Turk J
Field Crops
2017, 22(1), 81-88
DOI: 10.17557/TJFC.303888

RESPONSE OF THREE OAT FORMS TO SPRINKLING IRRIGATION AND NITROGEN FERTILIZATION

Katarzyna PANASIEWICZ, Wiesław KOZIARA, Agnieszka FALIGOWSKA

Poznan University of Life Sciences, Department of Agronomy, POLAND
Corresponding author: panas@up.poznan.pl

Received: 21.10.2015

ABSTRACT

The aim of this study was to assess the effect of sprinkling irrigation and nitrogen fertilization on the leaf area index (LAI), chlorophyll content (SPAD), grain quality, as well as grain yield and yield components in three oat forms (tall husked, dwarf husked and hulles). Field trials were conducted in 2008 and 2009 on the fields of the Experimental and Teaching Station in Gorzyń (the branch in Złotniki), which belongs to the Poznań University of Life Sciences. Sprinkling irrigation increased the grain yield of oat by 1.45 t ha^{-1}, (51.8%). The highest grain yield was recorded for the tall husked form (STH 8007). Nitrogen fertilization significantly increased the oat grain yield as the increase in the rate of nitrogen application to 100 kg N ha^{-1} was observed. The greatest contents of protein and fat, as well as the highest SPAD value and chlorophyll content were found in the hulless oat form. The best quality sowing material was produced by the tall husked form. It was manifested with a higher germination energy and germination capacity as well as lower shares of healthy non-germinating and abnormally germinating kernels.

Key words: grain yield, LAI, oat, seed value, SPAD, sprinkling irrigation.

INTRODUCTION

In recent years in Poland, the oat cultivation area has been estimated to be 500 thousand ha with harvested yields of approximately 1.4 million tons (the mean grain yield of 2.5 t ha^{-1}). This represent 5.5% of the world production. Such a yielding level is not satisfactory, thus currently conducted breeding work is focused on the improvement of both the volume and quality of grain yield. Due to changes in the use of oats in Poland, this plant species, particularly its new cultivars, have to meet diverse expectations. The changes result from a decreased population of horses as well as an increased interest of pharmacological, cosmetics, food industries and also the energy industry in oat cultivation.

The low yielding of oats in Poland is connected with the fact that those species are frequently grown on light soils with extensive farming methods. Apart from soil conditions a considerable role is also played by changes in climate conditions, manifested in increased temperatures and uneven distribution of precipitation.

Water is a major factor determining both the volume and stability of yielding, particularly in years with a disadvantageous distribution of natural precipitation (Koziara et al., 2006). In turn, nitrogen is a nutrient with the greatest potential effect on growth and development of cereals. Both deficit and excess of nitrogen has an adverse effect on growth and development of cereals (Sułek et al., 2007). Efficiency of nitrogen fertilization is frequently limited, especially in light soils, by the amount and distribution of precipitation (Maral et al., 2013). At an adverse distribution of weather conditions the interaction of sprinkling irrigation with fertilization may determine the volume of yields and the utilization of applied nitrogen.

The aim of this study was to assess the response of different oat forms to sprinkling irrigation and nitrogen fertilization. Those two factors have an influence on the estimation of the nutritional status of plants, grain yield, yield components, chemical composition and value of seed.

MATERIALS AND METHODS

Field trials were conducted in 2008–2009 on the fields of the Experimental and Teaching Station in Gorzyń (the branch in Złotniki), which belongs to the Poznań University of Life Sciences (N: 52° 29' 0" E: 16° 49' 53"). The experiment was performed in 4 replications in the randomized complete block (split-split-plot). According to the international WRB classification [2006] the soil is classified as Albic Luvisols. Based on the grain size distribution the soil is a loamy sand underlined by loam [Marcinek and Komisarek, 2011]. The arable layer has a slightly acid reaction, pH in 1M KCL ranges from 5 to 6. This soil is abundant in phosphorus (0.78 mg P kg^{-1} soil) and potassium (1.35 mg K kg^{-1} soil), and poor in magnesium (0.45 mg Mg kg^{-1} soil). The groundwater table lies at a depth from 2.9 to 5.5 m and is not available to plant roots. For this reason water relations in the soil of the experimental field are based on precipitation. In each year of the study oats were growing after the potatoes.

The first factor was the water variant (T0- non-irrigated vs. T1- irrigated). Irrigation was performed at the soil moisture content decreasing below 70% of the field capacity. A semi-stationary sprinkler with NAAN 233/91 sprinklers with nozzle diameter of 7 mm and water output of 5 mm $h^{-1}$was used to perform the irrigation. In the first year of the study the sprinkling irrigation was performed once at an application rate of 40 mm. In the second year of the study the sprinkling irrigation was performed five times at a single water application rate of 40 mm. The second factor was the form of oat (tall husked cv. STH 8007; dwarf husked cv. STH 7105; hulless cv. POLAR), coming from the Plant Breeding Station in Strzelce. The third factor was the dose of nitrogen (0, 50, 100, 150 kg N ha^{-1}). Nitrogen fertilization was applied at 50 kg N ha^{-1} before sowing. The combinations of nitrogen level of 50, 100, 150 kg N ha^{-1} respectively were used. What is more, the nitrogen fertilization was applied at the level of 100 and 150 per 50 kg N ha^{-1} applied at the tillering stage (BBCH 21). At the heading stage (BBCH 51) only the nitrogen level 150 kg N ha^{-1} per 50 kg N ha^{-1} was applied. Moreover, a phosphorus fertilization and potassium fertilization was applied before sowing at 34.9 kg P ha^{-1} and 83 kg K ha^{-1}respectively.

Oat was grown after winter triticale, in the four-course rotation with a 50% share of cereals. Sowing in both years of the analyses was performed in the first decade of April. Harvest was performed in the first decade of August. The seeding rate was established at 350 germinating seeds per m^2 based on the quality of the sowing material. The other cultivation measures were performed following the recommendations for cultivation of this species.

The nutrient status of plants for nitrogen (SPAD) was assessed with the use of the N-Tester device. The ratio of leaf assimilating area of oat plants to the leaf area index (LAI) of the field was determined with the use of LAI-meter (Li-Cor brand). The ratio was calculated at the milk stage (BBCH 73-75).

Analysis of the basic chemical composition of grain was performed. Determination of dry matter [PN-91/A-74010], crude ash [ICC method 104/1], crude fat [ICC-Standard No. 136. 1984] as well as fiber and protein concentration was done according to Kjeldahl method [Van Soest, 1963]. Nitrogen-free extractives were determined in dry matter as 100 - % (contents of protein + fat + ash + crude fiber).

The seeding value of grain was determined in a sample of 400 clean kernels (4 x 100) from each plot being germinated with the use of optimal moisture and temperature conditions. Parameters of seeding value were determined according to ISTA (2006).

The agronomic efficiency of nitrogen (A_E) (Novoa and Loomis 1981) was calculated as a ratio of an increase in yield under the influence of nitrogen fertilization (grain yield at N_x –grain yield at N_0) to the applied nitrogen fertilization rate of N_x. The value of the agronomic efficiency of nitrogen was expressed in kg kg^{-1}. Physiological efficiency (P_E) (Novoa and Loomis 1981) was calculated as a ratio of increase in yield under the influence of fertilization (grain yield at N_x – grain yield at N_0) to the increment in nitrogen uptake (uptake at N_x – uptake at N_0) and it was expressed in kg kg^{-1}. The utilization of nitrogen (Novoa and Loomis 1981) was calculated as the quotient of agronomic efficiency to physiological efficiency and it was expressed in percent.

All data were processed with the use of the analysis of variance (ANOVA) with the SAS package (SAS Institute, 1999). The means of treatment were compared with the use of Tukey's Multiple Range test and least significant difference (LSD) was declared at $P<0.01$ and $P<0.05$. The data were analyzed as a split-split-plot in randomized complete block design with four replications.

Many literature reports indicate that stability of yielding and productivity of plants are determined first of all by weather conditions (Krasowicz et al., 2009; Tamm, 2003; Peltonen-Sainio et al., 2010; Maral et al., 2013). According to Hisir et al., (2012), a particularly important role in the yielding of oat is played by temperatures in the period of May - June.

In the Wielkopolska region, the weather conditions around the year are shaped mainly by the polar-marine (59.0%) and polar continental (28.0%) air masses (Olejniczak citing Woś 1989). As a result, the climate in Wielkopolska is characterized by variability and diversity of weather types. This is confirmed by the analysis of the collected weather data (tab. 1). The mean annual temperature in the analyzed period was 11.0 ºC in 2008 and 10.2 ºC in 2009, at the multiannual mean of 8.6 ºC. What is more, during the vegetation season of oat in both years of the study the recorded temperature was higher than the multiannual mean for that period. The multiannual mean temperature was 15.2 ºC, while in the years of the study it was 17.6 ºC and 17.5 ºC, respectively. Total annual precipitations were 505.3 and 657.4 mm, while in the vegetation season of oat they were 182.5 and 342.0 mm, at the multiannual mean for that period of 265.9 mm.

Table 1. The meteorological characteristic of experimental place in the year 2008 and 2009.

Specification	January	February	March	April	May	June	July	August	September	October	November	December	Average
50 years average of temperature [1951-2000] [˚C]	-1.5	-0.5	3.3	8.3	13.9	17.2	18.8	18.1	13.5	8.9	3.6	0.0	8.6
Average of temperature in 2008 [˚C]	2.4	4.4	5.4	10.0	16.2	20.6	22.2	19.7	14.4	9.9	5.4	1.5	11.0
Average of temperature in 2009 [˚C]	-2.4	0.1	4.5	14.2	15.1	16.7	21.7	21.4	17.0	7.9	6.6	-0.3	10.2
50 years average of precipitation [1951-2000] [mm]	28.3	26.5	29.8	31.4	48.5	59.6	76.4	53.2	46.0	34.4	35.4	39.0	508.5
Average of precipitation in 2008 [mm]	72.8	15.4	54.8	77.5	9.5	8.4	46.6	88.6	16.8	69.4	20.5	25.0	505.3
Average of precipitation in 2009 [mm]	16.3	32.9	56.8	16.0	92.3	129.1	104.6	26.1	53.9	59.4	38.2	31.8	657.4

RESULTS AND DISCUSSION

Sprinkling irrigation applied in this study increased the yield of oat grain by 1.45 t ha^{-1} i.e., 51.8% (tab. 2). These results are consistent with those presented by other authors. In the study presented by Kaczmarczyk et al., (1997) in relation to non-irrigated treatments the grain yield of oat increased by 86%. Koziara et al., (2005) recorded an increase in yield ranging from 0.18 t ha^{-1} (5.1%) to 1.77 t ha^{-1} (115.7%), but as it was indicated by those authors obtained effect is to a considerable degree dependent on the year of study and in individual years the distribution of precipitation is more important than the precipitation total in the period of oat growth.

Apart from weather factors the yield of oat is also determined by the genetic factor (Hisir et al., 2012). In this study among the greatest grain yield was produced by the tall husked form (STH 8007) while the value of grain yield was at the lowest level in the hulless form (Polar). In relation to the tall husked oat the dwarf husked form produced 0.42 t ha^{-1} lower yields i.e., 11.3%, while the hulless form produced 1.36 t ha^{-1} lower yields i.e., 49.3%.

The lower yielding of hulless forms in relation to husked forms was reported by Szmigiel and Oleksy, (2005). Brunava et al., (2014) stated that for the husked forms the yields ranged from 4.31 to 5.30 t ha^{-1}, while in hulless forms the range was between 3.20 – 3.69 t ha^{-1}. However, those authors indicated the share of glumelles in the husked form, amounting to 25-30%. Tobiasz-Salach et al., (2011) in turn showed in their studies on the economic value of six dwarf cultivars (including STH 7105 and one tall cultivar Krezus) that dwarf forms produced yields lower by on average 1 ton per hectare in comparison to tall cultivars.

Nitrogen fertilization significantly modified the volume of grain yield in oat. An increase in the nitrogen application rates within the adopted levels i.e., 0-150 kg N ha^{-1}, caused an increase in the grain yield. A significant increase was reported for a dose of up to 100 kg N ha^{-1}. Mohr et al., (2007) found that a dose of 100 kg N ha^{-1} is sufficient to obtain an optimal yield of oat. The observation was made based on 3-years studies with differentiated doses of nitrogen fertilization at two locations.

The compared in this study forms of oats were characterized by a high resistance to lodging. Even for objects which were irrigated and fertilized with nitrogen this phenomenon was not observed.

Statistical analysis showed that sprinkling irrigation applied in the experiments significantly modified the thousand kernel weight as well as the panicles number per unit area. In the case of these yield components, irrigation had a positive effect on the value of both of them. The thousand kernel weight was increased by 7.2% and panicle number was increased by 21.2%.

Recorded results are consistent with those given by Koziara et al., (2005), in which the authors showed an increase in the thousand kernel weight and the panicles number per unit area by approximately 15% and an increase in the number of grain per panicle by 13.6%.

Both oat forms analyzed in this study as well as nitrogen fertilization significantly modified all the investigated yield components in those species. Greater values of the parameters were found for the tall husked form. The thousand kernel weight in this form was greater than the value of this trait for the dwarf form by 11.1% and by 35.4% than in the hulless form. Similarly, Sykut-Domańska (2012) showed that the hulless cultivars exhibit a lower values of both TKW and the mass of hectoliter parameters when compared to the husked forms.

Table 2. Yield and yield components of oat depending on sprinkling irrigation, form of oats and N fertilization

Factor	Level	TKW (g)	Panicle number per 1m^2	Grain number per panicle	Grain yield (t ha^{-1})	SPAD	LAI
		**	**	ns	**	**	*
Water Variant	T0	27.9b	316b	52.8	2.80b	679a	0.98b
	T1	29.9a	383a	59.2	4.25a	629b	1.83a
	LSD	0.68	15.3	7.62	0.21	19.9	0.06
		**	**	**	**	*	*
Form	TH	29.6b	375a	50.9b	3.70b	665a	0.98c
	DH	32.9a	366a	56.6a	4.12a	621b	1.24b
	H	24.3c	307b	60.5a	2.76c	677a	1.99a
	LSD	0.75	19.5	5.33	0.16	42.2	0.16
		**	**	**	**	**	**
Nitrogen Fertilization (kg N ha^{-1})	0	29.4a	309d	47.5c	2.39c	560d	0.84d
	50	28.7b	334c	56.9b	3.54b	617c	1.29c
	100	28.7b	359b	57.4b	4.02a	695b	1.66b
	150	28.8ab	397a	62.2a	4.16a	743a	1.83a
	LSD	0.62	22.9	3.49	0.17	43.6	0.12

LSD values	TKW	Panicle number per 1m^2	Grain number per panicle	Grain yield	SPAD	LAI
WV×F	**	ns	ns	ns	ns	ns
WV× NF	ns	ns	ns	**	ns	ns
F× NF	**	**	ns	**	ns	ns
WV×F× NF	**	ns	ns	ns	ns	ns

NS: not significant; *P < 0.05 and **P < 0.01. Water variant: T0- non-irrigated; T1- irrigated. Form: TH, tall husked; DH, dwarf husked; H, hulless. TKW: Thousand kernel weight; SPAD: Soil - Plant Analysis Development; LAI: leaf area index.

The greatest panicle number was observed in the dwarf husked form (375 grain m^{-2}), while no significant variation was observed between this form and the tall husked form (366 grain m^{-2}). The lowest panicle number in this study was recorded in the hulless cultivar, amounting to 307 grain m^{-2}. Similarly, Dumlupinar et al. (2011) reported significant differences in PN m^{-2} values among different forms of oats.

Similar results were reported by Tobiasz-Salach et al., (2011), who observed a significantly lower value of a thousand kernel weight and a lower number of grain in the panicle in the dwarf form of oats. What is more, a greater panicle number in comparison to the tall form was observed.

A decrease in TKW was shown for the application of an increasing nitrogen doses (within the range of 0-150 kg ha^{-1}). Significant differences between treatments were recorded only in relation to the treatment with no application of nitrogen fertilization. The results were shown to be consistent with earlier studies conducted by Mohr et al., (2007).

In this study, a panicle number per unit area increased significantly under the influence of nitrogen fertilization. The values were ranging from 309 grain m^{-2} for the control (no nitrogen fertilization applied) to 397 grain m^{-2} at the highest adopted fertilization level. What is more, a study conducted by Maral et al., (2013) indicated an increase in PN value resulting from an increase in nitrogen dose. The values of nitrogen dose were ranging from 393 grain m^{-2} for the treatment without nitrogen fertilization to 536 grain m^{-2} for the treatment with the highest applied doses of this nutrient.

In this study the number of grain in panicle increased under the influence of nitrogen fertilization. No significant differences were observed for the nitrogen concentration ranging from 50 to 100 kg N ha^{-1}. A similar dependence for this trait on nitrogen fertilization was reported in the experiments presented by Koziara et al., (2005) and Maral et al., (2013).

In this study the assessment of nutrient status of plants as well as the accumulation of oat biomass indicates a significant and independent effect of sprinkling irrigation, oat form and nitrogen fertilization on values of these traits. Sprinkling irrigation caused a reduction of leaf chlorophyll contents, but an increase in the leaf area index. Among the compared oat forms the highest SPAD and LAI values were recorded in the hulless form, amounting to 677 and 1.99 respectively. The lowest

SPAD value of 625 was recorded in the dwarf husked form, while the lowest LAI value was found in the tall husked form, amounting to 0.98. Similarly, Hisir et al., (2012) observed considerable variation in chlorophyll content and leaf area index (LAI) depending on the genotype, recording the highest LAI (6.28) in cv. Antalya TR 40707 and the lowest LAI (4.86) in cv. Ankara 76. Chlorophyll content in the compared cultivars ranged from 45.02 to 54.00 mg m^{-2}.

Nitrogen fertilization influenced values of both analyzed indexes. With an increase in nitrogen application rate a significant increase was observed both in the index of plant nutrition status (SPAD) and leaf area (LAI).

Chemical analyses for contents of ash and chemical components in oat grain indicate a varied effect of sprinkling irrigation, oat form and nitrogen fertilization on the concentrations of individual components (tab. 3). Sprinkling irrigation significantly modified contents of protein and ash in grain. Oat forms differed greatly in terms of grain quality, which was expressed using such parameters as contents of protein, fiber, fat, nitrogen-free extractives and ash. In turn, nitrogen fertilization significantly affected contents of protein, fiber and ash.

Table 3. Organic components and ash contents in grain of oat (% DM)

Factor	Level	Crude protein	Crude fiber	Crude lipides	N – free extract	Ash
		**	ns	ns	ns	**
Water Variant	T0	14.0a	9.56	5.22	60.7	2.68b
	T1	11.7b	10.5	5.15	61.4	3.02a
	LSD	0.80	1.04	0.30	1.04	0.09
		**	**	**	**	**
Form	TH	11.6c	11.1a	4.09c	62.2a	2.90a
	DH	12.8b	12.0a	4.86b	59.3b	2.99a
	H	14.4a	7.00b	6.60a	61.6a	2.67b
	LSD	0.98	1.27	0.37	1.27	0.11
		**	*	ns	ns	*
Nitrogen Fertilization (kg N ha^{-1})	0	11.9b	11.4a	5.05	60.6	2.96a
	50	12.4b	10.2ab	5.36	61.3	2.78b
	100	13.0ab	9.61b	5.32	61.2	2.84 b
	150	14.1a	8.94b	5.00	61.1	2.82b
	LSD	1.13	1.47	0.43	1.47	0.12
LSD values		**Crude protein**	**Crude fiber**	**Crude lipides**	**N – free extract**	**Ash**
WV×F		ns	ns	ns	ns	ns
WV× NF		ns	ns	ns	ns	ns
F× NF		ns	ns	ns	ns	ns
WV×F× NF		ns	ns	ns	ns	ns

NS: not significant; *P < 0.05 and **P < 0.01. Water variant: T0- non-irrigated; T1- irrigated. Form: TH, tall husked; DH, dwarf husked; H, hulless.

Results showed that sprinkling irrigation reduced protein content and increased fiber content. In a study conducted by Koziara et al., (2005) sprinkling irrigation caused also a reduction in protein contents in grain but it had no significant effect on the concentrations of the other organic components and ash.

The analyzed forms differed significantly in the contents of protein and fat. Moreover, a significant differentiation was recorded for contents of fiber and ash between the tall husked form and the hulless form as well as between the dwarf husked form and the hulless form. The contents of nitrogen-free extractives varied between the dwarf husked form and the tall husked form as well as between the dwarf husked form and the hulless form. Among the compared forms the greatest contents of protein and fat were found for the hulless form (Polar). The greatest content of fiber and ash was observed in the dwarf husked form (STH 7105) while the content of nitrogen-free extractives was the highest in the tall husked form (STH 8007). Tobiasz-Salach et al., (2011) in turn, found no significant variation in the chemical composition between the dwarf and tall forms.

In grains of hulless forms a greater content of protein was reported by Szmigiel and Oleksy, (2005), while Brunava et al., (2014) showed a greater content of fat whereas lower contents of fiber and ash was recorded by Biel et al., (2009).

It is frequently stressed in literature sources that due to the high content of fiber husked forms are not very popular in feeding monogastric animals (Biel et al., 2009, Iqbal et al., 2013).

Analysis of the chemical composition of grain depending on nitrogen fertilization showed that with an increase in nitrogen doses the content of protein increased significantly. What is more, when the nitrogen dose increased the content of fiber and ash decreased. A similar dependence was recorded by Iqbal et al., (2013).

Among numerous indexes facilitating assessment of efficiency of the applied nitrogen dose, it is useful to determine agronomic efficiency, physiological efficiency and the utilization of nitrogen (Loomis and Novoa, 1981). Both Polish and foreign literature sources report that the agronomic efficiency of nitrogen, expressed in the increase in yield per unit of nitrogen applied in fertilizer, decreases with an increase in the nitrogen application rate (Gauer et al., 1992; Hussain et al., 1996; Koziara et al., 2006; Panasiewicz 2013). In order to determine productive efficiency of the applied nitrogen fertilization the investigations included agronomic and physiolgical efficiencies as well as utilization of nitrogen (tab. 4). Based on the recorded results it may be stated that in both water variants efficiency of applied nitrogen decreased with an increase in the nitrogen application rate, which results from the limited capacity of oat plants to convert this nutrient into the harvested grain. This is shown by the results of assessed physiological and agronomic efficiencies, indicating a reduction of grain yield per unit of nitrogen applied in fertilizer. Sprinkling irrigation contributed to the improvement of both agronomic efficiency and physiological efficiency. The utilization of nitrogen, determined on the agronomic and physiological efficiencies, showed that when growing oat at natural precipitation for the lowest adopted nitrogen dose the value of this index was approximately 22%, while for the highest dose the value was 17.7%, whereas at the application of irrigation the value was 44.8% and 34.4% respectively. Similar results in their investigations were recorded by Koziara et al., (2005) as in non-irrigated oat the productivity of nitrogen from the dose of 50 kg N ha^{-1} was 9.5 kg grain. At the application of 150 kg N ha^{-1} the productivity decreased to 3.8 kg, whereas in irrigated oat it was greater and amounted to 20.2 and 8.9 kg grain respectively.

Table 4. Agronomic efficiency, physiological efficiency and utilization of nitrogen fertilizer depending on sprinkling irrigation and N fertilization in oat

Water variant	**Nitrogen fertilization (kg N ha^{-1})**				
	0-50	0-100	0-150	50-100	100-150
AE (kg grain kg N^{-1})					
T0	13.4	10.2	7.2	7.0	1.2
T1	31.0	22.0	15.8	13.0	3.4
PE (kg grain kg N^{-1})					
T0	60.2	44.3	41.9	39.5	10.7
T1	69.2	57.5	45.9	41.0	12.7
NUE (%)					
T0	22.2	23.0	17.2	17.7	11.2
T1	44.8	38.3	34.4	31.7	26.8

AE - Agronomic efficiency; PE - Physiological efficiency; NUE - Nitrogen-use efficiency

In this study, similarly as in that of the above-mentioned authors, sprinkling irrigation improved the values of both agronomic and physiological efficiency.

Assessment of seeding value showed a significant effect of sprinkling irrigation on the number of abnormally germinating kernels (tab. 5), significantly increasing their share in grain yield.

The oat form significantly modified the seeding value of oat grain. The highest quality pf seeding material was produced in the case of the tall husked form, which was manifested in the higher value of germination energy and germination capacity, as well as the lower shares of healthy non-germinating and abnormally germinating kernels. Also nitrogen fertilization with an increase in the nitrogen dose contributed to an improvement of seeding value expressed in germination energy and germination capacity. Literature sources very rarely present results of studies concerning the effect of sprinkling irrigation and nitrogen fertilization seeding value of oat grain.

Table 5. Grain value of oat depending on sprinkling irrigation and N fertilization

Factor	Level	Energy capacity (%)	Germination capacity (%)	Share of healthy and not germinated kernels (pc)	Share of abnormally germinating kernels (pc)	Share of rooting kernels (pc)
		ns	ns	ns	*	ns
Water variant	T0	91	95	0.7	1.9b	2.8
	T1	89	94	0.8	2.5a	2.9
	LSD	1.6	1.3	0.44	0.56	0.7
		**	**	**	**	**
Form	TH	95a	97a	0.1b	0.5c	2.5b
	DH	85c	91c	1.8a	4.5a	2.3b
	H	90b	94b	0.3b	1.7b	3.7a
	LSD	1.7	1.5	0.61	0.86	0.75
		**	**	**	**	**
Nitrogen Fertilization (kg N·ha^{-1})	0	88c	92c	0.8b	2.5b	3.8a
	50	87c	92c	1.3a	3.6a	3.1a
	100	90b	95b	0.6b	2.2b	2.3ab
	150	94a	97a	0.2bc	0.7c	2.1ab
	LSD	1.5	1.3	0.43	0.58	0.89
LSD values		**Energy capacity**	**Germination capacity**	**Share of healthy and not germinated kernels**	**Share of abnormally germinating kernels**	**Share of rotting kernels**
WV×F		*	ns	ns	ns	*
WV× NF		*	ns	ns	ns	ns
F× NF		**	**	**	**	ns
WV×F× NF		**	*	ns	**	**

NS: not significant; *P < 0.05 and **P < 0.01. Water variant: T0- non-irrigated; T1- irrigated. Form: TH, tall husked; DH, dwarf husked; H, hulless.

CONCLUSIONS

Grain yield in oat is depended on sprinkling irrigation, oat form and nitrogen fertilization. The increase in yield under the influence of sprinkling irrigation is depended to a considerable extent on weather conditions and amounted on average to 52%. Among the assessed oat forms the highest yield was produced by the tall husked form (STH 8007).

The hulless oat form was characterized by the greatest contents of protein and fat, as well as leaf chlorophyll content (SPAD) and assimilating leaf area (LAI).

The results showed that nitrogen fertilization improved seed value while sprinkling irrigation had no significant influence on this parameters. The best quality seeding material was produced by the tall husked form, which was manifested in higher values of germination energy and germination capacity as well as lower shares of healthy non-germinating and abnormally germinating kernels.

LITERATURE CITED

Biel, W., Bobko, K. and R. Maciorowski. 2009. Chemical composition and nutritive value of husked and naked oats grain. J. Cereal Sci. 49: 413-418.

Brunava, L. Alsina, I. Zute, S. Sterna, V. and Z. Vicupe. 2014. Some chemical, yield and quality properties of domestic oat cultivars. Foodbalt. http://llufb.llu.lv/conference/foodbalt/2014/FoodBalt_Proceedings_2014-72-76.pdf

Dumlupinar, Z., H. Maral, R. Kara, T. Dokuyucu and A. Akkaya. 2011. Evaluation of Turkish oat landraces based on grain yield, yield components and some quality traits. Turk J Field Crops. 16(2): 190-196.

El-Metwally, El-M.Am, Hassanein, M.A. Hussein, M.M. El-Noemani, A.A. and H.K. Keheal. 2012. Triticale (*Triticosecale*) yield as affected by sowing dates and NPK fertilizers in Egyptian new reclaimed sandy soils. J. Apply. Sci. Res., 8(4): 2412-2418.

Gauer L.E., C.A. Grant, D.T. Gehl and L.D. Bailey. 1992. Effects of nitrogen fertilization on grain protein content, nitrogen uptake and nitrogen use efficiency of six spring wheat cultivars in relation to estimated moisture supply. Can. J. Plant Sci., 72 (1): 235–241.

Hisir, Y. Kara, R. and T. Dokuyucu. 2012. Evaluation of oat (*Avena sativa* L.) genotypes for grain yield and physiological traits. Zemdirbyste=Agriculture, vol. 99, no. 1, pp. 55-60.

Hussain, G., Al-Jaloud A.A. and S. Karimulla. 1996. Effect of treated effluent irrigation and nitrogen on yield and nitrogen use efficiency of wheat. Agric. Water Manage., 30: 175-184.

ISTA, 2006. International Rules for Seed Testing. International Seed Testing Association, Basserdorf, Switzerland.

IUSS Working Group WRB. 2006. World reference base for soil resources. 2nd edition. World Soil Resources Reports 103. FAO, Rome: pp. 132.

Karczmarczyk S., Koszański Z., Podsiadło C. and A. Kocmit. 1997. Effect of irrigation and mineral fertilization on spring cereals cultivated on a sandy soil. Part I. Yield of plants. Romanian Agricultural Research. 7-8: 21-24.

Koziara, W. 1996. Growth, development and yielding of spring and winter triticale depending on weather and cultivation factors. Rocz. AR Poznań. Rozprawy Naukowe. 269: pp. 99.

Koziara W., Panasiewicz K. and H. Sulewska. 2005. Yielding and chemical composition of oats grain depending on irrigation and nitrogen fertilization. Scientific Papers of Agricultural University of Poznań, series Agriculture vol. 5:13-23.

Koziara W., Panasiewicz K. and H. Sulewska. 2006. Effects of nitrogen fertilization in spring triticale in non-irrigated and irrigated fields. Folia Universitatis Agriculturae Stetinensis (247): 89-95.

Krasowicz S., Stuczyński T. and A. Doroszewski. 2009. Plant production in Poland in view of natural and economic and organisational conditions. Studia i Raporty IUNG-PIB, Puławy,14: 27-54.

Maral, H., Dumlupinar, Z., Dokuyucu, T. and A. Akkaya. 2013. Response of six oat (*Avena sativa* L.) cultivars to nitrogen fertilization for agronomical traits. Turk J Field Crops, 18(2), 254-259.

Marcinek, J. and J. Komisarek. (red.) 2011. Classification of soils in Poland. Roczniki Gleboznawcze. vol. 62 book 3 pp. 193.

Mohr, R. M., Grant, C. A., May, W. E. and F. C. Stevenson. 2007. The influence of nitrogen, phosphorus and potash fertilizer application on oat yield and quality. Can. J. Soil Sci. 87: 459–468.

Novoa, R. and R.S. Loomis.1981. Nitrogen and plant production. Plant and Soil, vol. 58: 177-204.

Olejniczak, E. 1989. Natural conditions for agricultural production. IUNG Puławy, A 76, 32.

Panasiewicz, K. 2013. The effect of weather and cultivation conditions on growth and yielding of spring triticale. Rozprawy Naukowe 453. Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu. pp. 142.

Peltonen-Sainio, P., Jauhiainen, L., Trnka, M., Olesen, J. E., Calanca P., Eckersten, H., Eitzinger, J., Gobin, A., Kersebaum, K. C., Kozyra, J., Kumar, S., Marta, A. D., Micale, F., Schaap, B., Seguin, B., Skjelvåg, A. O. and S. Orlandini. 2010. Coincidence of variation in yield and climate in Europe. Agriculture, Ecosystems & Environment. 139 (4): 483-489.

Sułek, A., Podolska, G., Leszczyńska, D. and K. Noworolnik. 2007. Response of cereals to nitrogen fertilization. Studia i Raporty IUNG-PIB. 9: 29–36.

Sykut-Domańska, E. 2012. Characteristics of selected physical traits of grain in naked and common oat (*Avena sativa* L.). Acta Agrophysica 19 (4): 845 - 856.

Szmigiel, A. and A. Oleksy. 2005. Yielding of naked and husked forms of spring barley and oat in mixed and pure sowing on soils of the very good wheat complex. Biul IHAR 236:173-182.

Tamm, I. 2003. Genetic and environmental variation of grain yield of oat varieties. Agronomy Research 1, 93-97.

Tobiasz-Salach, R. Jankowska, D. Bobrecka-Jamro, D. and E. Szpunar–Krok. 2011. Yield and chemical composition of the grain of new dwarf breeding lines of oat (*Avena sativa* L.). Acta Sci. Pol. Agricultura 10(4):161-171.

Van Soest, P.J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method of determination of fibre and lignin. J.A.O.A.C 4.6 ,82.