RESEARCH ARTICLE **(Open Access)**

Estimation of Grain Yield, Grain Components and Correlations between Them in some Oat Cultivars

ISUF KAZIU[1]*, FOTO KASHTA[2], ASLLAN CELAMI[1]

[1]Agricultural Technology Transfer Center (ATTC), Fushë Krujë, Albania

[2]Department of Agronomy, Agricultural University of Tirana, Albania

Abstract

The experiment was carried out at ATTC Fushë Krujë during 2014-2015 and 2015-2016. The experimental design was according to randomized complete block at 4 replications. The aim of the study was to determine the differences between 10 oat cultivars (*A. sativa* L.) for the grain yield and its related elements, and correlation coefficients between them. The correlation coefficients were determined between grain yield (GY) and plant height (PH), number of productive tillers m^{-2} (NPT), panicle length (PL), grain number $panicle^{-1}$ (NGP), panicle weight (PW), 1000 grain weight (1000 GW), harvest index (HI). Based on the results of the correlation coefficients, GY was negatively correlated with PH (r = - 0.23), PT (r = -0.36) and 1000 GW (r = - 0.29). In addition, our study showed that taller stem cultivars had lower production than short stem cultivars, which is reflected in their lower production. This trait showed a strong positive correlation with PL (r = 0.31), NGP (r = 0.78), PW (r = 0.95) and HI (r = 0.97). The data showed that the cultivars with these higher traits showed a higher grain yield. In our study, the results of related correlations show that traits such as plant height, panicle length, grains number panicle $^{-1}$, panicle weight and harvest index can be used as an evaluation criterion in breeding work with oats in the climatic conditions of Albania.

Keywords: *Avena sativa*, correlation, cultivars, grain production, traits.

1. Introduction

Oat (*Avena sativa* L.) is a cereal crop and used worldwide for human food and animal feed. Compared to other cereal crops, oats are thought to be more suitable for cultivation in marginal environments, including cool – wet climates and soil with low fertility [16]. However, the production of oats cannot compete with wheat and barley production in other areas of production. Thus, it is necessary to improve its grain production for most areas where crops are cultivated. Grain yield is the result of a number of complex morphological and physiological processes affecting each other and occurring in different stages of growth [11, 2]. Generally, the oat breeders select varieties based on grain yield and desirable traits, observed from heading to maturity. In addition to grain yield, these traits are the number of panicle per m^2 or productive tillers per m^2, plant height, number of grains per panicle, panicle weight, 1000-grain weight, panicle length, harvest index, etc. There is a lot of agreement among plant breeders that related between agronomic traits are very important to increase the use of indirect selection to improve grain production [4]. Benin al., [4] reported that the direct and indirect effects of panicle weight, number of panicle/plant, and average grain weight may help to identify high-yielding oat plants and improve genetic gain. The number of panicle/plant seems to be the most closely related trait with grain production of individual oat plants (through the calculation of simple correlation) through direct effects on grain production [19]. Moradi et al., [20] also determined that the number of panicle per m^2 and the number of grains/panicle showed highest direct effect on oat grain production. But for other cereal crops, grain production is reported to be affected by the direct effects of the total number of tillers and days to bloom (flowering) [3], the number of panicle/plant, the number of grains/panicle and the 1000- grain weight [29], number of grains/panicle and plant length [26],

*Corresponding author: Isuf Kaziu; E-mail: isufkaziu@yahoo.com
(Accepted for publication March 20, 2019)
ISSN: 2218-2020, © Agricultural University of Tirana

productive tillers, panicle length and flowering time [17], plant height and number of tillers [18] number of panicles/plant and spikelet's/panicle, number of productive tillers, number of grains/panicle and 100 – grain weight and biological production, harvest index and 1000 – grain weight [27]. The purpose of this study was to evaluate the coefficients of correlation between grain yield and some agronomic traits such as plant height, number of productive tillers, panicle length, number of grains/ panicle, panicle weight, 1000 – grain weight and harvest index in the conditions of Albania.

2. Material and Methods

Experiment was carried out during the years 2014 - 2015 and 2015 - 2016 on the land of the Agricultural Transfer Center of Fushe Kruja, which is located in the geographical area 41°28'20.02 "N and 19°40'38.56" E. The soil was sub-clay layer with neutral pH, medium in available nitrogen (0.1 - 0.15%) and phosphorus (10-20 ppm) and rich in available potassium (8-15 ppm). The object of the study ware ten cultivars of oats, Timer Van Gele, Torpan, Bendo, Goka, Visto, Abed Minor, Argus and Këmishtaj (local cultivar) representing ten variants of the experiment. The experimental design was the randomized complete block with four replications and each variant (plot) had a size of 10 m^2 (5 x 2 m). Six rows were planted in each variant (plot) with a distance of 20 cm between them. Planting was carried out at the beginning of November at a rate of 450 seeds per m^2. The agro-technology was the same as used in the common cultivation of oat. Agronomic characters recorded were: Plant height (PH) (cm), number of productive tillers per m^2 (NPT), panicle length (PL cm), grains number panicle^{-1} (GNP), panicle weight (PW g), 1000 grain weight (1000 GW g), grain yield (GY kv / ha) and harvest index (HI) (%). For recording the data in the maturity stage, ten plants were randomly obtained for each variant (plot) in the four repetitions. The height of the plant (PH) in cm is calculated as the average of the length of ten plants by measuring from the base where the plant is related to the soil to the tip of the main plant panicle. The number of productive tillers (NPT) was made by counting productive tillers in one-meter length in the two middle rows of each variant (plot) and then converted into tillers per m^2. The length of panicle (PL) in cm is calculated as the average of the length of panicles of the ten plants taken for analysis, by measuring the length of the panicle from its first branch to its peak. The number of grain per panicle (NGP) is calculated as the average of the grains for each panicle by thrashing them separately and counting them. At the same time their weighing was done and is calculated by the average weight of grains panicle in grams (PW) (g). The weight of 1000 grains (1000 grain weight) (g) is calculated as a weight average of 1000 grains by doing three tests for each variant in each of the four replications. Grain yield (GY) (kv/ha) was determined by weight of grain production after harvesting and threshing of the remaining surface. The harvest index (HI) (%) is calculated as the ratio of economic production (grain production) to biological production (straw production + grain production). Harvest index = [economic production kv/ha (grain yield) / total biological production kv/ha (biological yield)] x 100. Statistical analysis: data were subjected to statistical analysis using the standard ANOVA procedure for the randomized block and averages between the traits were compared using the lowest certified difference (LSD) for the probability level P 0.05. The correlation coefficients between all the pairs of traits were calculated based on the Pearson method.

3. Results and Discussion

The observed traits are biometric or quantitative indicators in which, besides the genetic factor (inheritance), environmental factors and conditions of cultivation also influence. Differences from year to year are mainly due to the impact of environmental factors (weather conditions) while differences between genotypes (cultivars) are the result of genetic inheritance or genetic factor. The fact that variations between cultivars for the two years studied are on the same line, so the cultivars that had higher indices in the first year also appear in the second year of study shows that these differences among cultivars are influencing genetic factor.

3.1. Plant height (cm)

Plant height of different cultivars are given in Table 1. The variance analysis showed significant differences between them. These differences are the result of their genetic composition since agro-ecological factors and cultivation conditions were the same. The maximum plant height was recorded in cultivars Gele Van Timer and USO-32, (160.4 cm and 154.2 cm respectively), while the minimum value in the Flavia cultivar (118.5

cm). (Table 1). When oats are cultivated for grain production, high plant height is not always a desirable trait as it determines a greater tendency to lodging the plants, especially in heavy rainfall and strong winds and consequently (influencing) reduction of yield. Additionally, in our study it was found that taller stem cultivars had lower production than short-stem cultivars, which is reflected in their lower production and lower harvest index.

Table 1. Average grain yield values and yield components

Nr	Cultivars	PH (cm)	NPT	PL (cm)	NGP	1000 GW (g)	PW (g)	GY (kv/ha)	HI (%)
1	Gele Van Timer	160.4	409	33.1	135.9	21.6	2.9	42.0	25.7
2	Torpan	133.0	423	32.8	159.6	23.8	3.8	53.5	33.45
3	Bendo	135.2	407	36.3	153.5	23.5	3.6	52.0	32.6
4	Goka	140.5	413	31	146.7	25.1	3.7	52.2	34.8
5	Visto	139.2	397	33.3	128.3	23.4	3	46.7	29.3
6	Abed minor	147.0	403	33.4	144.7	25.1	3.6	51.6	33.07
7	Argus	131.6	474	37.8	134.0	24.7	3.3	47.5	28.98
8	Këmishtaj	132.5	406	29.7	144.9	23.5	3.4	49.5	30.78
9	Flavia	118.5	450	28.8	93.7	29.8	2.8	43.4	27.19
10	USO-32	154.2	465	26	104.9	30.3	3.2	44.9	28.25
11	**LSD 0.05**	**6.23**	**18.7**	**2.43**	**5.06**	**0.92**	**0.48**	**3.6**	**0.83**

PH- Plant height, NPT - number of productive tillers/m^2, PL - panicle lenght, NGP - number of grain/panicle, 1000 GW - 1000 grain weight, GY - grain yield, HI - harvest index

3.2. Number of productive tillerss per m^2

The data showed significant differences among cultivars for the number of tillers per m^2. Many authors [22, 30, 1] have found in their works that the number of tillers varies depending on the biological type of cultivars, results that are confirmed in our study. The maximum number of productive tillers per m^2 was recorded in cultivars Argus, USO-32 and Flavia (474, 465 and 450 tillers per m^2 respectively). The number of tillers per m^2 is a parameter with a significant contribution to the yeild. In general, the number of tillers per m^2 is directly proportional to the fresh fodder production, but in our case it did not affect the grain yield of oats. Indeed, the three cultivars above mentioned, although had a larger number of productive tillers per m^2, grain production was lower, respectively (47.5, 43.4 and 44.9 kv / ha). All the other cultivars had similar results for this parameter.

3.3. Panicle length

The average data of two years showed that genotypes differ between them for the length of panicle. The values of this trait vary from 26 cm to 37.8 cm. The largest panicle cultivars resulted in higher grain production. This is explained by the fact that this trait has also affected other production traits such as the number of grain/panicle and panicle weight. Our data are consistent with the literature conclusions [30] where it is reported that panicle length is affected more by genetic factors.

3.4. Number of grain/panicle and panicle weight

The number of grain per panicle and the weight of panicle is a major traits for the production of oats. Our data showed the difference between years and cultivars (genotypes) for these indicators. The change in years was due to the impact of environmental conditions, while the difference between cultivars (genotypes) was due to genetic influence. The average number of grain/panicle was 134.6. The maximum number of grain/panicle was recorded in the cultivar Torpan (159.6) and local cultivar Këmishtaj (144.9). Cultivar Flavia was found to be inferior to this trait (93.7). The average value of the panicle weight trait was 3.33g. The maximum value was recorded in cultivars Torpan and Goka 3.8 and 3.7 g, respectively and lower values in cultivars Flavia and Gele van Timer 2.8 and 2.9 gr, respectively. The data showed that the cultivars with high values of this trait, allways associated with a higher grain yield.

3.5. 1000 grain weight

This trait describes the size and nutritional values of the grain. This trait is influenced by genetic factors, agroecological conditions and cultivation technology. It is important to note that the weight of 1000 grains did not change significantly from year to year, This fact shows that the trait is affected by genetic factors In the previous works of many authors [7, 21, 5, 30, 6], differences between oat genotypes are reported for the weight of 1000 grains. The weight of 1000 grains is a factor that best describes the potentials for high production of cultivars. The data is presented in Table 1 and the differences among cultivars for this trait were significativ (P <0.05) The weight of 1000 grains varies between 21.56 and 30.3 g. This trait was higher for USO-32 and Flavia cultivars 30.3. and 29.8 g respectively. Cultivar Gele Van Timer had the lowest weight of 1000-grains with 21.56 g.

3.6. Harvest index

The harvest index is an important factor in plant production and its improvement has been one of the greatest achievements that distinguish cultivated varieties from wild ones [12, 14]. Thus a high harvest index means that the allocation of carbon is directed to grain rather than biomass production and a high harvest index can be considered as a good trait in the selection of crops for high yield. In our study, the Harvest Index (HI) also showed a high level of variation among cultivars. According to Peltonen-Sainio et al. [23], this confirms the complex nature of HI and its dependence on the components that determine it (biological and coconut production). Based on the two-year study data, the highest harvest index was obtained from Goka cultivar (34.8), with a significant difference compared to other cultivars in the study. It followed by Torpan (33.45) and Abed minor (33.07) that were in the same group. The lowest harvest index was obtained from the Gele Van Timer cultivar (25.7).

3.7. Grain yield

The two-year average data presented in Table 1 showed significant differences, not only between cultivars (due to their different genetic construct), but also differences between the years (due to the impact of climatic conditions). The highest yield was obtained from Torpan and Goga cultivars with 53.5 and 52.2 kv/ha respectively. Also, cultivars Bendo (52 kv/ha) and Abed minor (51.6 kv/ha) were cultivars with higher production than other cultivars and these cultivars are in the same group with Torpan cultivar. The above mentioned cultivars, compared to the average yield of all varieties (45.7 kv / ha), provided higher grain yield at rate 17.1%, 14.2%, 13.7% and 12.9% respectively. The highest production in cultivars Torpan, Goga and Bendo was related to production traits. In these cultivars, traits such as panicle length (32.8, 31, 36.3), number grains/panicle (159.9, 146.7, 153.5) and the panicle weight (3.8, 3.7, 3.6) were higher than other cultivars. As the average of two years the lowest grain yield (42 kv / ha) was obtained from cultivar Gele Van Timer. Other cultivars like Flavia (43.4 kv / ha) and USO-32 (44.9 kv / ha) belong to the same group as regards grain production. The remaining cultivars, including the local cultivar (Këmishtaj), occupy an intermediate position between the two above-mentioned groups. Similar results in line with our findings have been reported by previous studies [31]. Dokuyucu et al. [11] reported the great importance of the genetic structure in production. In the literature, various authors [8] concluded that differences in grain production and weight of 1000 grains are affected by genetic factors. Other courses [24] suggest their use as criteria for selection of crops with grain yield and high biomass. In addition to the genetic factor in some studies [10], it was determined that wheat yields were more influenced by environmental factors rather than genetic factors. While in some others [28] it is concluded that cereal production was influenced by both climatic conditions and genetic factors. Nawaz et al. [22], showed that grain yield varied for all cultivars. Gautam et al. [13], determined a major difference in wheat yield among genotypes. Buerstmayr et al. [6], found substantive genetic differences and high inheritance for grain yield between genotypes. Ahmad et al. [1], also reported that grain yield is affected by genetic factors.

3.8. Correlations between studied traits

The correlation coefficients between all pairs of studied traits in this experiment are given in Table 2.

3.8.1. Plant height x other variables

Based on the obtained results, there is a non-significant and negative correlation between the plant height (PH) and other studied traits. This coefficient is higher but in the negative value between the pair of traits as plant height (PH) x grain yield (GY) (r = - 0.23) and plant (PH) height x weight of 1000 grains (GW) (r = - 0.21). This situation can be explained by the fact that higher stem plants are more likely to lodging. Also other authors in their studies [6] found significant and negative correlations between plant height and grain yield in oat plants and at the same time that the plant height and lodging were also positively related. Likewise, [25] it is reported that short stem cereal crops are associated with increased yield. These results are consistent with our results.

Table 2. Coefficients of correlation between the studied traits

	PH	NPT	PL	NGP	GW	PW	GY	HI
PH	1							
NPT	-0.19	1						
PL	-0.10	-0.16	1					
NPG	0.10	-0.57**	0.57**	1				
GW	-0.21*	0.66**	-0.66**	-0.79**	1			
PW	-0.04	-0.24*	0.25*	0.78**	-0.25*	1		
GY	-0.23*	-0.36*	0.31*	0.78**	-0.29*	0.95**	1	
HI	-0.17	-0.39*	0.19	0.70**	-0.20*	0.93**	0.97**	1

PH- Plant height, NPT - number of productive tillers/m^2, PL - panicle length, NGP - number of grain/panicle, GW - 1000 grain weight, GY - grain yield, HI - harvest index

3.8.2. Correlation between grain yield and production traits

Grain yields (GY) showed a strong positive correlation with panicle weight (PW) (r = 0.95), harvest index (HI) (r = 0.93), number of grains/panicle (NGP) (r = 0.78) and panicle length (PL) (r = 0.31). Also, the number of grains/panicle showed a high positive correlation with the weight of panicle (r = 0.78) and the harvest index (r = 0.7). So, the bigger the number of grains/panicle, the greater the panicle weight and consequently the higher yield of the grain. Our data is consistent with the findings of other authors [9]. Therefore, selection of these traits can be effective in improving oat grain production.

The number of productive tillers per m^2 (NPT) showed a positive correlation with 1000 grain weight (GW) (r = 0.66), and with traits such as panicle length (PL), number of grain/panicle (NGP), panicle weight (PW), grain yield (GY) and harvest index (HI) (r = - 0.16, r = - 0.57, r = - 0.24, r = - 0.36 and r = - 0.39 respectively) showed negative correlation.

The weight of 1000 grains (GW) is an important trait of production, but in our study it resulted in negative correlation with plant height (r = - 0.21), panicle length (r = - 0.66), number of grains/panicle (r = - 0.79), panicle weight (r = - 0.25), grain yield (r = - 0.29) and harvest index (r = - 0.20). Our data are consistent with the previous findings of Hasan et al. [15].

4. Conclusions

Based on correlation coefficients, grain yield had a strong positive correlation with traits: panicle length, number of grains/panicle and panicle weight, traits that are defined as the best selection criteria for improving oat grain production. On the other hand, the number of productive tillers per square meter exhibited a strong positive correlation with the weight of 1000 grains, while the number of grains/panicle showed a negative correlation to the weight of 1000 grains, so these traits could be considered as important criteria for improvement of the weight of 1000 seeds.

5. References

1. Ahmad, G., Ansar, M., Kalem, S., Nabi, G., M. Hussain, 2008. **Performance of early maturing oats (*Avena sativa* L.) cultivars for yield and quality**. J. Agric. Res. 46(4): 341-346.
2. Akhtar, L.H., M.A. Pervez and M. Nasim. 2011. **Genetic divergence and inter-relationship studies in chickpea (*Cicer arietinum* L.)**. *Pak. J. Agri. Sci*., 48: 35-39.
3. Amirthadevarathinam A. 1983. **Genetic variability, correlation and path analysis of yield components in upland rice**. Madras Agric. Journal, 70(12): 781-785.

4. Benin G, Carvalho FIF, Oliveira AC, Marchioro VS, Lorencetti C, Kurek AJ, Silva A, Cargnin GA, Simioni D. 2003. **Correlation estimates and path analysis as selection criteria for grain yield in oat R. Bras. Agrociência**, (9)1: 09-16.
5. Browne, R.A., White. E.M., Burke. J.I. (2006). **Responses of developmental yield formation processes in oats to variety, nitrogen, seed rate and plant growth regulator and their relationship to quality**. J. Agric. Sci. (Camb.). 144: 533-545.
6. Buerstmayr, H., Krenn, N., Stephan, U., Grausgruber, H., E. Zechner, 2007. **Agronomic performance and quality of oat (*Avena sativa* L.) genotypes of worldwide origin produced under Central European growing conditions**. Field Crops Res. 101: 341-351.
7. Chalmers, A.G., Dyer, C.J., Sylvester-Bradley, R. (1998). **Effects of nitrogen fertilizer on the grain yield and quality of winter oats**. J. Agric. Sci. (Camb.). 131: 395-407.
8. Corville Baltenberger, D.C., K.J. Frey, 1987. **Genotypic variability in response of oat to delayed sowing**. Agron. J. 79: 813-816.
9. Dinesh Tulsiram Surje and Dilip Kumar De, 2014**. Correlation Coefficient Study in Oat (*Avena sativa* L.) Genotypes for Fodder and Grain Yield Characters**. *J. Agric. Technol.*, 1(1): 89-93.
10. Doehlert, D.C., McMullen, M.S., J.J. Hammond, 2001. **Genotypic and environmental effects on grain yield and quality of oat grown in North Dakota**. Crop Sci. 41: 1066-1072.
11. Dokuyucu, T. and A. Akkaya. 1999. **Path coefficient analysis and correlation of grain yield and yield components of wheat (*Triticum aestivum* L.) genotypes**. *Rachis Newsletters*, 18(2): 17-20.
12. Donald, C.M. and Hamblin, J. (1976). **The biological yield and harvest index of cereals as agronomic and plant breeding criteria**. Adv. Agron. 28. 361–405.
13. Gautam, S.K., Verma, A.K., S.R. Vishwakarma, 2006. **Genetic variability and association of morpho-physiological characters in oat (*Avena sativa* L.)**. Farm Science Journal. 15(1): 82-83.
14. Gepts, P. **Crop domestication as a long-term selection experiment**. Plant breeding reviews. 2004; 24:1–44.
15. Hasan Vaisi and Ahmad Reza Golparvar (2013). **Determination of the best indirect selection criteria to improve grain yield and seed weight in oat (*Avena Sativa* L.) genotypes**. *International Journal of Farming and Allied Sciences*. Available online at www.ijfas.com © 2013 IJFAS Journal – 2013 – 2 – 19/747 – 750.
16. Hoffmann, L.A. 1995. **World production and use of oats.** In: *The Oat Crop Production and Utilization*. (Ed.): R.W. Welch. Chapman and Hall, London, pp. 34-61.
17. İbrahim SM, Ramalingam A, Subramanian M. 1990. **Path analysis of rice grain yield under rainfed lowland conditions**. IRRN, 15(1): 11-13.
18. Kumar CRA. 1992. **Variability and character association studies in upland rice**. Oryza, 29(1): 31-34.
19. Lorencetti C, Marchioro VS, Lorencetti C. Kurek AJ, Silva A, Cargnin GA, Simioni D. 2006. **Applicability of phenotypic and canonic correlations and path coefficients in the selection of oat genotypes**. Sci. Agric. (Piracicaba, Braz.), 3(1): 11-19.
20. Moradi M, Rezai A, Arzani A. 2005. **Path analysis for yield and related traits in oats..Journal of Science and Technology of Agriculture and Natural Resources**, 9(1): 173-180.
21. May, W.E., Mohr, R.M., Lafond, G.P., Johnston, A.M., Stevenson, F.C. (2004). **Early seeding dates improve oat yield and quality in the eastern prairies**. Can. J. Plant Sci. 84: 431-442. DOI: 10.4141/P00-127.
22. Nawaz, N., Razzaq, A., Ali, Z., Sarwar, G., M. Yousaf, 2004. **Performance of different oat (*Avena sativa* L.) varieties under the agro-climatic conditions of Bahawalpur-Pakistan**. Int. J. Agri. Biol. 6(4): 624-626.
23. Peltonen-Sainio, P., Muurinen, S., Rajala, A. and Jauhiainen, L. "**Variation in harvest index of modern spring barley, oat and wheat cultivars adapted to northern growing conditions**." Journal of Agricultural Science. vol. 146. No. 1. pp. 35–47. 2008

24. Robertson, L.D. and Frey, K.J. 1987. **Honeycomb design for selection among homozygous oat lines**. Crop Science. 27:1105 – 1108.
25. Rocquigny PM, Entz MH, Gentile RM, Duguid SD. 2004. **Yield physiology of a semi dwarf and tall oat cultivar**. Crop Sci., 44: 2116-212.
26. Ruben SOW, Katuli SD. 1989. **Path analysis of yield components and selected agronomic traits of upland rice breeding lines**. IRRN, 14(4): 11-12.
27. Sürek H, Korkut ZK, Bilgin O. 1998. **Correlation and path analysis for yield and yield components in rice in an 8- parent half diallel set of crosses**. Oryza, 35(1): 15-18.
28. Tamn, I., 2003**. Genetic and environmental variation of grain yield of oat varieties. Agronomy Research**. 1: 93-97.
29. Yang, H.S. 1986. **Studies on the main traits of inter varietals hybrid progenies in indica rice**. *Fujan-Agricultural Science and Technology*, 6; 2 – 4.
30. Yanming, M., ZhiYong, L., Yu Ting, B., Wei, W., W. Hao, 2006. **Study on diversity of oats varieties in Xinjiang. Xinjiang Agricultural Sciences**. 43(6): 510-513.
31. Yilmaz, H.A. and T. Dokuyucu, 1994. **Determination of high yielding and suitable bread wheat genotypes for Kahramanmaras conditions**. Turkey I. Field Crops Congress, pp. 303-306.