

Determining of Yield Performances of Some Imi Resistant Sunflower Hybrids in Trakya Region, Turkey

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Abstract: Sunflower (*Helianthus annuus* L.) is one of the main oil crops in the world but it is the essential oilseed in Turkey. Sunflower grows widely in the Turkey and also other countries due to higher adaption capability, higher mechanization use, easy marketing, and also it is one of most preferable and consuming vegetable oil in Turkey. Weeds and broomrape parasite is the devastating biotic stress factor limited seed and oil yield in sunflower production. Clearfield System hybrids resistant to Imidazilonone (IMI) herbicide which controls both broomrape and also key broad-leaf weeds is commonly use in the world widely, because Clearfield system is easy solution both for broomrape problem and also especially large leaf weeds such as *Xanthium strumarium* Wallr. *Chenopodium album* L., *Echinochloa crus-galli*, *Sinapsis arvensis* L., *Amaranthus* spp., *Solanum nigrum* L., *Datura stramonium* L. ragweed, *Avena* spp. etc. in sunflower production. The study conducted to determine IMI sunflower hybrid performances in yield conducted trials in Tekirdag and Edirne, Trakya Region which is European part of Turkey. This region has more than 40 % of sunflower production areas in Turkey. IMI candidate hybrids were existed in yield trials and all important yield traits were measured and compared with control hybrids which are most selling commercial hybrids in the market in 2017. Some candidate hybrids had higher performances in the trials.

Keywords: Sunflower, Sustainable production, Clearfield, Hybrids

Introduction

Sunflower is the third important oil crop in the world after soybean, canola. The 60% of world sunflower planting area is located in Black Sea countries as Ukraine, Russia, Romania, Bulgaria, Turkey and Moldova. Sunflower is the most important oilseed in Turkey and also the most preferable and consuming vegetable oil in Turkey because of higher adaption capability, higher mechanization use, easy marketing. Turkish sunflower planted areas mostly located in Trakya Region which is European part of Turkey. Konya and Adana provinces are other main planting areas in Turkey (Demirci and Kaya, 2009; Skoric and Pacureanu, 2010; Kaya et al., 2004; Sala et al., 2012).

As being a summer crop, sunflower influence more environmental conditions especially drought and hot temperatures during the vegetation period. Therefore, sunflower seed and oil yield more changeable based on climatic conditions in different years in Turkey and also other sunflower growing countries in drylands. On the other hand, biotic stresses such as diseases, broomrape parasite and weeds are also the main limiting factors of sunflower yield (Neshev et al., 2017; Kaya et al., 2014a, b and c).

Broomrape parasite (*Orobanche cumana* Wallr.) affects sunflower yield severely until 100% and exist one of the top most limiting factors for sunflower production in especially in Eastern Europe and Black Sea Region. Broomrape which is holoparasitic weed and has not chlorophyll has been generating new aggressive races

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historically against sunflower resistant genotypes almost 100 years in Europe. The first races of broomrape parasite (A and B) identified by Russian researchers in the 1960-1970s period. Other 3 races (C, D and E) were appeared following years and determined by sunflower differentials carrying the dominant resistant genes in Romania. Furthermore, F race firstly appeared in Spain then later in Turkey and other Balkan country and identified by Spanish researchers. In the recent years, new and virulent broomrape populations called as G, H or I races have been determined in sunflower cultivated areas, over the different regions of the world (Alonso, 1996; Pacureanu et al., 1998; Demirci and Kaya, 2009; Skoric and Pacureanu, 2010; Kaya et al., 2004; Sala et al., 2012; Kaya et al., 2014a, b and c).

Clearfield technology (CL) with Imidazolinone (IMI) tolerant hybrids and IMI herbicide as post emergence application control successfully broomrape and common weeds. IMI herbicide tolerant wild sunflower population was discovered firstly in soybean field in Kansas, USA in 1996 then IMI tolerant genes were transferred via backcrossing then tolerant lines were developed firstly in USDA sunflower program in Fargo, ND, US (Al Khatib et al., 1998; Miller and Al Khatib, 2002). First CL hybrids were introduced to farmers firstly in 2003 in Turkey lately Argentina, US and other countries [17]. In Clearfield system, IMI post emergence herbicides (Imazamox (40 g/l)) applied 6-8 leaf stage control effectively both broomrape and major broadleaf weeds such as *Xanthium strumarium* Wallr., *Chenopodium album* L., *Echinochloa crus-galli*, *Sinapsis arvensis* L., *Amaranthus* spp., *Solanum nigrum* L., *Datura stramonium* L. ragweed, *Avena* spp. etc. resulting important yield losses in sunflower [Demirci and Kaya, 2009; Elezovic, et al, 2012; Evci et al., 2011; Kaya et al., 2014a, b and c).

The second IMI tolerance source known as Clearfield Plus® (CL Plus) was developed by seed mutagenesis and selection with imazapyr in sunflower. This new traits present better stability of the herbicide tolerance in different environmental conditions, permit developing new herbicide formulations providing more flexible and reliable weed control, higher oil content, etc. than previous classical CL system (Elezovic, et al, 2012; Evci et al., 2011; Sala et al., 2012; Pfenning et al., 2016; Balabanova and Vassilev, 2015).

The study covers conducted yield trials in 2017 for determining the performance of CL sunflower hybrids in Tekirdag and Edirne provinces in Trakya Region which has more than 40 % of sunflower production areas in Turkey.

Material and Method

The yield trials were conducted in Edirne and Tekirdag location in 2017 to determine yield performances of candidate sunflower IMI type hybrids. There were 23 hybrids including 4 controls from commercial hybrids (and P-LC108 from Pioneer Seed, SY Bento from Syngenta, Meteor from May Seed and LG-5565 CL from Limagrain Seed Co.) in the market. The experimental design was a Randomized Complete Block Design with four replicates. The four rows plots were 7,50-m long with the 70 x 35 cm plant spacing. Total plot area at planting was 7,5*2,8 as 21 m². The middle two rows were harvested and the border rows were discarded, and plot size was 9.66 m² at harvest. The compose fertilizers (20-20-0, Zn) were applied 200 kg/ha dose at planting. Weed control was with IMI herbicide (Imazamox (40 g/l) with 1.25 l / ha dose after 6-8 leaf stage. Statistical analysis was performed with JMP statistical program.

Tekirdag location was conducted in Beyazkoy village fields, Saray County and the trials were planted by hand in 15 April 2017. Emergence date of sunflower plants was in 22 April 2017 and left only one plant each as mentioned plant density above. The trials were harvested by hand in 25 August 2017 as middle two rows except one plant at the beginning of the middle rows. Edirne location was conducted in Sarayakpınar village fields and the trials were planted by hand in 28 April 2017. Emergence date of sunflower plants was in 5 May 2017 and the trials were harvested by hand in 5 September 2017.

Seed yield (SY), 1000 seed weight (TSW), flowering and physiological maturity period, plant height (PH), head diameter (HD), husk (HC) and oil content (OC) were measured in the study. The flowering period (FP) of hybrids were measured at stage which 50% of plants in the plot with first open ligule petals. The physiological maturity period (PM) of hybrids were counted at the stage which the back of heads was yellow and 10 % were brown color. The plant height and head diameter of hybrids were measured from 3 plants at mid rows of the plots in each replication at PM stage. Oil content of the hybrids were determined utilizing Nuclear Magnetic Resonance (NMR) analysis.

IMI herbicides which is selling in the market in Turkey advised normally to apply 1.25 l / ha to farmers but double dose (2.50 l / ha) applied at 6-8 leaves stage in the research to abstain any double dose application in the sunflower production. SY Gibraltar hybrid from Syngenta Seed Co. as non IMI resistant and P-LC108 as IMI resistant hybrid from Pioneer Seed Co. were existed as control in the research.

Phytotoxicity trial was conducted in Sarayakpinar village fields in Edirne. The trials were planted by hand in 28 April 2017 and emergence date of sunflower plants was in 5 May 2017. Phytotoxicity observations were performed at first and 2nd week after application in the study. The IMI herbicide were applied at May 22nd, 2017 and First observation was performed at May 28th, 2017 and second one was on June 5th, 2017 respectively.

The phytotoxicity levels were determined as 1-9 scale (1 = No Damage, 2= Light Yellow, 3= Yellowish Green, 4=Yellow, 5= The growth reducing, 6= Deformations in some plants, 7= Deformations in many plants, 8= Some death plants, 9= All plants dead.). The hybrids of resistance to IMI herbicide were evaluated based on these phytotoxicity levels in the study (Evci et al., 2011; Pfenning et al., 2016; Balabanova and Vassilev, 2015).

Results and Discussion

Based on the study results, some candidate sunflower hybrids exhibited higher performance than control hybrids in Tekirdag location (Table 1). Highest seed and oil yield was obtained from DT5234 CLP sunflower hybrid. This hybrid exists also having higher oil content hybrids in the study and also has the largest head diameter. The highest oil content as 46,44% was obtained from NS--H-7801 hybrid in the research.

Table 1. Yield trial results of sunflower IMI hybrids in Beyazkoy, Saray, Tekirdag locations

#	Cultivars	Flower Days	Phy. Matur Days	Plant Height (cm)	Head Diamtr (cm)	Hectolt Weight (g/lt)	Oil content (%)	Oil Yield (kg/da)	Group	Seed Yield (kg/da)	Group
1	P-LC108 (C)	59	99	171	18	40,8	38,33	100,7	D-G	263	A-D
2	SY BENTO (C)	61	100	178	16	44,1	44,80	112,2	B-D	250	B-E
3	METEOR (C)	62	98	178	19	43,7	39,58	109,2	B-E	276	A-C
4	LG5565CL (C)	61	98	174	18	45,3	42,01	117,8	A-C	280	A-B
5	SUNFLORA	64	100	146	23	41,5	36,83	70,6	K-L	192	G-I
6	PARAISO102 CL	68	97	150	15	38,8	44,59	94,9	F-I	213	F-I
7	SURIMI CL	65	98	190	18	41,9	42,88	85,1	H-J	198	G-I
8	PUNTASOL CL	68	97	169	18	38,2	40,82	91,6	G-I	224	E-G
9	CARRERA CLP	66	97	174	19	42,3	45,55	121,5	A-B	267	A-D
10	DT5234 CLP	66	99	175	19	42,7	45,68	131,2	A	287	A
11	162 IMI	66	96	156	18	40,2	34,88	68,8	K-L	197	G-I
12	1448 IMI	58	93	143	16	44,1	29,23	35,8	M	122	I
13	NS--H-7800	68	100	141	16	42,7	43,21	94,9	E-I	220	E-H
14	NS--H-7801	67	101	171	17	43,1	46,44	113,4	B-D	244	C-F
15	NS--H-7806	67	100	193	16	43,2	42,21	94,5	F-I	224	E-G
16	NS--H-7812	67	99	194	18	41,6	41,86	98,0	E-H	234	D-F
17	NS--H-7854	64	98	196	18	41,6	35,82	70,8	K-L	198	G-I
18	NS--H-7851	68	99	141	15	40,9	37,88	69,9	K-L	185	I
19	NS--H-7850	66	100	214	19	40,0	36,72	70,3	K-L	191	G-I
20	NS--H-7856	63	98	190	15	39,1	39,57	73,5	J-L	186	H-I
21	NS--H-7863	66	97	159	18	37,6	37,27	66,5	L	178	H-I
22	NS--H-7859	68	100	192	15	39,8	42,18	82,2	I-K	195	G-I
23	IMI044AXIMI-NI	67	99	172	18	34,0	43,64	105,7	C-F	242	C-F

Seed Yield CV (%): 11,4 kg/da

Oil Yield CV (%) 11,1 kg/da

Similar to Tekirdag location, some candidate sunflower hybrids exhibited higher performance like control hybrids in Edirne location based on the study results (Table 2). However, the highest seed yield was obtained from LG5565CL sunflower commercial hybrid and the highest oil yield obtained from P-LC108 sunflower control hybrid. The highest oil content as 45,0 % was obtained from NS--H-7801 hybrid similar to Tekirdag location in the research.

Based on the average results in the study, some candidate sunflower hybrids exhibited higher performance than control hybrids in average values for both two locations (Table 4). Highest seed and oil yield was obtained from LG5565CL sunflower hybrid for two locations. DT5234 CLP candidate, P-LC108 control hybrid and IMIO44AXIMI-NI candidate hybrid existed respectively as higher seed and oil yield in the study. The highest oil content as 46,44% was obtained from NS--H-7801 hybrid in the research. IMIO44AXIMI-NI candidate hybrid followed this one respectively for oil content.

The phytotoxicity levels of candidate hybrids were evaluated in the study (Table 3). Based on these evaluations, the hybrids were not influenced from normal dose of IMI application. While non tolerant control hybrid SY Gibraltar hybrid was influenced fully and all plants died, IMI resistant P-LC108 control hybrid were not influenced one and double doses. However, Sunflora, Paraiso 102 CL, Surimi CL, 162 IMI, 1448 IMI, NS--H-7800, NS--H-7801 hybrids were influenced more double IMI herbicide applications based on one week observations. Furthermore, the symptoms of IMI herbicide still kept in Sunflora, 162 IMI and 1448 IMI hybrids and these hybrids were classified as non-tolerant to IMI herbicide.

Table 2. Yield trial results of sunflower IMI hybrids in Edirne location

#	Cultivars	Flowering days	Hectoliter Weight (g/lt)	Oil content (%)	Oil Yield (kg/da)	Group	Seed Yield (kg/da)	Group
1	P-LC108 (C)	58	38,6	40,2	110,0	A	261,5	A-B
2	SY BENTO (C)	62	42,4	41,9	79,4	D-H	226,0	C-F
3	METEOR (C)	59	41,2	38,0	90,2	B-F	247,0	A-C
4	LG5565CL (C)	61	43,0	39,6	107	A-B	287,5	A
5	SUNFLORA	64	40,6	36,0	44,9	J	159,0	G-H
6	PARAISO 102 CL	62	35,8	42,0	95,9	A-E	243,0	A-D
7	SURIMI CL	62	40,5	40,0	84,3	C-G	211,5	B-E
8	PUNTASOL CL	65	36,1	41,9	97,6	A-D	224,5	B-E
9	CARRERA CLP	64	39,4	41,2	76,4	F-I	236,0	C-F
10	DT5234 CLP	64	40,5	42,9	92,3	A-F	229,8	B-E
11	162 IMI	62	37,5	35,4	42,3	J	156,5	H
12	1448 IMI	59	44,3	30,5	60,0	H-J	154,0	E-F
13	NS--H-7800	66	39,7	40,6	76,9	E-I	210,5	C-F
14	NS--H-7801	66	40,3	45,0	88,6	B-F	222,5	C-F
15	NS--H-7806	64	40,3	40,4	82,4	C-G	218,0	B-F
16	NS--H-7812	65	37,9	41,2	90,6	B-F	228,0	B-E
17	NS--H-7854	65	40,2	36,6	78,8	D-H	203,0	C-F
18	NS--H-7851	66	39,0	38,8	66,9	G-I	176,0	F-G
19	NS--H-7850	65	38,7	34,1	58,8	I-J	189,0	E-F
20	NS--H-7856	65	38,1	39,3	86,9	C-F	204,0	B-E
21	NS--H-7863	62	35,9	37,8	82,5	C-G	195,0	B-F
22	NS--H-7859	64	36,7	43,2	86,9	C-F	194,5	D-F
23	IMIO44A X IMI-NI	63	35,7	43,5	102,0	A-C	237,0	B-E

Seed Yield CV (%): 16,6 kg/da

Oil Yield CV % 16,6 kg/da

Table 3. The phytotoxicity observations of sunflower IMI hybrids in the study

#	Cultivars	One week after application*	Two weeks after application*
1	SY GIBRALTAR (C)	9	9
2	P-LC108 (C)	1	1
3	SUNFLORA	4	3
4	PARAISO 102 CL	3	1
5	SURIMI CL	3	1
6	PUNTASOL CL	1	1
7	CARRERA CLP	1	1
8	DT5234 CLP	1	1
9	162 IMI	4	3
10	1448 IMI	4	3
11	NS--H-7800	3	1
12	NS--H-7801	3	1
13	NS--H-7806	1	1
14	NS--H-7812	1	1
15	NS--H-7854	1	1
16	NS--H-7851	1	1
17	NS--H-7850	1	1
18	NS--H-7856	1	1
19	NS--H-7863	1	1
20	NS--H-7859	1	1
21	IMIO44A X IMI-NI	1	1

*The phytotoxicity levels: 1-9 scale (1 = No Damage, 2= Light Yellow, 3= Yellowish Green, 4=Yellow, 5= The growth reducing, 6= Deformations in some plants, 7= Deformations in many plants, 8= Some death plants, 9= All plants dead.).

Table 4. Yield trial results of sunflower IMI hybrids in the average of Edirne and Tekirdag locations

#	Cultivars	Flowering Time	Hectoliter Weight (g/lt)	Oil content (%)	Oil Yield (kg/da)	Group	Seed Yield (kg/da)	Group
1	P-LC108 (C)	59	36,4	40,2	106,0	A-B	264,1	A-B
2	SY BENTO (C)	62	40,7	41,9	96,5	B-E	228,6	C-F
3	METEOR (C)	61	38,6	38,0	100,0	A-D	262,9	A-C
4	LG5565CL (C)	61	40,6	39,6	113,0	A	285,5	A
5	SUNFLORA	64	39,6	36,0	58,2	J-K	160,9	I
6	PARAISO 102 CL	65	32,8	42,0	95,9	B-E	229,1	C-F
7	SURIMI CL	64	39,0	40,0	85,2	E-G	213,8	E-G
8	PUNTASOL CL	67	33,9	41,9	95,1	B-F	227,1	D-F
9	CARRERA CLP	65	36,4	41,2	99,6	A-E	238,6	B-E
10	DT5234 CLP	65	38,3	42,9	112,0	A	260,1	A-D
11	162 IMI	64	34,7	35,4	55,8	J-K	158,3	I
12	1448 IMI	59	44,4	30,5	48,0	K	155,8	I
13	NS--H-7800	67	36,6	40,6	86,5	D-G	212,6	E-G
14	NS--H-7801	67	37,4	45,0	102,0	A-C	225,5	D-F
15	NS--H-7806	66	37,3	40,4	89,0	C-G	220,1	E-G
16	NS--H-7812	66	34,1	41,2	94,8	B-F	229,9	B-F
17	NS--H-7854	65	38,8	36,6	75,2	G-I	205,4	E-H
18	NS--H-7851	67	37,0	38,8	68,8	H-J	177,7	H-I
19	NS--H-7850	66	37,4	34,1	64,8	I-J	189,7	H-I
20	NS--H-7856	64	37,0	39,3	80,6	F-H	205,4	E-H
21	NS--H-7863	64	34,2	37,8	74,9	G-I	197,8	F-H
22	NS--H-7859	66	33,5	43,2	84,9	E-G	196,6	F-H
23	IMIO44A X IMI-NI	65	37,4	43,5	104,0	A-B	240,2	B-E

Seed Yield CV (%): 16,2 kg/da

Oil Yield CV % 17,4 kg/da

Conclusions

Based on the study, some candidate hybrids exhibit over performance than control hybrids. DT5234 CLP and IMIO44AXIMI-NI candidate hybrids exhibited higher seed and oil yield in the study. They will be evaluated in this year then if still keep higher performances, they will send the registration to commercialize and sell to farmers for further years.

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