double crosses and three-way crosses were produced due to the low level of agricultural practices and low seed yield of the parental lines. Intensive introduction of single crosses occurred after 1975 and, very soon single crosses replaced all other hybrid categories on market, except the multiple line crosses produced for export to the former USSR. Emerging of multinational seed companies on former Yugoslav seed market took place during the 1980's. In spite of this, Croatian maize seed producers (Bc Institute for Breeding and Production of field crops in Zagreb - Bc institute, and Agricultural Institute Osijek in Osijek - Os institute) still have approximately 65-70% of the market share.

Recent developments in Croatian maize seed production

Because of the latter big market share, all developments in maize seed production in Croatia could be presented through figures of the two national producers, Bc institute and Os institute. Total seed production hectarage ranged from about 7200 ha (1987) and 4650 ha (1988) to 1378 ha (1998) and 147 ha (1998) for Bc and Os institute respectively (*Figure 2*). Rapid decrease of seed production of Bc and Os hybrids after 1990 is the consequence of smaller acreage under maize production due to disintegration of former Yugoslavia, and of discontinuity of export to the former USSR. Until 1990, up to 50% of the Croatian seed production was or-

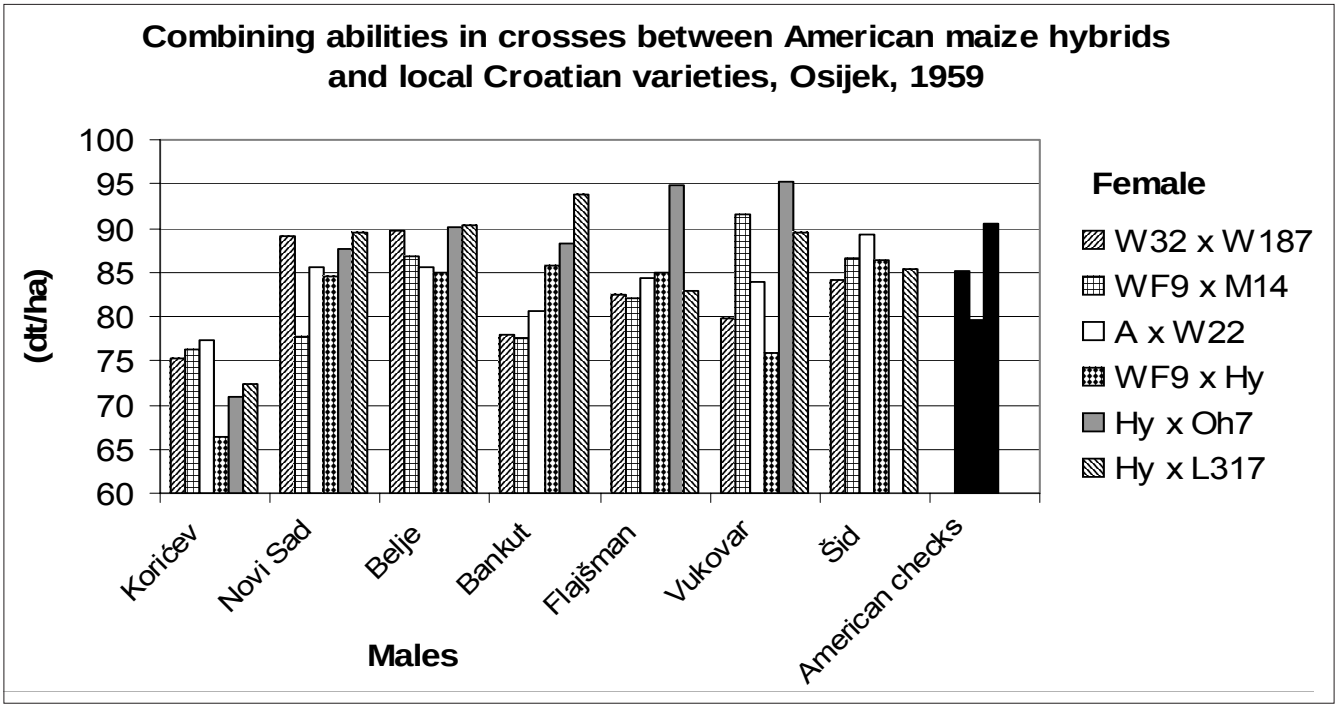

Figure 1: **Mean yields of crosses between American single crosses (females) and local varieties (males) at 14% moisture, Osijek (Eastern Croatia), 1959.**

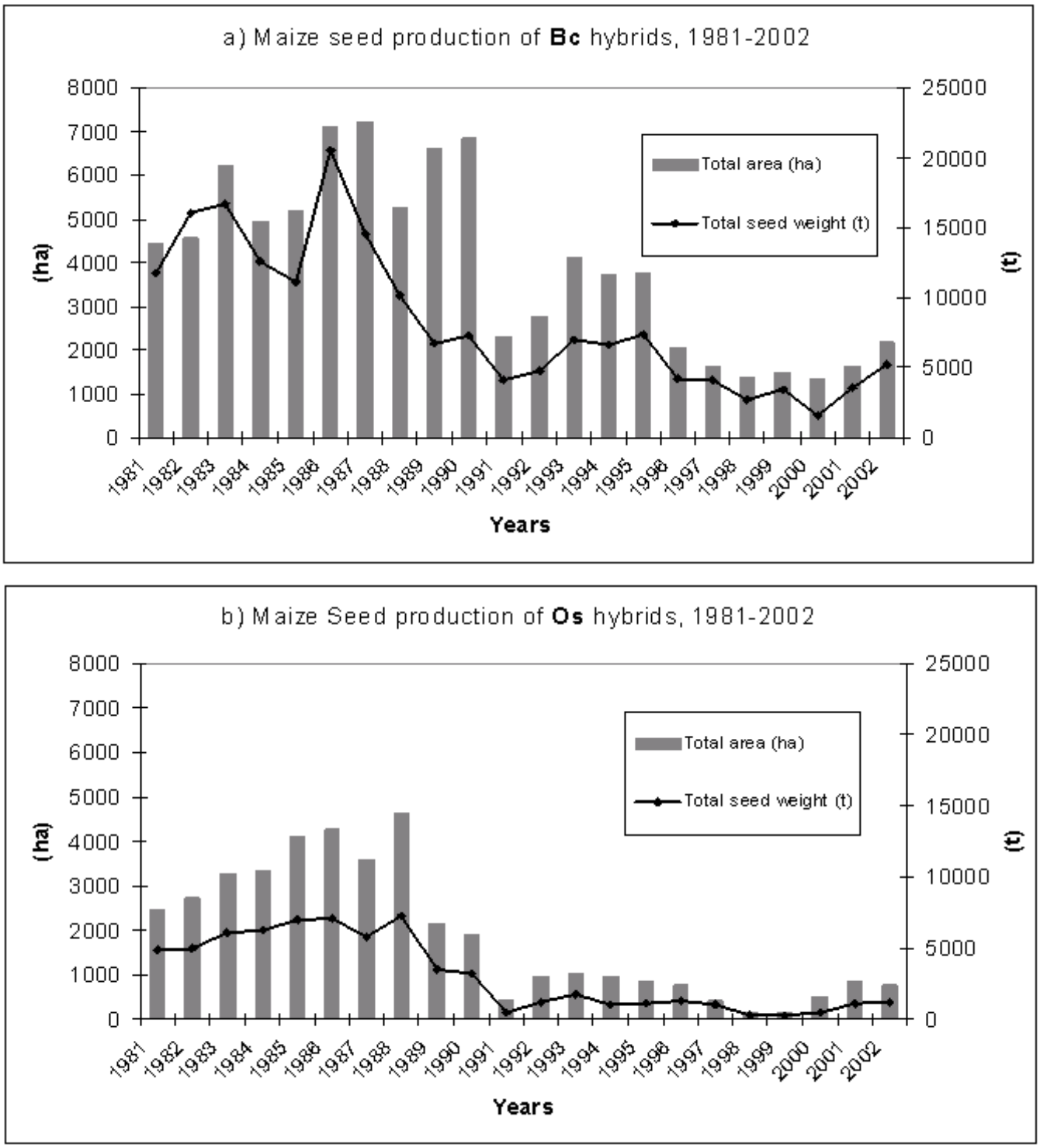

Figure 2: **Total area (ha) and total seed weight (t) of maize seed production of two leading producers in Croatia: a) Bc institute, b) Os institute.**

ganized in Voivodina (Serbia) due to very good production conditions for the longer vegetation hybrids.

The hybrid seed yield varied from less than 1.0 t/ha (Os material in 2000) to more than 3.5 t/ha (Bc material in 1982) (*Figure 3*), mostly due to weather conditions in particular year. However, it is obvious a tendency of higher yield for Bc seed production (with exception of the years 1989, 1990 and 1993). Constant differences in yield seed production between Bc and Os institute has occurred because of higher portion of earlier hybrids in Bc production range (*Figure 4*). Earlier hybrids frequently have „sister" lines as female parent (modified three-way cross), which can result in higher yield in seed production. In Os hybrids, however predominate mid-late and late hybrids in which no sister lines are utilized, resulting in lower yields under Croatian production conditions. It is known that yield potential of female parent increases with longer vegetation period, but it could be realized only under outstandingly good climatic conditions. This occurs only sel-

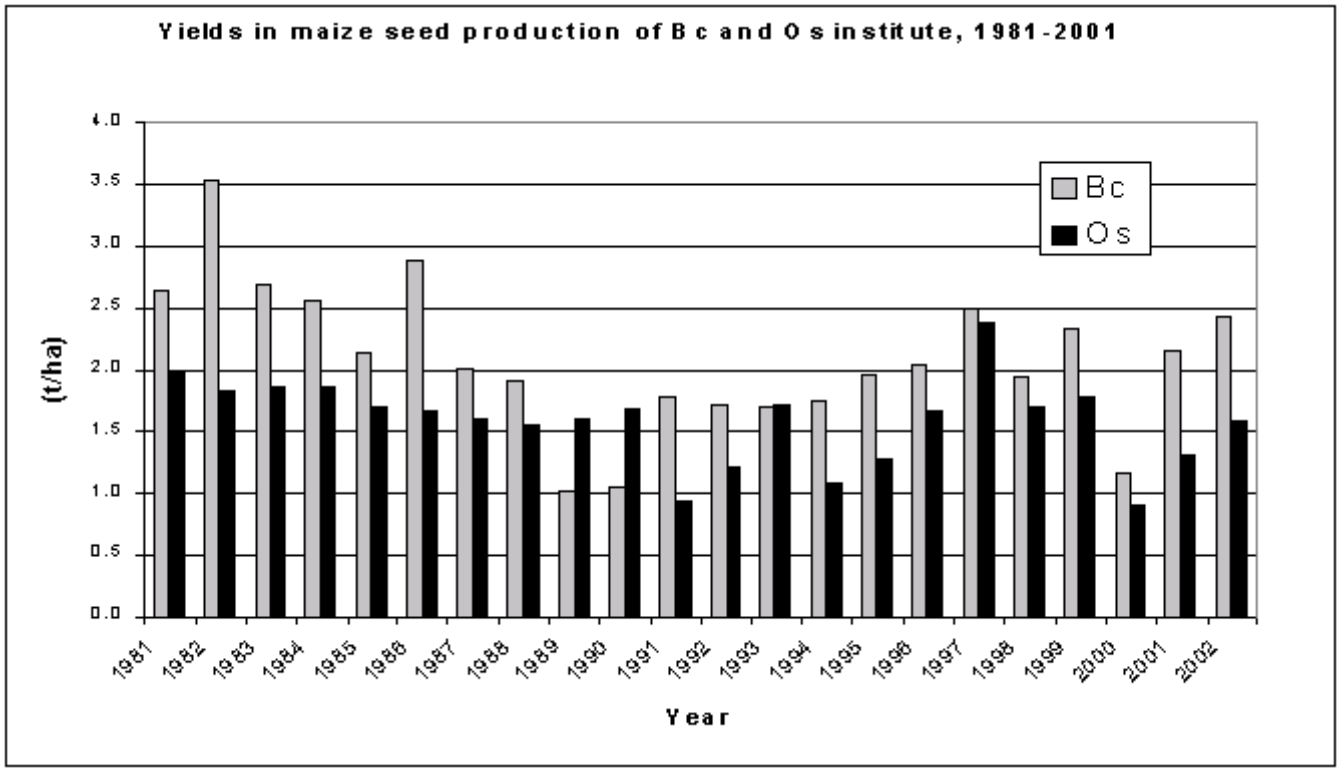

Figure 3: **Grain yield in maize seed production of Bc and Os institute, 1981-2001.**

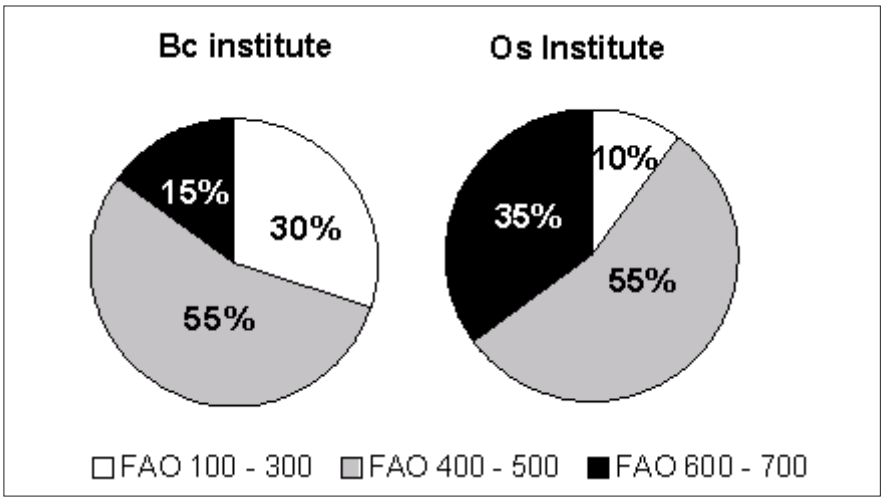

Figure 4: **Percentages of FAO maturity groups in maize seed production, Bc and Os institute, 15 year average (1988-2003).**

dom in Eastern Croatia. However, some inbred lines of B73 type have yielded regularly more than 5.0 t/ha of seed in some areas of Turkey, compared with an average of 0.9 - 1.5 t/ha in Eastern Croatia. The main reason for low yield in Eastern Croatia is lack and/or unfavorable distribution of rainfall in period from flowering to waxy dough stage in long vegetation germplasm.

Nevertheless, when the conditions are more favorable, yields in seed production in Eastern Croatia could be as high as 3.1, 3.9, and 4.4 t/ha for FAO group 300, 400 and 500, respectively (VUJEVIC et al., 1993). In 1997, the highest yielding year in the last 15 years (*Figure 3*), yields of commercial inbred lines of FAO groups 500 and 600 in field trials ranged from 4.4 t/ha (Mo17) to 5.0 t/ha (Os 86-39 - the line of WF9 origin) (Jambroviæ, 1997). According to these experimental results, it is realistic to expect in good years in Eastern Croatia to obtain 2.3-3.0 t/ha and 3.0-3.7 t/ha of seed for FAO 300-400 and FAO 500-600 inbreds, respectively.

Outlock

There are two main goals to achieve: 1) to increase seed production area in Croatia from 2500-5000 ha (figures for last five years) to 10000-12000 ha, and 2) to increase mean yield in maize seed production. Relatively high increase of seed production area in future is feasible considering total usable land available. The main issue is to find optimally isolated area for seed production, since former big socialistic „combinates“ - the only direct seed producers even now, are dissipating in the transitional processes. The emerging new farms are still small in capacity and they had too dispersed land plots for producing seed of good quality. New farmers who got this land are still not well educated to carry out such specific agricultural production. Increasing of yield in seed production should be at least to 3.0 t/ha. This is a big challenge for seed production technologists as well as for maize breeders. Another very important subject is irrigation because of aforementioned problems with drought. However, irrigation issue should be put in a wider context due to necessary big investments, what is not only the question of seed production. Wrong cultural practice played sometimes very impor-

tant role in poor synchronization („nicking“) of parental lines resulting in low yields in seed production. It was shown that post-emergence herbicides can change pollination-silking interval between parental lines, especially by split-date plantings of parents. Another problem in Croatia is poor machinery for quality seed harvest, which can be solved soon. The main goals for breeders should be 1) to develop parental lines which are better yielding in seed production, 2) to create hybrids that have simple seed production (e.g. concurrent planting of both parents), that can result in better yields, too, 3) to develop inbred lines resistant to major diseases and pests using either conventional and/or biotechnological techniques, 4) to consider the possibilities of (re)using cytoplasmic male sterility (CMS), as one of permanent topics in maize seed production.

There is a big chance for maize breeders and seed producers in Croatia to export seed of Croatian maize hybrids due to the long tradition and experience in maize production supported by favorable growing conditions. Particularly, Middle East seems to be of prime export interest. In some countries of this region growing of Croatian maize hybrids can be seen already.

References

BRANDOLINI, A.G., 1969: European races of maize. Proc. Annu. Corn Sorghum Res. Conf. 24:36-48.

JAMBROVIC, A., 1998: Nasljednost gospodarski vaznih svojstava kod inbred linija kukuruza domaceg i stranog podrijetla. MS thesis, University of Zagreb.

RADIC, LJ., 1986: Kukuruz u Slavoniji i Baranji - Oplemenjivanje (Manuscript - Agricultural institute Osijek.

TOMIC, F., MARUŠIC, 1994: Stanje i perspektive melioracija u Hrvatskoj. Conference-Poljoprivreda i gospodarenje vodama, Bizovac, Croatia, November 17-19, 1994.

VUJEVIC, S., I. BRKIC, D. ŠIMIC, 1993: Prinos zrna linija kukuruza (Zea mays, L.) i njihovih hibrida u grupama 300, 400 i 500 u dialelnim krizanjima. Poljoprivredne aktualnosti, Vol. 29, No. 1-2: 51-60.