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Variation of physiological growth indices, biomass and dry matter yield in some maize hybrids

SHUKRI FETAHU[1]*, SALI ALIU[1], IMER RUSINOVCI[1], FETAH ELEZI[3], KEMAJL BISLIMI[2], AVNI BEHLULI[1], QENDRIM SHABANI[1]

[1]University of Prishtina, Faculty of Agriculture and Veterinary, Department of Crop Production, Prishtina, Kosova

2University of Prishtina, Faculty of Mathematical and Natural Science, Department of Biology, Prishtina, Kosova

3Agricultural University of Tirana, Faculty of Agriculture and Environment, Dep. of Plant Production, Tirana Albania

* Corresponding author E-mail: shfetahu@hotmail.com & shukri.fetahu@uni-pr.edu

Abstract:

In order to determine variation of physiological growth indices, biomass and dry matter yield, for six maize hybrids (MH), it was set up a field trial on randomized complete block design (RCDB), with three replications, with 6 MH: BC38W, BC408, ZP434, NSSC444, ESP500 and LUCE, during the years 2010 and 2011 (Y), at Experimental Farm (EF), Faculty of Agriculture and Veterinary in Prishtina, located in geographical position: N 42º 38'97" and E 21º 08'45" and 570 MASL. Growth rate, biomass and dry matter of maize performance are depending from specific characteristics: maize hybrids (MH), environmental condition (EC) and cropping system (CS). Information on silage maize yield can help silage growers and users, to choose hybrids that best fit their needs. The physiological growth indices, biomass and dry matter yield, were conducted according to the formula: (MH-6 x Y-2 x P4 x R3) =144 combinations. Hybrid selection for a specific location, suitable for the agro-ecological condition is one of the essential principles for improving yield for silage or grain, without increasing of cost of maize production. Means results for evaluated maize hybrids and parameters were: Absolute growth rate (AGRμ=5.43), crop growth rate (CGRμ=30.98), total plant biomass (TPBμ=585.39 g plant^{-1}) and total dry matter (TDMμ=22.52 ton ha^{-1}).The aim of this study was to determine physiological growth indices, biomass and dry matter yield, in suitable agro-ecological conditions of Kosovo. The obtained results were with wide range variability and high significant differences between hybrids and years on the level P< 0.01.

Keywords: Maize hybrid, biomass, dray matter, growth rate, yield.

1. Introduction

Maize production is important in both terms: for grain and silage, due to the fact of its high yield, high energy forage, produced with lower labour and machinery requirements than other forage crops [1, 2]. During 2011, in the world maize was harvested in 170.398.070 ha, with annual production 883.460.240 tons, with an average yield 5184.7 kg ha^{-1} [3]. In the past maize in Kosovo, was cultivated more for grain as human and animal feed. Actually the total planted area with maize is 70 to 80.000 ha, with an average grain yield 3 to 4 ton ha^{-1} [4].

Therefore based on the area and production, maize it ranks second among field crops in Kosovo [5]. Recently, Kosovo's farmers has increased inters for biomass production for silage as animal feed. However in Kosovo, maize yield per hectare is lower in comparison to the world and other maize growing countries. Among the main reasons are lack of local hybrids, limited use of fertilizers, and lack of irrigations, traditional maize production and rare utilization maize biomass for silage. Hybrid development is one part of the issue, and on the other hand is very important interaction by genotype and environment [6]. Early hybrids produce less leaves and permeate various stages of growth at a faster rate. Hybrids with later maturity develop more leaves and permeate slower growth stages.

To maximise their returns, silage growers should look to introduce hybrids that are best suited to their farm system for several criteria as: desired harvest time, high yield hybrids for biomass and dry matter, maize using for grain or silage quality traits are all important considerations in the hybrid selection process.

Therefore maize productions are affected by several factors: late sowing and unfavourable environmental condition, as consequence is reduction of grain yield [7]. Maximal economic yield in maize are depending on water availability and soil fertility [8]. Crop rotation had effect on yield of dry matter [9],

also plant density and rate of nitrogen had influence on accumulation of biomass and dry matter yields [2].

Growth analysis is one approach to the analysis of plant biomass and dry matter, affected by genetic structure, environmental and production technology [10]. Maize varieties should be cultivated according to the areas of their adaptability for increased grain and biomass yield per unit area [7].

Due to the large number of hybrids available in market from different companies, growers are interesting to choose the best hybrid, which will fulfil the increasing needs for maize silage in livestock production.

Therefore, the aim of this study was to evaluate biomass and dry matter yield, physiological growth indices, for different maize hybrids in suitable agro-ecological conditions of Kosovo.

2. Material and Methods

During 2010 (Y-1) and 2011 (Y-2), a randomized complete block design trial (RCBD), with six different maize hybrids (MH), and three replications was conducted at experimental didactic farm (EDF), in Prishtina, situated between 42°38'97'' N latitude and 21°08'45'' E latitude, at an elevation of 570 MASL. The size of individual plots was 35 m^2. The distance between rows was 70 cm, whereas the distance between plants within rows was 25 cm or 70 x 25 cm = 5. 7 plant m^{-2} or 57.100 plants ha^{-1}.

Maize hybrids, originating from five different Institutes and belonging to FAO groups: 300, 400 and 500, were included in this field trial. Two hybrids originated from, Bc Institute– Croatia: BC38W (H-1) and BC408 (H-2), two hybrids from Serbia: ZP434 (H-3) and NSSC444 (H-4), one from Pioneer Hi-Bred Int. ESP500 (H-5) and one from KWS- Germany LUCE (H-6).

Basic fertilizers were applied 300 kg ha^{-1} NPK (15:15:15). Supplemental fertilizer, 200 kg ha^{-1} (URE 46% N), was applied in two equal split rate: first was applied 15 days, and second 30 days after emerging. The obtained data for traits were analysed by (ANOVA).

Measurements: The measurements were conducting in field and laboratory conditions. They included absolute growth rate AGR (g $plant^{-1}$ day^{-1}) and crop growth rate CGR (g m^{-2} day^{-1}), and total maize biomass TPB (g $plant^{-1}$) and total dry matter TDM (ton ha^{-1}).

The basic data were obtained from samples of 10 plants, randomly chosen in the middle rows of each plot. Regarding to CGR and AGR up to silking days, maize plants were, harvested manually, and cut in small partitions, mixed and measured. Plants weight was measured in g $plant^{-1}$ at temperature 105°C for 24 hours to constant weight.

Yield of TPB g palnt-1and TDM ton ha^{-1} was determined at harvesting time of plant, at time of black layer formation.

For the analysis TPB and TDM, samples were composed from 10 plants and their corresponding whole plants (stalk, leaves and ears).

Data associated with TPB and TDM, was obtained weight of whole plants.

$$\boldsymbol{AGR = \frac{WP}{Dm}\ x\ (g\ plant^{-1} day^{-1})}$$

AGR= absolute growth rate

Wp = g $plant^{-1}$ $day^{-1;}$ Dm= Days to maturity

$$\boldsymbol{CGR = \frac{Wp}{Ds}\ x\ No.of\ plant\ m^{-2}\ (g\ m^{-2} day^{-1})}$$

CGR= crop growth rate

W_P = g $plant^{-1}$$day^{-1}$ Ds= Days to silking

3. Results and Discussion

Absolute growth rate (AGR) and crop growth rate (CGR): Obtained results for AGR and CGR, indicated high significant differences among maize hybrids and years (Table 1). Mean value for two years and their comparisons for total gain weight by a plant within a specific time, regarding AGR and CGR were: 5.43 g $plant^{-1}$ day^{-1} and 30.98 g m^{-2} day^{-1}. Individual maize hybrid, H-2 in first Y-1 for AGR and CGR, had highest mean value 6.16 g $plant^{-1}$ day^{-1} and 35.15 g m^2 day^{-1}, on the other hand hybrid H-1, in the second Y-2, had the lowest average value for AGR and CGR (4.46 g $plant^{-1}$ day^{-1} and 25.46 g m^2 day^{-1}), both of them were statistically higher significant ($P<0.01$) than other hybrids.

Maize hybrids (H-3, H-4 and H-5) had statistically similarity mean value for AGR and CGR, except H-1 and H-2, (but H-6 was closer to H-2). The total mean value of AGR and CGR up to silking was higher in the Y-1 than in the Y-2. Mean results for AGR and CGR, per plant was high significantly affected by maize hybrids and years ($P<0.01$), but interaction among hybrids x years, aren't significantly. Different results for AGR and CGR were reported by [11] for AGR, 6.97 g $plant^{-1}$ $days^{-1}$ as the results of increasing plant density. Late sowing increased CGR, because of high radiation, use efficiency and higher percent radiation interception as suggested by [12].

Also Molnarova and Szucs [13] reported different results (18.38 to 22.05 g m^{-2} day^{-1}) on CGR at some maize hybrids. In agreement with the results reported by [14], cultivars effect was highly significant for CGR; from 12.83 to 21.69 g m^{-2}, but our results are higher. The maximum average data of CGR for maize grown in the growth rooms from 15 days before to 15 days after silking was in excess of 40 g m^{-2} day^{-1} [15], our results are in field condition and are lower.

According to the results reported by [16], for AGR and CGR, for some different maize hybrids, average value up to silking was: 5.03 to 8.24 g $plant^{-1}$ day^{-1} and 23.62 to 38.71g $m^{-2}day^{-1}$, our findings are in agreement to these results, for the reason that results were achieved in similar agro ecological conditions of Kosova.

Table 1. Absolute growth rate (AGR) and crop growth rate (CGR)

Hybrid	*FAO-group*	*AGR (g plant^{-1} day^{-1})*			*CGR(g m^2 day^{-1})*		
		Y1	**Y2**	**X**	**Y1**	**Y2**	**X**
H-1	300	5.41^{A-C}	4.46^{C}	4.93^{BC}	30.88^{A-C}	25.46^{C}	28.17^{BC}
H-2	400	6.16^{A}	5.95^{AB}	6.05^{AB}	35.15^{A}	33.99^{AB}	34.57^{AB}
H-3	400	5.46^{A-C}	5.27^{A-C}	5.36^{A-C}	31.16^{A-C}	30.07^{A-C}	30.61^{A-C}
H-4	400	5.55^{A-C}	5.26^{A-C}	5.41^{A-C}	31.69^{A-C}	30.06^{A-C}	30.88^{A-C}
H-5	500	5.08^{A-C}	5.05^{A-C}	5.07^{A-C}	29.02^{A-C}	28.83^{A-C}	28.92^{A-C}
H-6	500	5.98^{AB}	5.49^{A-C}	5.74^{AB}	34.13^{AB}	31.37^{A-C}	32.75^{AB}
μ		5.60	5.25^{A-C}	5.43^{A-C}	32.00^{A-C}	29.96^{A-C}	30.98^{A-C}
		Hybrid (H)	**Years (Y)**	**H x Y**	**Hybrid (H)**	**Years (Y)**	**H x Y**
LSDp=0.05		0.5053	0.2642	0.6791	2.885	1.5081	3.877
LSDp=0.01		0.7187	0.3704	0.9573	4.1045	2.1144	5.465

Means that do not share a letter are significantly different. All Pair wise Comparisons

Total plant biomass TPB per plant and TDM dry matter per hectare: Maize field is a complex and constantly changing community composed from many individual maize plants. Significant differences attributed to the mean effect for accumulation of TPB and TDM, affected by different maize hybrids and years (Table 2). During the year Y-1, hybrid H-6, at time of black layer formation at constant moisture, produced more TPB (729.23 g $plant^{-1}$), while hybrid H-1 produced less TPB (584.10 g $plant^{-1}$). Difference among them was +145.13 g $plant^{-1}$ or 22.48 %. However in the year Y-2, higher value for TPB, had hybrid H-2, FAO-400 (583.43 g $plant^{-1}$), while hybrid H-1, FAO-300, produced lowest TPB (419.12 g $plant^{-1}$), difference among them was +164.31 g $plant^{-1}$ or 31.27 %. Highest TPB per plant, in year Y-1, was found to hybrid H-6, FAO-600 (729.23 g $plant^{-1}$) while the hybrid H-1, FAO-300, in year Y-2, had the lowest TPB (419.12 g $plant^{-1}$). The difference among hybrids and years, regarding extreme value for TPB, were +310.11 g $plant^{-1}$ or 52.97 %, high significant on level (P< 0.01). Achieved results and findings for TPB, are in compliance with findings of biological dry matter in some hybrids from 652.5 to 893.1 g $plant^{-1}$ [7].

Regarding TDM obtained results for two years, at time of black layer formation at constant moisture, hybrid H-2, FAO-400, produced 25.17 ton ha^{-1} while hybrid H-1, FAO-300 produced 20.38 ton ha^{-1}. Difference among hybrids were + 4.79 tons ha^{-1} or 21, 27 %, high significant on level P<0.01. Highest TDM tons per ha^{-1}, in year Y-1 were found to hybrid H-2, FAO-400 (27.02 ton ha^{-1}) while the hybrid H-1, FAO-300, in year Y-2, had the lowest TDM (17.05 ton ha^{-1}). The difference among hybrids and years, regarding extreme value for TDM, were +9.95 tons ha^{-1} or 44.15%, and high significant on level (P<0.01). Obtained results indicate that the different hybrids and years had high influence for TPB and TDM accumulation. Our achieved results and findings for TDM are in compliance with findings of numerous researchers, who have determined different traits for dry matter yield. Çarpici et al. [2] presented different results for TDM from 18,719 to 21.263 tons ha^{-1}. Khan et al. [16] found a biological yield in some maize genotypes from 9.62 to 20.04 tons ha^{-1}, while Birch et al. [17] reported different results of biomass from 11.4 to 28.18 tons ha^{-1}, similar results were found by [19, 20].

Table 2. Total plant biomass per plant (TPB) and total dry matter (TDM) per hectare

Hybrid	*Total plant biomass g plant^{-1} (TPB)*		*X*	*Total dry matter (TDM) tons ha^{-1}*		*X*
	Y_1	Y_2		Y_1	Y_2	
H-1	584.10 $^{A-D}$	419.12^{E}	501.60 $^{C-E}$	23.69 $^{A-G}$	17.075^{H}	20.38^{C-H}
H-2	695.53 ^{AB}	583.43^{A-D}	639.48 $^{A-D}$	27.02^{A}	23.33^{A-G}	25.17^{A-C}
H-3	616.67 $^{A-D}$	516.03^{C-E}	566.35 $^{B-E}$	23.66 $^{A-G}$	19.97^{E-H}	21.81^{B-H}
H-4	627.13 $^{A-D}$	515.95^{C-E}	571.54^{B-E}	23.70^{A-G}	19.67^{F-H}	21.68^{B-H}
H-5	620.00 $^{A-D}$	535.15^{C-E}	577.57 $^{A-D}$	24.64^{A-E}	19.56^{F-H}	22.10^{B-G}
H-6	729.23^{A}	582.42^{A-D}	655.82 $^{A-C}$	26.51^{AB}	21.42^{C-H}	23.97^{A-F}
µ	645.44 $^{A-C}$	525.35^{C-E}	585.39 $^{A-D}$	24.87^{A-D}	20.17^{D-H}	22.52^{C-G}
	Hybrid (H)	**Years (Y)**	**H x Y**	**Hybrid (H)**	**Years (Y)**	**H x Y**
LSDp=0.05	60.74	31.623	81.058	2.209	1.161	2.976
LSDp=0.01	85.58	44.336	114.256	3.142	1.627	4.194

Means that do not share a letter are significantly different. All Pair wise Comparisons

4. Conclusions

Despite of different country origin, institutes and pedigree of maize hybrids, they were evaluated in same agro-ecological conditions, therefore it was possible to identified significant differences among maize hybrids and years, for all evaluated traits; AGR, CGR particularly TPB and TDM.

Careful maize hybrid selection, as way is essential in achieving high accumulation of biomass and dry matter, to increasing yield per plant and per hectare, without increasing of cost of maize production.

Farmers and maize growers should be encouraged not only to use proper plant spacing but also to grow hybrid maize, that perform better adaptability in the specific agro ecological condition.

Among the investigated hybrids, hybrid H-2 realized more productivity for parameters AGR, CGR, TPB and TDM. Therefore, based on the obtained results, this hybrid will be recommended for cultivation.

5. References

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