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Improving of Simple Selection Index to Determine Oat (*Avena sativa* L.) Genotypes for Dual Purpose Production

Tevrican DOKUYUCU[1]*, Tuğba BAŞKONUŞ[1], Ziya DUMLUPINAR[2]*

[1]*Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Department of Field Crops, 46100, Kahramanmaras, Türkiye*
[2]*Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Department of Agricultural Biotechnology, 46100, Kahramanmaras, Türkiye*

✉ *Corresponding author: zdumlupinar@ksu.edu.tr*

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ABSTRACT

Selection indices might be crucial to develop multipurpose genotypes in most environments for oat production. This study aimed to improve simple selection index value to determine oat genotypes for dual purpose production. The research was carried out in Kahramanmaras conditions for two consecutive years between 2020-21 and 2021-22. In the research, a total number of 28 oat genotypes (10 landraces and 18 commercial cultivars) were used as plant materials and, plant height (PH), panicle numbers m-2 (PN m-2), grain number per panicle (GNP), thousand-kernel weight (TKW), harvest Index (HI), dry hay yield (DHY) and grain yield (GY) traits were investigated. Based on grain yield and dry hay yield, formula of selection index value for dual purposed oat genotypes was determined; SI (Selection Index) = AGYG (Average Grain Yield of Each Genotype) – AGYE (Average Grain Yield of Genotypes by the Experiments)/AGYE + ADHYG (Average Dry Hay Yield of Each Genotype)-ADHYE (Average Dry Hay Yield by Experiments)/ADHYE. Total selection index value was also obtained by collecting of selection index values belong to other investigated traits and dual purposed selection index values of oat genotypes.

According to the results, Kahraman with 0.784 value had the highest selection index, which can be used to determine the dual purposed oat genotypes. This genotype was also followed by Kirklar (0.355), TL227 (0.629) and TL341 (0.579) oat genotypes. These oat genotypes with higher selection index values may be suggested for both DHY and GY. Total selection index vales also pointed out same oat genotypes for the experiment region. The results also showed that formula of this simple selection index value may be applied for other cereals such as corn, wheat, barley sorghum etc. and as well as the different traits.

1. INTRODUCTION

Oat (*Avena sativa* L.) as a cool season cereal crop is grown for human food and livestock feed grown annually both in autumn and spring through the world (Hocaoglu, 2022). Oat breeders aim to improve oat genotypes suitable for growing as dual- purposed crop (Iannucci et al., 2011). In literature, dual purposed crops defined as "grain harvest after grazing or cutting" (Suttie and Reynolds, 2004). However, in recent years, cereals (oat, barley and triticale) used as dual purposed crops produced limited biomass due to climate change and irregular precipitation all over the world, as well as low grain yield after grazing or cutting. Thus, there are too limited environments that dual purposed oat grown worldwide. Fewer grain and fodder (biomass) yields are obtained in most environments due to low temperature or inadequate precipitation after cutting or grazing. Francia et al. (2006) reported significant reduces in oat grain yield after grazing. In addition to this, activity of grazing or cutting of dual purposed oat is very limited due to wet soils during winter conditions in larger areas. Oat is grown for grain or fodder crop as a pure stand as well as accompanied plant with the most common annual forage legumes in most environments of the world. Therefore, selection of oat genotypes with higher grain and hay yield as a pure stand in many of environments is crucial. Cereals are crucial for animal feed with high dry matter contents (Basaran et al. 2017). Oat breeders have also put effort to improve oat genotypes with higher grain yield and hay yield without lodging. In practice, oat growers can harvest oat plants for hay product in 3/4 part of oat field, then leave 1/4 parts of oat in field to harvest for grain, or vice versa. Thus, we suggest using dual purposed oat varieties with higher grain and hay yield in the same season in oat production systems. Adapting of dual purposed oat varieties may provide an option to oat growers to decide harvesting for grain or hay in same season based on the environmental conditions such as drought in generative period and market prices. Determination of oat genotypes with higher grain yield and hay yield is being gradually important by oat breeders. Thus, this research suggests a selection index value to determine dual purposed oat genotypes with higher grain and hay yield in oat production areas.

Bio-agronomic characterization carried out using appropriate statistical methods continues to be a useful tool for the initial description and classification of oat collections, as it allows plant breeders to identify and select valuable genetic resources for direct use by farmers, in breeding programs, or for planning efficient germplasm conservation and use (Achleitner et al. 2008; Rezai and Frey, 1990). In literature, harvest index (HI) which is ratio of grain weight to total plant weight, was improved by Beaven in 1914 as called migration coefficient (Donald and Hamplin, 1976). "The migration coefficient" concept was largely ignored until 1962, in 1962, Donald suggested term "harvest index" and recommended it as an important reference to assess progress in germplasm development towards improved yield potential. In recent years, there has been substantial attention given to harvest indices of crops and association of HI with grain yield (Sinclair, 1998). Leaf area index was the other important index to evaluate the crops as vegetative growth (Fang et al., 2019). Golden ratio was also another mathematical model applied to plants (Zhang et al., 2014). Harmonization ratios of post to pre-anthesis durations of wheat genotypes by thermal times to investigate relationships between harmonization ratios and grain yield, phenological periods by the thermal times (Akkaya et al., 2006). As seen in literature, improved index values are used efficiently in breeding programs of cereal plants.

Some researchers used to evaluate the traits by principal component analysis and coefficient of correlations. Iannucci et al. (2011) reported that the genetic variation in the germplasm for agronomic characteristics can be subjected to multivariate analysis (principal component analysis (PCA) and cluster analysis) to establish the relationships among various accessions. However, these models frequently don't give any chance to evaluate the performance of oat genotypes for grain yield and hay yields simultaneously. In many researches related with oat genotypes, determining oat genotypes with higher grain yield and hay yield is not easy. There is no available formula to evaluate the performance of oat genotypes for both grain yield and hay yield at the same season in literature. Oat breeders need a simple formula giving certain results to determine the oat genotypes with higher grain and hay yield. For these reasons, this research aimed to improve a simple selection index or formula to evaluate dual purposed oat genotypes for higher grain and hay yields, at the same season.

2. MATERIALS AND METHODS

This research was carried out in Kahramanmaras, Turkiye, for two years, between 2020 and 2022. Results of soil analysis and climate data were given in Table 1 and 2, respectively. The information about oat genotypes used in the study is also given in Table 3.

The soil of the experiment sites had a clay loam structure in both years and had moderate organic matter, unsaline, neutral in pH, and high phosphorus (Table 1).

Table 1. Some physical and chemical properties of experiment soils.

Properties	2020	2021
Saturation (%)	57.4	57.6
pH	6.5	7.0
Salt (%)	0.1	0.1
$CaCO_3$ (%)	0.3	5.2
Organic matter (%)	2.8	3.8
K (mg kg^{-1})	235	129.0
P (mg kg^{-1})	16.2	18.7

Table 2. Climate data of experiment years in Kahramanmaras location of Turkiye

Months	Rainfall (mm)			Temperature (°C)			Relative Humidity (%)	
	2020-2021	2021- 2022	1930-2023	2020-2021	2021- 2022	1930-2023	2020-2021	2021- 2022
November	55.4	15.80	78	12.4	13.8	11.9	65.9	63.0
December	56.8	120.8	130.6	8.2	7.5	6.7	74.7	69.8
January	211.6	128	124	7.0	4.5	4.8	70.2	71.4
February	29.6	70.6	112.2	9.3	8.7	6.2	59.8	69.3
March	129.2	99.8	95.1	10.4	7.1	10.4	61.2	62.1
April	16.8	9	73	16.6	18.2	15.1	57.5	45.7
May	13.2	28	38.8	23.5	20.4	20.1	43.3	50.7
June	0	4	8.6	25.5	26.2	24.9	49.0	50.8
Total	512.6	476	660.3					
Average				14.1	13.3	12.5	60.2	60.3

In the experiments, 28 oat genotypes were sown in a randomized complete block designs with four replications in the both years. Oat seeds (450 seeds m^{-2}) were sown in plots with 5 m long in 6 rows with 0.20 m apart. Sowing dates were on 18 October 2020 in the first year and 22 October 2021 in the second year. Fertilizers were supplied as the pure 69 kg ha^{-1} P_2O_5 and 27 kg N ha^{-1} with 150 kg ha^{-1} di-ammonium- phosphate in first year, 50 kg ha^{-1} P_2O_5 and 50 kg N ha^{-1} with 20-20 compose fertilizer (250 kg ha^{-1}) in the second year, at sowing time. Top dress was supplied as 56 kg N ha^{-1} with 215 kg ha^{-1} Ammonium Nitrate (26%) at jointing stage in both years. Herbicide (Fullamin 50 LC) was used for broad leaf weed control in the first year on 08 March 2020 at the tillering stage and in the second year on 06 April 2021 at the starting of jointing stage.

Table 3. Oat genotypes used in the experiments

No	Cultivar Name	Origin	Featured Traits	Registration Date
1	Kirklar	Turkiye	Higher Grain Yield (GY) and thousand-kernel weight (GW)	2014
2	Kahraman	Turkiye	Higher GY and Biomass Yield (BY), stem thickness	2014
3	Sebat	Turkiye	Medium plant height (PH)	2011
4	Yeniceri	Turkiye	Higher Yield and TKW	2013
5	Sari	Turkiye	Higher Panicle weight and TKW	2014
6	Arslanbey	Turkiye	Early maturity, higher stability,	2017
7	Amasya	Turkiye	Local variety	Landrace
8	Ankara 84	Turkiye	Registered local variety	1975
9	2-3	Turkiye	Registered local variety	1963
10	Checota	USA	Medium Earliness, medium resistance to winter	1986
11	Faikbey	Turkiye	Resistance to lodging, higher PH	2004
12	Seydisehir	Turkiye	Resistance to lodging, higher PH	2004
13	Yesilkoy-330	Turkiye	Registered local variety	1975
14	Dirilis	Turkiye	Higher BY, higher stem thickness	2017
15	TL 38	Turkiye	Genetic Resources Nursey	Landrace
16	TL42	Turkiye	Genetic Resources Nursey	Landrace
17	TL137	Turkiye	Genetic Resources Nursey	Landrace
18	TL 218	Turkiye	Genetic Resources Nursey	Landrace
19	TL 227	Turkiye	Genetic Resources Nursey	Landrace
20	TL 242	Turkiye	Genetic Resources Nursey	Landrace
21	TL 330	Turkiye	Genetic Resources Nursey	Landrace
22	TL 341	Turkiye	Genetic Resources Nursey	Landrace
23	TL 374	Turkiye	Genetic Resources of Nursey	Landrace
24	Yazir	Turkiye	Early maturity	2021
25	Kazan	Turkiye	High hay yield	2020
26	Otag	Turkiye	High hay yield	2020
27	Katmerli	Turkiye	Early maturity	2020
28	Yagiz	Turkiye	Non-lodging high grain and hay yield	2024 production permitted

In the experiments, traits such as plant height (PH), panicle number per square meter (PN m^{-2}), grain number per panicle (GNP), thousand-kernel weight (TKW), harvest index (HI), dry hay yield (DHY) and grain yield (GY) were investigated by the methods used by Nawaz et al. (2004), Assefa (2006), Gautam et al. (2006); Dumlupinar et al. (2017), Ceri and Acar (2019).

The data obtained from two-year trial results was subjected to variance analysis and means were compared using LSD test (JMP 15.1 SAS Institute Inc., 2020).

Formula of selection index for dual purposed oat genotypes,

$$\text{Selection Index (SI)} = \frac{\text{AGYG} - AGYE}{\text{AGYE}} + \frac{\text{ADHYG} - ADHYE}{\text{ADHYE}}$$

where,

AGYG: Average Grain Yield of Each Genotype

AGYE: Average Grain Yield of Genotypes by the Experiments

ADHYG: Average Dry Hay Yield of Each Genotype

ADHYE: Average Dry Hay Yield of Genotypes by Experiments

Selection index was calculated for the investigated traits as following;

For Dry High Yield (ADHYG-ADHYE)/ADHYE;

For Plant Height (APHG-APHE)/APHE;

For Panicle Number per m^2 (APNG-APNE)/APNE;

For Grain Number per Panicle (AGNPG-AGNPE)/AGNPE;

For Thousand Kernel Weight (ATKWG-ATKWE)/ATKWE;

For Harvest Index (AHIG-AHIE)/AHIE;

This formula was improved by modified land equivalent ratio (LER) formula, which evaluate the performances of crop varieties in mixed and sole production systems (Dariush et al., 2006). Selection index formula will give us an index value about the performance of oat genotypes having higher or less grain and dry hay yield compared to the average grain and dry hay yield of experiments. Genotypes having higher GY and DHY compared to average GY and DHY of experiments will have higher selection index values, genotypes with less GY and DHY compared to average of experiments will have lesser values on selection index. Thus, selection index value for two important traits for GY and DHY of genotypes will be applied successfully for selection of dual purposed oat genotypes. This formula can be applied for the other cereals and traits. For example, this formula may be easily applied for selection of corn varieties for high GY and silage yield.

Total selection index was also calculated as the sum of all index values of dual purpose and the other traits in the experiment.

3. RESULTS AND DISCUSSION

According to the results, years were found significantly different for all investigated traits except TKW, while genotypes and G×Y interaction varied substantially for all characteristics except DHY (Table 4). The mean values of the investigated traits are shown in Table 5 and calculated selection index values is given in Table 6.

Table 4. Degrees of freedom, and mean square values of investigated traits for oat genotypes.

	DF	DHY	GY(MS)	PH	PN m^{-2}	GNP	TKW	HI
Years	1	7.2477**	313543.68**	1199.09**	663394.34**	2339704.0**	8.66^{ns}	7782.15**
Genotypes	27	0.0914^{ns}	9436.31**	512.64**	24084.27**	101847.8**	90.2543**	102.7484*
G×Y	27	0.0783^{ns}	2856.15*	261.66**	27681.49**	46810.98**	7.47882*	177.60648**
Error	110	0.0653	1407.4	94.59	6662.6	10414.7	4.6915	51.615
CV %		2.44	16.11	9.44	20.91	14.44	7.95	51.61

**p<0.01, *p<0.05, ^{ns}: not significant

According to the results, dry hay yields of genotypes were changed between 13060- 8190 kg ha^{-1} with TL218 and Kazan genotypes, respectively. TL218 oat genotype was followed by Sebat, Yeniceri, Sari, Amasya, Ankara 84, Checota, Faikbey, Yagiz, TL42, TL227, TL242, TL341, TL374 and Dirilis oat genotypes for DHY (Table 5). Dry hay yield among the years was significantly different due to climate differences, especially rainfall and temperature. Previous works also pointed out oat genotypes with different DHY. Ceri and Acar (2019), reported 6140 to 9940 kg ha^{-1} dry hay yield. Kılınc and Gokkus (2022) reported dry hay yield varied between 530 to 2030 kg ha $^{-1}$ in oat genotypes. GY of oat genotypes were changed between 3152 kg ha^{-1} and 1713 kg ha^{-1} with Kahraman and Otag oat genotypes, respectively. Kahraman and TL227 oat genotypes were the same group for GY (Table 5). A significant variation among the years due to climate changes especially for the rainfall and temperature was detected for grain yield of oat genotypes. As an average, oat genotypes had GY with 1955 kg ha^{-1} and 2774 kg ha^{-1} in the first and second years, respectively. In previous works, researcher reported that GY between 4950 and 2360 kg ha^{-1} by Dumlupinar et al. (2012), between 8600-3350 kg ha^{-1} by Sabanduzen and Akcura (2017), 1150 and 710 kg ha^{-1} by Sonkaya (2019), between 6142- 4026 kg ha^{-1} by Duzme (2020), between 6229-3537 kg ha^{-1} by Yasar (2021). These differences between the results were due to change of environmental conditions in years and genotypic variance. Oat genotypes differently responded to the experiment location with different climate and topographical conditions, causing significantly different results for PH, PN m^{-2}, GNP, TKW and HI (Table 4) which is also in line with previous works. Ercan et al. (2016) reported that grain yield varying among the oat genotypes 2360-4950 kg ha^{-1}. Halil and Uzun (2019) reported that average grain yield oat genotypes were found 4548 kg ha^{-1}. Yasar (2021) reported that grain yield varied between 3537-6229 kg ha^{-1} in oat genotypes. Caliskan and Koc (2019) reported that plant height varying among the oat genotypes were 135- 175 cm. Hocaoglu (2020) reported plant height varied between 98-163 cm in oat genotypes. Ataman (2022), reported plant height varied between 42-84.1 cm. Altuner and Ulker (2019) reported that panicle number 340 PN m^{-2} as the lowest while 380 PN m^{-2} the highest. Kececioglu et al. (2021) reported that panicle number varying among the oat genotypes 502-630 PN m^{-2}. Ercan et al. (2016) reported that grain numbers per panicle among the oat genotypes 47-93 grains per panicle. Yilmaz and Sonkaya (2020) reported that grain number per panicle varying among the oat genotypes 28 to 46 grains per panicle, Kahraman et al. (2021) reported that grain number per panicle among the oat genotypes 64- 143 grains. Ercan et al (2016) reported that thousand-kernel weight varying among the oat genotypes 25-51 g. Dumlupinar et al (2017) reported that thousand-kernel weight varied 16.32- 42.62g in oat genotypes. Duzme (2020) reported that harvest index of oat genotypes was found between 7.2 to 36.5%. Ataman (2022) reported that harvest index varied between 36.3-63%.

Table 5. Average values of two years for investigated traits of oat genotypes.

	Genotypes	DHY (kg ha^{-1})	GY (kg ha^{-1})	PH (cm)	PN m^{-2}	GNP	TKW (g)	HI (%)
1	Kirklar	9640 B-E	2869 BC	103.7 B-F	287.5 KL	705.3 EFG	33 AB	29.87 BC
2	Kahraman	9870B-E	3152 A	102.2 C-G	354.1 H-J	681.16 G-J	29.6 C-F	31.77 AB
3	Sebat	10530 A-E	2256 GJI	103.5 B-F	268.3 L	816.5 B-E	23.6 I-M	26.67 FG
4	Yeniceri	10650 A-E	2683 D	97.2 D-H	371.6 F-I	837.16 ABC	23.3 KLM	23.63 H-K
5	Sari	10440 A-E	2314 FGHI	1106.8 A-E	517.5 A	735.6 C-G	27.7 EFG	23.92 H-K
6	Arslanbey	9510 B-E	2617 DE	89.9 HIJ	411.6 C-F	729.1 C-G	32.1 BC	25.37 F-I
7	Amasya	12270 AB	2241 HI	113.5 AB	442.5 B-D	678.3 G-J	25.8 G-J	29.14 C-E
8	Ankara 84	11640 A-D	2421 FG	105.8 A-E	458.3 B	714.3 D-G	23.3 J-M	27.13 D-F
9	Apak 2-3	8990 CDE	2710 E-I	104.8 B-E	432.5 B-D	573.5 JKL	29.4 DEF	19.10 MN
10	Checota	12210 AB	2356 FGH	112.2 ABC	355 H-J	820.3 A-E	29.8 CDE	24.35 G-J
11	Faikbey	11670 A-D	2642 DE	111.4 ABC	315.8 JK	823.3 A-D	24.8 H-K	27.32 D-F
12	Seydisehir	9820 B-E	2681 D	112.0 ABC	332.5 I-K	806.6 C-F	23.3 KLM	22.17 JK
13	Yeskoy-330	10070 B-E	2177 IJ	109.4 ABC	417.5 B-E	665.6 G-K	23.3 KLM	22.14 JK
14	Dirilis	10520 A-E	2021 JKL	85.1 IJ	451.6 BC	698.6 FGH	26.8 GH	25.72 F-H
15	TL 38	9120 CDE	2357 FGHI	104.9 BDE	361.6 G-I	803 C-F	24 I-L	33.55 A
16	TL42	10690 A-E	2013 JKL	104.7 BDE	310 J-L	933.5 A	24.1 I-L	19.52 LM
17	TL137	10040 B-E	2474 EF	104 BDEF	445.8 B-D	579.6 I-L	31.7 BCD	24.63 G-I
18	TL 218	13060 A	2216 HI	108.7 ABC	332.5 I-K	747.16 C-G	32 BC	27.44 C-F
19	TL 227	11830 ABC	3006 AB	110 ABC	401.6 D-G	587 H-L	34.7 A	23.83 H-K
20	TL 242	10810 A-E	2264 GJI	109.2 ABC	427.5 B-E	678.3 G-J	25. H-K	21.62 KL
21	TL 330	9480 B-E	2430 FG	107.5 A-D	440 B-D	529.6 L	28.1 EFG	29.26 CD
22	TL 341	11420 A-D	2741 CD	109.7 ABC	430 B-E	735.6 C-G	31.2 BCD	25.52 F-H
23	TL 374	12350 AB	1760 M	116.1 A	386.6 E-H	691.6 F-I	24.1 I-L	16.74 N
24	Yazir	9280 CDE	1886 LM	93.3 F-J	400.8 D-G	770.6 C-G	21.2 M	23.40 H-K
25	Kazan	8190 E	2210 HI	82.3 J	444.1 B-D	559.16 L	33.4 AB	26.75 E-G
26	Otag	8850 DE	1713 M	91.1 G-J	267.5 L	924 AB	24.3 I-L	21.76 KL
27	Katmerli	9130 CDE	1992 KL	86.1 HIJ	433.3 B-D	360.6 M	21.8 LM	22.94 I-K
28	Yagiz	10520 A-E	2021 JKL	85.1 IJ	451.6 BC	698.6 FGH	26.8 GH	25.72-H

According to the selection index values calculated for DHY of oat genotypes, TL227 (0.346), TL341 (0.318) and Kahraman (0.290) oat genotypes had positive and the highest selection index values for DHY. In addition to these Faikbey (0.235) and Kirklar (0.215) oat genotypes also had positive selection index values for DHY (Table 6). This means that oat genotypes with positive and higher selection index values had higher DHY than the average DHY of experiments. Especially, oat genotypes (TL227 and TL341) with positive and higher selection index values were suitable for experiment location, may also be suggested for the higher DHY.

According to the results, selection index values of oat genotypes for GY, Kahraman (0.494) and Kirklar (0.440) oat genotypes had higher selection index values, and these genotypes were followed by TL227 (0.283), TL341 (0.261) and Sari (0.254) (Table 6). These cultivars had higher GY than the average GY of experiments. Especially Kahraman and Kirklar genotypes for GY with higher selection index values may be suggested for experiment location.

Table 6. Calculated selection index values for the oat genotypes by the investigated traits

Genotypes	DHY (kg ha^{-1})	GY (kg ha^{-1})	Dual purposed SI	PH (cm)	PN m^{-2}	GNP	TKW (g)	HI (%)	Total SI
Sari	0.062	0.254	0.316	0.049	0.303	-0.004	-0.007	-0.067	0.590
Seydisehir	0.187	0.169	0.356	0.248	-0.014	0.143	-0.012	0.017	0.738
Sebat	-0.027	-0.055	-0.082	-0.080	-0.358	0.059	-0.153	0.016	-0.598
Ankara 84	0.183	0.098	0.281	0.098	0.197	0.081	-0.102	0.104	0.659
Apak 2-3	-0.275	-0.309	-0.584	-0.190	0.013	-0.279	-0.007	-0.333	-1.380
Checota	0.199	0.046	0.245	0.062	-0.094	0.157	0.059	-0.035	0.394
Yeniceri	0.090	0.078	0.168	0.009	0.086	0.295	-0.011	0.076	0.623
Kirklar	0.215	0.440	0.655	0.159	-0.050	0.234	0.420	0.403	1.821
Amasya	0.187	-0.001	0.186	-0.004	0.081	-0.045	-0.106	0.108	0.220
Kahraman	0.290	0.494	0.784	0.269	0.240	0.320	0.451	0.598	2.662
Faikbey	0.235	0.175	0.410	0.217	-0.073	0.306	0.026	0.205	1.091
Arslanbey	-0.046	0.100	0.054	-0.081	0.161	0.197	0.282	0.117	0.730
Yesilkoy	-0.245	-0.205	-0.450	0.014	-0.010	-0.225	-0.057	-0.197	-0.925
Dirilis	-0.005	-0.320	-0.325	-0.493	0.011	-0.148	-0.164	-0.120	-1.239
TL38	-0.131	0.015	-0.116	-0.022	-0.093	0.106	-0.140	0.316	0.051
TL42	-0.131	-0.047	-0.178	-0.122	-0.354	0.134	-0.265	-0.307	-1.092
TL137	-0.060	0.113	0.053	0.069	0.188	-0.142	0.206	0.027	0.401
TL218	0.037	-0.059	-0.022	-0.024	-0.211	-0.005	0.151	0.303	0.192
TL227	0.346	0.283	0.629	0.324	0.299	0.114	0.541	0.220	2.127
TL242	-0.136	-0.034	-0.170	-0.135	0.052	-0.118	-0.121	-0.181	-0.673
TL330	-0.119	-0.092	-0.211	0.112	0.154	-0.278	0.057	0.193	0.027
TL341	0.318	0.261	0.579	0.242	0.206	0.200	0.302	0.175	1.704
TL374	-0.132	-0.180	-0.312	-0.225	-0.265	-0.159	-0.373	-0.588	-1.922
Yazir	-0.264	-0.382	-0.646	-0.278	-0.175	-0.111	-0.426	-0.270	-1.906
Kazan	-0.198	-0.249	-0.447	-0.296	0.072	-0.316	0.159	0.001	-0.827
Otag	-0.476	-0.513	-0.989	-0.370	-0.590	0.032	-0.386	-0.408	-2.711
Katmerli	-0.192	-0.338	-0.530	-0.387	-0.044	-0.644	-0.355	-0.240	-2.200
Yagiz	0.076	0.055	0.131	0.069	0.216	0.067	0.055	0.200	0.738

Sum of selection indices of DHY and GY a new selection index value for dual purposed oat genotypes. These selection index values will give us information about dual purposed oat genotypes having higher DHY and GY over the average of experiments and experiment region. According to the results, oat genotype, Kahraman with 0.784 selection index value had the highest selection index, which will be used to determine dual purposed oat genotypes. This genotype was also followed by Kahraman (0.784), Kirklar (0.655), TL227 (0.629) and TL341 (0.579) oat genotypes (Table 6). These oat genotypes with higher selection index may be suggested for experiment location for both DHY and GY. Oat genotypes with selection index values below zero are unsuitable for dual purposes for DHY and GY in experiment location. We can understand that Kahraman, Kirklar and TL227 genotypes with positive and higher selection index values had higher DHY and GY than the other oat genotypes. These genotypes were suitable for dual purposed production in experiment region and might be registered.

Selection index values may also be calculated for the other traits related to GY and DHY. Selection index values of plant height were positive and higher for TL227 (0.324), Kahraman (0.269), Seydişehir (0.248) and TL341 (0.242) genotypes. Otag (-0.989), Yazir (-0.646) and Katmerli (-0.530) oat genotypes had the negative and less selection index values for PH. This situation was due to those cultivars with negative and the less selection index values were improved for Konya region where winter conditions are harsher than Kahramanmaras experiment site. Therefore, growth of these oat cultivars with negative and the less selection index values were slower and unsuitable for experiment location.

Selection index values of Sari (0.303), TL227 (0.299), Kahraman (0.240) and TL341 (0.206) oat genotypes for PN m^2 were positive and higher values than the other genotypes. Otag (-0.590) Sebat (-0.358) and TL42 (-0.354) oat genotypes had negative and the lowest selection index values in the experiment.

Calculated selection index values for grain numbers per panicle (GNP) were the positive and higher for Kahraman (0.320), Faikbey (0.306), Yeniceri (0.295), Kirklar (0.234) and TL341 (0.200) genotypes. It was negative and lowest for Katmerli (-0.644) and Kazan (-0.316) genotypes.

While TL227 (0.541), Kahraman (0.451), Kirklar (0.420) and TL341 (0.302) oat genotypes had positive and higher selection index values for TKW, Yazir (-0.426), Otag (-0.386), TL374 (-0.373) and Katmerli (-0.355) oat genoypes had negative and lowest selection index values for TKW.

Selection index values of HI for Kahraman (0.598), Kirklar (0.403), TL38 (0.316) and TL218 (0.303) oat genotypes were positive and higher than the other genotypes. TL374 (-0.588) and Otag (-0.488) oat genotypes had negative and less selection index values for HI.

As mentioned above, selection index values may be calculated for each yield related traits such as PH, PN m^{-2}, GNP and TKW, and HI. These values of yield related traits may provide information about oat genotypes. In addition, all these selection index values may be collected with dual purposed selection index values and another selection index called total selection index value might be obtained. These total selection index values may give us information about oat genotypes that best for all the investigated traits.

According to the total selection index values, Kahraman oat genotype with (2.662) had the highest value followed by TL227 (2.127), Kirklar (1.821) and TL341 (1.704) oat genotypes.

It is concluded that commercial cultivars Kahraman and Kirklar may be suggested for GY, DHY and related traits for experiment location. In addition, oat genotypes TL227 and TL341 may be evaluated to register for DHY and GY as well as yield related traits for experiment location. Oat genotypes with negative and lower total selection index values were not suitable for experiment region and oat genotypes with lower but positive total selection index values may also be evaluated for the other locations.

4. CONCLUSION

The results show that calculated selection index value for oat genotypes will give us an information about the both GY and DHY of dual purposed oat genotypes which will be the best for any region. Thus, GY and DHY of oat genotypes would be evaluated together, and chosen of oat genotypes with the highest GY and DHY for dual purposed production. According to the results of dual purposed and total selection index values, commercial oat cultivars Kahraman and Kirklar were determined suitable for dual purposed oat production. TL227 and TL341 oat genotypes were suggested to register for experiment region. This selection index values may be calculated for the other cereals such as corn, wheat, barley, rye, sorghum etc. This selection index value will help us to select the cereal varieties with higher GY and silage or dry hay yields, or the other yield related traits. For example, corn varieties with higher GY and silage yields may be selected by the selection index values for dual purposed. This selection index value may be easily applied for the other cereals.

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