Bulgarian Journal of Agricultural Science, 21 (No 6) 2015, 1222-1228
Agricultural Academy

DETERMINATINON OF RICE (*ORYZA SATIVA L.*) GENOTYPES SUITABLE FOR DRIP IRRIGATION

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Abstract

BESER, N., H. SUREK, S. SAHIN, R. KAYA, B. TUNA and R. CAKIR. Determinatinon of rice (*Oryza sativa* L.) genotypes suitable for drip irrigation. *Bulg. J. Agric. Sci.*, 21: 1222–1228

This study was carried out at Trakya Agricultural Research Institute during 2007 and 2009 to find out suitable rice genotypes for drip irrigation. Irrigation drip laterals with an emitter discharge rate of 2 L h^{-1} and emitter spacing of 0.30 m were used each plot. Distances between laterals was 80 cm. As a two years mean 789 mm water was given with drip irrigation (including seasonal rainfall). According to two year means, Akceltik had the lowest days to flowering and days to maturity with 85 and 116 days respectively, Aromatik-1 had the highest days to flowering with 102 days and YRF-203 had the highest days to maturity with 133 days respectively. Akceltik had the highest plant height with 98.1 cm and Kiziltan had the lowest plant height with 65.8 cm. YRF-203 had the longest panicle with 20.08 cm. Cultivar Edirne had the highest brown rice yield with 81.45% and Cultivar Gonen had the highest total rice yield with 70.76%. On the other hand Veneria had the highest head rice yield with 61.88% .The number of fertile panicle per square meter was the highest at cultivar Aromatik-1 (264/ m^2). Genotype YRF-203 attained highest percentage of sterile spikelet (37.55%) while Akçeltik produced lowest percentage of sterile spikelet (8.83%). Maximum 1000 kernel weight was obtained from cultivar Negis. The genotype Veneria gained the highest biological yield (1.568 t/ha). Percentage of harvest index was the highest in genotype Kiziltan (47.5%) while it was lowest in genotype YRF-203 (21.3%). The highest yield (6.517 t/ha) was obtained with Duragan rice variety, it followed by Osmancik-97, Halilbey and Kiziltan with 6.238, 6.231 and 5.980 t/ha yield respectively. From this study, it was found that that Duragan, Osmancik-97 and Halilbey rice cultivars are adaptable for drip irrigation and these varieties could be grown under drip irrigation conditions with using about 50% less water than the flooded irrigation conditions.

Key words: drip irrigation, milling yield, morphological characteristics, rice (*Oryza sativa* L), yield, yield components

Introduction

Substantial amount of water was needed for rice production because rice is mostly grown under flooded conditions in Turkey and all around the world. Water is one of the most important limiting factor for rice production, and it must be used without wasting a single drop of it. Rice is produced at between 41 000 ha to 100 000 ha depending on mainly rice prices and water availability under irrigated lowland conditions in Turkey and, water consumption under lowland irrigation system was found 1328 mm (Ayday et al., 1981), 1767.8 mm (Ozkara, 1981) and 2036 mm (Bayrak, 1986) in rice in Turkey by different researchers. In International Rice Research Institute (IRRI) between 650 and 830 mm water was used for aerobic rice, while 1350 mm irrigation water was used for traditional flooded conditions (Castaneda et al., 2002).

Various studies have been done to use water more efficiently during rice production. About 14- 40% less (2.4- 4.4 h/ha) rice yield was obtained under aerobic conditions in IRRI. Requirement for water was found between 746 to 1071 mm under sprinkler irrigation in Australia (Fukai and Inthapan, 1988), and 6.84 kg/ha yield was obtained from Shinhakaburi

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rice cultivar under sprinkler irrigation conditions with irrigation 500-600 mm water (Inthapan and Fukai, 1988). Sprinkler irrigation saved water but decreased yield between 20% to 50% as compared to the continuous submergence of fields (Dabney and Hoff, 1989; Muirhead et al., 1989; McCauley, 1990). The reason of yield decrease was decreasing in 1000 kernel weight (Dabney and Hoff, 1989) and reduction of the number of kernel at panicle (Muirhead et al., 1989; McCauley, 1990). Water consumption in aerobic conditions was 50% less and water use efficiency was 64-88% higher than the traditional flooded conditions (Bauman et al., 2002). Underground drip irrigation systems used 80% less water than traditional system (Brian et al., 2006).

In addition to researches on irrigation methods, researches were carried out to improve rice cultivars need less water during production in China, Brazil and IRRI. As a result of these studies aerobic rice cultivars grown under without standing water conditions were improved. These aerobic rice cultivars need less water during production. It was report that there was interaction for cultivar and irrigation methods, while the highest yield was obtained from Sandora cultivar under drip irrigation, the lowest grain yield was obtained from the same cultivar under flooded conditions in Turkey (Beser, 1997).

It was reported that Sandora, Karmina, HS-96, Krosnadarsky-424, Ana/Mar, and HS-1 rice varieties were drought tolerant on the other hand Surek-95, Rocca, TR -489, Trakya, Serhat-92, TR-765 and Lap/PG varieties were susceptible to drought stress in Turkey (Surek et al., 1998). Han Dao 297, Han Dao 277, Han Dao 502, Han 58, Danjing 5, and Danjing 8 rice cultivars were developed for water shortage zone of Northern China to grow under aerobic condition. These varieties are grown about 140 000 ha area and 4.5 – 6.5 t/ha yield were obtained in North China from these cultivars. These aerobic cultivars use 60% less water than traditional rice cultivars and their water use efficiency 2 times higher than traditional cultivars (Huaqi et al., 2002). 5.3 t/ha yield was obtained from Rice cultivar Han Dao under aerobic conditions with 644 mm irrigation water in China (Xiaoguang et al., 2002). Aerobic rice also needs less worker force during production (Huaqi et al., 2002; Bauman et al., 2002). In Brasil, under sprinkler irrigation 5-7 t/ha yielding rice varieties were improved as a result of 20 years breeding studies (Mendoza et al., 2007)

It was reported that, some irrigation methods creating drought stress in rice increased the number of days to flowering and maturity (Dabney and Hoffman, 1989; Muirhed et al., 1989; Beser, 1997) and decreased plant height (McCauley, 1990; Beser, 1997; Surek et al., 1998). Significant cultivar irrigation methods interaction was also reported for plant height (McCauley, 1990).

The economic use of water has become more important and researches are underway to reduce irrigation water for rice production. Water-saving technologies for rice can be improved with improving irrigation systems and cultivars. To improve water saving technologies various researches have been carried out on different irrigation systems such as sprinkler, soil saturated, drip etc. Research on drip irrigation system in rice is new when we compare research on other water saving technologies in rice. Drip irrigation technologies can be used more cheaper than before because of improvements in drip irrigation technologies. With using drip irrigation less water can be used, in addition that fertilizer and chemical application can be more easier during rice crop production with drip irrigation. With drip irrigation rice production and harvesting will be more easier in addition that because of aerobic conditions during rice production, methane emission will be prevented.

Because of a great reduction in seepage, percolation and evaporation, drip irrigation technology allows for greater water use efficiency and high water saving compared with traditional flooded irrigation, but this technology should be used together with suitable genotypes. There were many research results to improve rice genotypes for aerobic conditions such as to improve rice cultivars for upland conditions, or to improve rice cultivars for sprinkler irrigations etc. But there is not any research results to improve rice genotypes adaptable for drip irrigation.

This study was carried out to evaluate 22 rice genotypes under drip irrigation to find out suitable genotypes to grow under drip irrigation, which is the new water saving technology for rice growing.

Materials and Methods

This study was carried out during 2007, 2008 and 2009 but 2008 experiment results were not used because of high weeds infestation. Field experiments were conducted at Trakya Agricultural Research Institute research field. Meteorological data for during rice production season of experiments are given in Table 1. Experiment was conducted at sandy soil in 2007 and clay soil in 2009.

Twenty two genotypes were evaluated in this research and are listed in Table 2 and Table 3. These genotypes were tested in a randomized complete block design with four replicates under drip irrigation. Plot size was 8 m^2 (1.6 m × 5 m). Each plot had 8 rows but 6 rows were dry seeded by hand for each plot. Distance between rows was 20 cm. After three rows one row was left empty. Seed rate was 100 kg/ha. Irrigation drip laterals with an emitter discharge rate of 2 L h^{-1} and emitter spacing of 0.30 m was used each plot. Distances between

Table 1
Meteorological data during experiments in 2007 and 2009

Month	May		June		July		August		September	
Year	2007	2009	2007	2009	2007	2009	2007	2009	2007	2009
The highest temperature, °C	26.4	32.8	31.9	36.4	32.5	38.7	34.5	37.2	26.4	26.4
The lowest temperature, °C	12.9	6.2	20	13.6	22.6	12.3	18.8	12.6	13.5	6.6
Mean temperature, °C	19.6	19	24.8	22.6	27	24.9	26.3	24.7	19.4	19.9
Number of rainy days	9	8	4	7	1	8	3	5	7	6
Total rainfall, mm	122	21.8	8.2	20.4	0.8	42.8	9.1	25.6	29	5.4

Source: Meteorological provincial directorate of Edirne

Table 2
Overall mean performance of morphological and milling characteristics of 22 rice genotypes under drip irrigation in 2007 and 2009

Cultivars	Days to flowering	Days to maturity	Plant height, cm	Panicle length, cm	Brown rice milling yield, %	Total rice milling yield, %	Head rice milling yield, %
Akceltik	85 k	116 k	98.13 a	17.60 b	73.05f	60.00 f	48.60 eh
Beser	88 hi	122 g	82.68 f	16.80 bd	78.19 bd	67.41 bd	56.13 ad
Demir	95 c	126 de	76.20 gh	13.83 gi	79.50 ac	64.85 de	47.41 fh
Ece	89 fg	123 fg	80.98 fg	12.68 j	76.93de	64.44 e	51.14 dg
Edirne	87 ij	124 f	93.13 bc	16.08 ce	81.45 a	70.71a	52.24 cg
Gonen	87 ij	121 h	95.68 ab	16.73 bd	80.88 a	70.76 a	54.60 be
Halilbey	88 ij	125 e	93.03 bc	15.80 de	79.26 ad	68.58 ac	56.33 ad
Kiral	91 e	127 cd	82.25 f	14.58 fg	80.26 ab	68.14 ac	46.43 gh
Kirkpinar	87 j	123 fg	90.83 cd	16.70 bd	79.55ac	69.29 ac	47.31 fh
Negis	88 ij	121 h	90.78 cd	16.93 bc	78.98 ad	68.86 ac	48.79 eh
Osmancik-97	87 ij	118 j	84.73 ef	13.98 gh	77.78 be	68.29 ac	53.48 cf
Serhat-92	89 gh	121 gh	93.70 ac	16.73 bd	77.44 ce	66.95 ce	53.48 cf
Surek-95	92 d	127 cd	84.48 ef	16.03 ce	79.11 ad	67.24 be	47.33 fh
Sumnu	90 eg	118 ij	75.38 hi	12.83 ij	80.08 ab	69.85 ab	55.43 bd
TR-1324	91 e	122 fg	87.78 de	14.65 fg	79.40 ad	69.09 ac	57.68 ac
Duragan	91 ef	119 i	85.48 ef	14.20 gh	80.94 a	70.36a	56.21ad
Kiziltan	95 c	129 b	65.78 k	13.33 hj	79.04 ad	69.39 ac	60.80 ab
Veneria	96 c	128 c	83.55 ef	12.50 j	79.75 ac	70.00 ab	61.88 a
YAR-96-V14	100 b	130 b	66.40 jk	16.28 ce	75.49 ef	65.19 de	54.98 be
Yavuz	90 eg	121 h	84.70 ef	15.28 ef	81.04 a	70.69 a	47.15 fh
YRF-203	101 ab	133 a	82.10 f	20.08 a	69.84 g	54.54 g	33.96 i
Aromatik-1	102 a	132 a	71.23 ij	16.65 bd	69.36 g	59.41 f	42.66 h
For overeal means of cultivar	CV (%) = 1.28	CV (%) = 1.02	CV (%)= 5.82	CV (%) = 6.71	CV (%) = 3.30	CV (%) = 4.32	CV (%) = 12.53
	Lsd (%5)= 1.15	Lsd (%5)= 1.25	Lsd (%5)= 4.84	Lsd (%5)= 1.03	Lsd (%5) = 2.54	Lsd (%5) = 2.87	Lsd (%5)= 6.39
	***P< 0.001	***P< 0.001	***P< 0.001	***P< 0.001	***P< 0.001	***P< 0.001	***P< 0.001

Means not sharing the letter similar differ significantly
Values are means of two years

laterals was 80 cm. Lateral was placed on the middle row of each three seeded rows. Irrigation water was applied according evaporated water from the A class evaporation pan at three times a week. In 2007, 668.5 mm water was applied with drip irrigation and 169.8 mm was rained, total 838.3 mm was supplied. In 2009, 624.4 mm water was applied with drip irrigation and 116 mm water was rained and total 740.4 mm water was supplied.

As a two years meanwhile 789 mm water was used for drip irrigation treatments (including seasonal rainfall). On the other hand at the another experiment next to drip irrigation experiment 1806 mm water was used for flooded conditions (including seasonal rainfall as a two year mean). When we compare drip irrigation and flooded irrigation we can say that 56% less water was used for drip irrigated treatments compared to flooded rice irrigation.

Experiments were fertilized 189 kg N/ha and 80 kg $P_2O_{5/}$ ha each year. Nitrogen was applied with 3 splits at before seeding, during tillering and during booting stage.

Yield, biological yield (above-ground yield), harvest index, number of fertile panicle per square meter, 1000 kernel weight, days to flowering, days to maturity, plant height, panicle length, brown rice milling yield, total rice milling yield and head rice milling yield were recorded (Anon,1996n, 2003) and the data thus collected were subjected to analysis of variance and two years mean were compared.

Table 3
Overall mean performance of yield and yield components of 22 rice genotypes under drip irrigation in 2007 and 2009

Genotype	Number of fertile panicle per square meter	Percentage of sterile spikelet per panicle, %	1000 kernel weight, g	Total biological yield, kg/ha	Harvest index, %	Paddy Yield, kg/ha
Akceltik	221 eh	8.83 e	25.04 i	1349.55 ae	31.99 h	444.78 eg
Beser	219 eh	10.74 ce	34.26 b	1183.63 de	45.42 ad	521.32 bf
Demir	255 ab	14.02 cd	26.65 gh	1356.73 ae	41.37 df	522.05 bf
Ece	195 hj	14.48 c	29.09 de	1474.74 ac	40.63 ef	576.24 ac
Edirne	184 j	10.39 ce	35.50 ab	1237.26 de	41.63 df	490.21 cf
Gonen	187 ij	13.05 ce	35.99 a	1354.27 ae	44.18 ae	579.32 ac
Halilbey	231 bf	11.28 ce	29.75 d	1528.54 ab	42.47 bf	623.13 ab
Kiral	252 ac	11.58 ce	35.55 ab	1333.66 be	46.08 ac	582.77 ac
Kirkpinar	185 j	11.55 ce	35.26 ab	1130.93 e	41.65 df	462.40 dg
Negis	173 j	10.59 ce	36.09 a	1257.76 ce	43.85 ae	530.26 be
Osmancik-97	226 cg	9.14 e	29.52 d	1412.90 ad	45.33 ad	623.78 ab
Serhat-92	241 af	13.37 ce	29.87 d	1311.72 be	41.08 df	521.50 bf
Surek-95	222 dh	11.18 ce	32.77 c	1328.28 be	42.05 cf	533.70 be
Sumnu	250 ad	9.40 de	25.74 gi	1345.76 ae	41.96 cf	537.99 be
TR-1324	200 gj	10.61 ce	31.65 c	1341.97 ae	43.98 ae	557.49 ad
Duragan	219 eh	9.25 de	30.01 d	1527.38 ab	43.16 ae	651.71 a
Kiziltan	215 fi	9.61 de	29.31 de	1315.74 be	47.50 a	598.08 ab
Veneria	225 cg	12.00 ce	26.86 fg	1568.48 a	38.69 fg	582.78 ac
YAR-96-V14	262 a	25.19 b	25.39 hi	1272.85 ce	35.17 gh	420.34 fg
Yavuz	219 eh	9.66 ce	28.02 ef	1170.88 e	46.67 ab	543.86 be
YRF-203	247 ae	37.55 a	20.74 j	1165.08 e	21.30 i	229.38 h
Aromatik-1	264 a	21.83 b	21.63 j	1206.21 de	33.82 h	369.07 g
For overeal means of cultivar	CV (%) = 12.73 Lsd (%5) = 28.01 ***P< 0.001	CV (%) = 36.49 Lsd (%5) = 4.85 ***P< 0.001	CV (%) = 4.63 Lsd (%5) = 1.93 ***P< 0.001	CV (%) = 17.72 Lsd (%5) = 232.55 ***P< 0.001	CV (%) = 10.85 Lsd (%5) = 4.39 ***P< 0.001	CV (%) = 19.84 Lsd (%5) = 102.64 ***P< 0.001

Means not sharing the letter similar differ significantly
Values are means of two years

Results

- Analysis of variance of 22 rice genotypes for two years mean under drip irrigation are given Table 2 and Table 3. As can be seen from Table 2 and Table 3, there are significant differences between genotypes for characters studied.
- Minimum days to flowering were noted in genotype Akçeltik (85 d) followed by Edirne (87 d), Gonen (87 d), Kirkpinar (87 d) and Osmancik-97 (87 d). Maximum days to flowering were noted in genotype Aromatik-1 (102 d). Days to maturity were minimum in genotype Akceltik (116 d) and maximum in YRF203 (133 d) and Aromatik-1 (132 d).
- The genotype Akceltik had the highest plant height (98.1cm) followed by Gonen (95.7cm) and Serhat-92 (93.7 cm). The lowest plant height was observed in genotype Kiziltan (65.8 cm). Genotype YRF-203 attained maximum panicle length (20.1 cm) followed by Akceltik (17.6 cm) and Negis (16.93 cm) while genotype Veneria (12.5 cm) produced lowest panicle length followed by Ece (12.68 cm).
- Percentage of brown rice milling yield was the highest in genotype Edirne (81.45%) followed by Yavuz (81.04%), Duragan (80.94%) and Gonen (80.88%) while it was lowest in genotype Aromatik-1 (69.36%) followed by YRF-203 (69.84%). Percentage of total milling yield was the highest in genotype Gonen (70.76%) followed by Edirne (70.7%), Yavuz (70.69%) and Duragan (70.36%), while it was lowest in genotype YRF-203 (54.5%) followed genotype Aromatik-1 (59.4%). Percentage of head rice yield is the one of the most important quality criteria in rice. The genotype Veneria produced the highest percentage of head rice yield (61.88%) followed by Kiziltan (60.8%), while genotype YRF-203 attained the lowest percentage of head rice yield (33.96%) followed Aromatik-1 (42.66%).
- The number of fertile panicle per square meter was the highest at cultivar Aromatik-1 (264/m^2) followed by YAR96V14 (262/m^2). The lowest number of fertile panicle per square meter was observed at cultivar Negis (173/m^2).
- Genotype YRF-203 attained highest percentage of sterile spikelet (37.55%) followed by YAR96V14 (25.19%) and Aromatik-1 (21.83%) while Akceltik produced lowest percentage of sterile spikelet (8.83%).
- Maximum 1000 kernel weight was obtained from cultivar Negis (36.09 g) and Gonen (35.99 g), followed by Kiral (35.55 g), Edirne (35.50 g) and Kirkpinar (35.26 g). Minumun 1000 kernel weight was obtained from genotype YRF-203 (20.74 g) and followed by Aromatik-1 (21.63 g).
- The genotype Veneria had the highest biological yield (1.568 t/ha) followed by Halilbey (1.528 t/ha) and Duragan (1.527 t/ha). The lowest biological yield was obtained from genotype Kirkpinar (1.130 t/ha), followed by YRF-203 (1.165 t/ha) and Yavuz (1.170 t/ha).
- Percentage of harvest index was the highest in genotype Kiziltan (47.5%) followed by Yavuz (46.67%), and Kiral (46.08%) while it was lowest in genotype YRF-203 (21.3%) followed by Akceltik (31.99%) and Aromatik-1 (33.82%). Atlin et al (2004) found that harvest index in aerobic rice cultivars was 40% and this was higher than the flood irrigated rice cultivars. In our experiments Kiziltan (47.5%), Yavuz (46.67%), and Kiral (46.08%) had very high harvest index.
- A comparison of data given in Table 3 showed that rice genotypes had considerable variations in yield under drip irrigation conditions. Duragan (6.517 t/ha,) Osmancik-97 (6.237 t/ha) and Halilbey (6.231 t/ha) were the three top yielders. On the other hand genotype YRF-203 had the lowest grain yield (2.293 t/ha) followed by Aromatik-1 (3.690 t/ha).

Discussion

Mean days to flowering were 85, 83, and 83 days at Osmancik-97, Edirne and Gonen cultivars respectively at the different experiments under flood irrigated conditions during 1994 and 2009 (Anon, 1994-2009). But the same cultivars had 87, 87 and 87 days to flowering at the our study. Cultivars had more days to flowering time under drip irrigation than the flooded irrigation. During long time researches under flooded conditions at Trakya Agricultural Research Institute, (Anon 1994 - 2009) Edirne cultivar mature earlier than the Osmancik-97 and Duragan cultivar, but in this study, under drip irrigation, Osmancik-97 (118 d) and Duragan (119 d) matured earlier than Edirne cultivar (124 d). We can say that Osmancik -97 and Duragan were more suitable cultivar to grow under drip irrigation because they were less effected than Edirne cultivar under the stress conditions of drip irrigation.

When we compare long time experiment results under flooded conditions (Anon 1994-2009) with our experiment results we can say that plant height of cultivars shorter under drip irrigation than the flooded conditions.

There were some research results that Irrigation practices that create drought stress had different effects on milling yield in rice, while some researcher found that it decreased milling yield (Mundy et al., 1989; Villarreal et al., 1990) some researcher found that it increased milling yield (Beser, 1997). These different results may be due to the differences in the varieties used in the studies. Significant cultivar irrigation methods interaction was also reported for milling yield (Mundy et al., 1989). One of the most important qual-

ity characteristics is head rice milling yield. In our experiments, the highest yielding cultivars under drip irrigation had acceptable head yield percentage with nearly 60% such as Halilbey (56.33%), Duragan (56.21%), and Osmancik-97 (53.48%).

Long term research results under flooded conditions at Trakya Agricultural Research Instituted showed that, one thousands kernel weight for Negis, Gonen, Edirne and Kirkpinar were (37-38.9), (39-40 g), (38-39 g) and (37-38 g) respectively (Anon, 1994-2009). From this study we obtained about 10% less one thousand kernel weight from the same cultivars. We can say that drip irrigation reduced one thousand kernel weight in rice.

Atlin et al (2004) found that harvest index in aerobic rice cultivars was 40% and this was higher than the flood irrigated rice cultivars. In our experiments Kiziltan (47.5%), Yavuz (46.67%), and Kiral (46.08%) had very high harvest index.

Bouman et al (2002) and Huqai et al (2002) obtained the highest yield from aerobic rice with 4.7 – 6.6 t/ha and 4.5 – 6.5 t/ha respectively. In this study we obtained the highest yield from Duragan variety with 6.527 t/ha using drip irrigation, and with drip irrigation 56% less water was used.

Conclusion

There were many research results to improve rice genotypes for aerobic conditions such as to improve rice cultivars for upland conditions, or to improve rice cultivars for less water conditions (sprinkler irrigation, soil saturated irrigations). But there is not any research results to improve rice genotypes adaptable for drip irrigation conditions. From this study it was found that Duragan, Osmancik-97 and Halilbey rice cultivars were adaptable to drip irrigation and they could be grown under drip irrigation conditions with using about 50% less water than flooded irrigation. Rice production with drip irrigation with varieties determined in this study can be done more economically, more easier and environment friendly (no methane emission) together with water saving. But weed control problem should be solved, because without standing water during rice growing, weed control is very difficult.

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Received February, 20, 2015; accepted for printing October, 5, 2015