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Agronomic Characteristics and Yield Performance of Different Corn Hybrids Harvested in Drained-Paddy and Upland Fields

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Abstract - The growth and yield performance of 19 new corn hybrids were evaluated. Results showed that all hybrids had a superior growth performance in the drained-paddy than in the upland field except for daeyul × cheongdo and hyoryeong × cheongdo in plant height, cheongdoyeop × wx-3 in tassel length, and cheongdo (black) × wx-3 in number of tassel branch. The same hybrids, except cheongdoyeop × wx-3, obtained lower ear quality in drained-paddy field compared to upland in terms of ear weight, and ear and grain setting length. The highest yield in the drained-paddy and upland fields was obtained in the hybrids ks5wx × ks6wx × cheongdo (1,633.3kg · $10a^{-1}$) and daeyul × wx-3 (1,516.7kg · $10a^{-1}$), respectively. Highest yield among the wx-3 crosses was obtained in daeyul which was 1,583.3kg · $10a^{-1}$ and 1,516.7kg · $10a^{-1}$ in drained-paddy and upland field, respectively. For the crosses of wx-8, highest yields were recorded in the cultivar bugye50 (1,466.7kg · $10a^{-1}$) and seokgul2 (1,384.6kg · $10a^{-1}$) for drained-paddy and upland field, respectively. In the case of cheongdo, highest yields were obtained in ks5wx × ks6wx (1,633.3kg · $10a^{-1}$) and seokgul4 (1,111.1kg · $10a^{-1}$) for drained-paddy and upland field, respectively. Result also showed that the drained-paddy soil had better physicochemical properties than the upland. The relatively high performance in terms of growth parameters and yield of corn hybrids planted in the drained-paddy field is in agreement with the higher organic matter and micro-element content of drained-paddy field.

Key words - Corn, Drained-paddy field, Hybrid, Upland field

Introduction

Corn is one of the important cereals in Korea. It has been traditionally cultivated in the upland but are now grown in drained-paddy field. This has given rise to the need for studying its growth and yield performance in drained-paddy field. In 2002, over 1,905 ha of paddy fields have been converted for growing upland crops which had increased to about 7,000 ha in 2004.

Soil in converted paddy fields that are used to produce upland crops have unique physical and chemical properties engendered by their transitional status (Takahashi and Toriyama, 2004). Growth and yield performance of upland crops grown in drained-paddy field is thus also affected. In case of soybean, which is an upland crop that is also nowadays being cultivated in drained-paddy field, reports have shown comparable and even better nutritional quality when cultivated in drained-paddy field (Kim *et al.,* 2004; Taira *et al.,* 2004; Ishiguro *et al.,* 2006; Eun *et al.,* 2007).

Corn cultivation in paddy field can be affected by soil type and waterlogging problems because it reduces the uptake of oxygen and certain nutrients from the soil (Armstrong, 1978; Reid, 1977). There is no readily available data on corn cultivation in drained-paddy field in Korea though it can be assumed to have been increasing just like soybean. In this study, the growth and yield performance of newly developed corn hybrids on drained-paddy and upland fields were investigated.

Materials and Methods

The experiment was conducted at the Kyungpook National University Agricultural Research Station in Gunwi on the summer season of 2006. Fertilizer was applied before harrowing at the rate of 150-130-130 ($N-P_2O_5-K_2O$kg · ha^{-1}) according to the standard recommendation. Seedbed, raised 25cm above the ground, was covered with black vinyl.

A total of 19 hybrid corn seeds provided by the International

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Agriculture Research Institute were tested in this experiment. The seeds were directly sown in the field and thinning was done after 25days. Empty or ungerminated holes were replaced. Parameters investigated were agronomic characteristics (plant height, culm length, tassel length and number of tassel branches), corn ear quality (number of ears, ear length, grain setting length, ear diameter, ear weight, grain setting-length/ear-length ratio) and yield. Agronomic characteristics were measured after the reproductive stage while corn ear quality and yield were measured during harvesting.

Soil samples were collected after harvest from 0 to 15cm depth. Soil samples were air-dried and ground to pass through a 2mm sieve. The sieved soil was used to determine the pH, organic matter (OM) content and phosphorus (P_2O_5) according to the methods of USSLS (1954), Kogut and Frid (1993) and Diamond (1995), respectively, while potassium (K), calcium (Ca), and magnesium (Mg) were determined by the procedure of Thomas (1982).

Data were analyzed using an analysis of variance (ANOVA) procedure (SAS Institute, Inc., Cary, NC, USA). Least significant differences between treatment means were obtained using Duncan's Multiple Range Test.

Results and Discussion

Agronomic characteristics

Table 1 showed the agronomic characteristics of different corn hybrids in drained-paddy and upland field. Almost all hybrids in the drained-paddy field obtained higher plant height compared with those of the upland. Only daeyul × cheongdo and hyoryeong × cheongdo in upland obtained higher plant height values than in drained-paddy field. Pakyesa × wx-3, seokgul2 × wx-3 and seokgul4 × cheongdo planted in both fields obtained similar plant heights. In the case of culm length, all hybrids in drained-paddy field obtained higher culm lengths than those in upland except for pakyesa × wx-3, asan × wx-8 and asan × cheongdo which obtained similar values with those in the upland. For percent culm length, almost all hybrids in drained-paddy field obtained higher values than in upland field except for pakyesa × wx-3, asan × wx-3, seokgul2 × wx-8, bugye50 × wx-8, asan × wx-8, asan × cheongdo which obtained similar values in both fields.

In the case of tassel length, hyoryeong × wx-8 and pakyesan × wx-8 in drained-paddy field obtained longer tassel length than in upland. The hybrids cheongdo yeop × wx-8 and seokgul4 × cheongdo in upland had longer tassel length than in drained-paddy soil. The rest of the hybrids obtained similar tassel length in both fields. Also, almost all hybrids planted in the drained-paddy field obtained more tassel tillers than those planted in the upland. Daeyul × wx-3, seokgul2 × wx-8, bugye50 × wx-8, asan × wx-8 and hyoryeong × cheongdo obtained similar number of tassel tillers in both fields while only cheongdo × wx-3 planted in the drained-paddy field obtained lower number of tassel tillers compared with that of the upland.

In general, the result showed better agronomic characteristics in hybrids planted in the drained-paddy field than in the upland. The better performing hybrids in terms of agronomic characteristics in both fields are cheongdo (black) × wx-3, uswx (11a) × cheongdo, pakyesan × wx-8, cheongdo × wx-8, hyoryeong × wx-8 and chalok1. The same hybrids were also better performing in the drained-paddy field than in upland.

Ear quality of corn hybrids

Table 2 showed the ear quality of different corn hybrids. The following hybrids obtained higher number of corn ears in the drained-paddy soil: daeyul × wx-3, bugye50 × wx-8, pakyesan × wx-8, cheongdo yeop × wx-8, hyoryeong × cheongdo and asan × cheongdo while the rest of the hybrids obtained similar values in both fields.

Almost all hybrids planted in the drained-paddy field obtained higher corn ear weights than upland. The hybrids seokgul2 × wx-3, asan × wx-3, cheongdo (black) × wx-3 and hyoryeong × cheongdo obtained higher corn ear weight in upland field. The hybrids pakyesan × wx-3, daeyul × wx-3, seokgul2 × wx-8 and daeyul × cheongdo obtained similar corn ear weigths in both fields. In case of grain setting-length/ear-length ratio, all hybrids obtained similar values except for pakyesan × wx-3 and cheongdo (black) × wx-3 which was higher in upland, and ks5wx × ks6wx × cheongdo, hyoryeong × wx-8 and chalok1 which was higher in drained-paddy field.

The result showed a general trend of higher corn ear weight in the hybrids planted in drained-paddy field. The other corn ear quality parameters did not show significant difference between two fields.

Yield at different soil types

Table 3 showed the yield performance of each cultivar. All hybrids obtained higher yield in drained-paddy field compared to

Table 1. Agronomic characteristics of corn hybrids planted in upland and drained-paddy fields

Hybrids	Plant height (cm)		Culm length (cm)		Percent culm length (%)		Tassel length (cm)		No. of tassel branch	
	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland
pakyesa × wx-3	160.5a	157.2a	84.0a	76.4a	52.3a	48.6a	40.0a	41.4a	16.4a	13.5b
seokgul2 × wx-3	147.0a	149.0a	73.5a	67.4b	50.0a	45.2b	38.8a	42.1a	17.2a	11.9b
asan × wx-3	149.0a	142.8b	68.0a	59.4b	45.6a	41.6a	42.5a	41.2a	18.2a	15.8b
daeyul × wx-3	167.5a	159.1b	92.7a	73.7b	55.3a	46.3b	39.1a	37.5a	17.7a	17.6a
cheongdo (black) × wx-3	195.5a	170.3b	125.8a	87.3b	64.3a	51.3b	41.0a	44.5a	14.1b	20.4a
seokgul2 × wx-8	180.5a	152.9b	88.0a	71.9b	48.8a	47.0a	38.7a	42.1a	16.1a	17.5a
bugye50 × wx-8	172.7a	146.1b	86.0a	67.8b	49.8a	46.4a	37.7a	38.5a	16.3a	17.1a
asan × wx-8	150.3a	138.5b	68.2a	63.2a	45.4a	45.6a	37.5a	37.9a	16.6a	16.7a
hyoryeong × wx-8	162.7a	113.0b	80.9a	31.6b	49.7a	28.0b	39.0a	35.4b	15.2a	9.6b
cheongdo × wx-8	157.3a	104.0b	73.5a	28.6b	46.7a	27.5b	39.0a	36.1a	16.7a	10.4b
pagyesa × wx-8	169.5a	94.0b	84.2a	23.0b	49.7a	24.5b	38.8a	32.5b	19.3a	6.0b
cheongdoyeop × wx-8	158.2a	151.2b	87.0a	70.6b	55.0a	46.7b	39.2b	44.1a	18.5a	18.9b
daeyul × cheongdo	150.0b	161.9a	83.5a	75.1b	55.7a	46.4b	37.4a	40.5a	23.2a	16.3b
seokgul4 × cheongdo	148.0a	145.3a	97.0a	63.8b	65.5a	43.9b	34.2b	43.5a	18.0a	14.3b
hyoryeong × cheongdo	141.8b	160.1a	103.3a	81.9b	72.8a	51.2b	38.2a	40.5a	19.0a	17.0a
uswx (11a) × cheongdo	195.0a	181.0b	90.9a	69.3b	46.6a	38.3b	41.5a	40.9a	16.7a	12.1b
asan × cheongdo	145.0a	127.3b	65.7a	59.8a	45.3a	47.0a	35.4a	38.6a	20.9a	10.5b
ks5wx × ks6wx × cheongdo	147.5a	105.1b	63.0a	32.7b	42.7a	31.1b	45.7a	34.7b	13.3a	7.2b
chalok1	117.0a	99.5b	53.0a	36.5b	45.3a	36.7b	38.0a	38.3a	11.8a	8.3b

*The same letters in each row of every parameter are not significantly different at 0.05 level by DMRT.

Table 2. Ear quality of corn hybrids planted in upland and drained-paddy fields

Hybrids	Number of ears		Ear length (cm)		Grain setting length (%)		Ear diameter (cm)		Ear weight (g)		Grain setting length: ear length ratio (%)	
	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland
pakyesa × wx-3	1.3a	1.4a	16.0a	17.5a	14.8b	16.8a	3.9a	3.6b	144.0a	141.6a	92.5b	96.0a
seokgul2 × wx-3	1.4a	1.1b	16.6a	16.0a	15.5a	14.9a	4.3a	4.1a	171.5b	181.5a	93.4a	93.1a
asan × wx-3	1.7a	1.5a	17.0a	16.5a	15.5a	14.9a	4.2a	4.2a	163.3b	194.6a	91.2a	90.3a
daeyul × wx-3	2.1a	1.3b	19.0a	17.7b	17.0a	16.1a	4.4a	4.3a	202.5a	194.5a	89.5a	91.0a
cheongdo (black) × wx-3	1.7a	1.8a	19.3a	19.3a	16.6b	18.2a	4.0a	4.1a	152.0b	192.0a	86.0b	94.3a
seokgul2 × wx-8	1.4a	1.6a	17.9a	17.4a	16.6a	16.2a	4.0a	4.1a	146.0a	146.9a	92.7a	93.1a
bugye50 × wx-8	1.6a	1.3b	16.9a	16.2a	15.5a	14.5a	4.1a	3.8b	140.0a	126.3b	91.7a	89.5a
asan × wx-8	1.2a	1.1a	16.5a	15.5a	15.4a	14.6a	3.8a	3.8a	136.0a	119.1b	93.3a	94.2a
hyoryeong × wx-8	1.4a	1.5a	17.2a	16.4a	15.7a	14.1b	3.9a	3.8a	153.5a	95.9b	91.3a	86.0b
cheongdo × wx-8	1.3a	1.3a	15.3a	15.9a	14.2a	14.6a	4.3a	3.9b	181.5a	122.1b	92.8a	91.8a
pagyesa × wx-8	1.8a	1.3b	17.4a	17.0a	16.5a	16.1a	4.2a	3.4b	154.5a	110.6b	94.8a	94.7a

Continued

Hybrids	Number of ears		Ear length (cm)		Grain setting length (%)		Ear diameter (cm)		Ear weight (g)		Grain setting length: ear length ratio (%)	
	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland	Drained -paddy	Upland
cheongdoyeop × wx-8	1.4a	1.2b	17.0a	15.8b	15.3a	14.0b	3.9a	3.5b	132.0a	121.1b	90.0a	88.6a
daeyul × cheongdo	1.5a	1.3a	15.9b	18.4a	14.3b	16.1a	3.9a	3.7a	141.0a	141.7a	89.9a	87.5a
seokgul4 × cheongdo	1.7a	1.7a	17.0a	17.4a	15.6a	15.8a	3.7a	3.4a	177.5a	140.0b	91.8a	90.8a
hyoryeong × cheongdo	1.7a	1.3b	15.8b	17.9a	15.0a	16.8a	3.7a	3.8a	131.5b	142.3a	94.9a	93.9a
uswx (11a) × cheongdo	1.2a	1.2a	21.4a	19.3b	19.0a	17.4b	4.4a	3.7b	205.4a	140.0b	88.8a	90.2a
asan × cheongdo	1.5a	1.0b	18.7a	17.6a	16.7a	15.8a	4.0a	3.8a	166.7a	100.0b	89.3a	89.8a
ks5wx × ks6wx × cheongdo	1.2a	1.1a	20.8a	18.2b	19.2a	14.3b	4.2a	3.5b	221.0a	118.4b	92.3a	78.6b
chalok1	1.1a	1.3a	14.6a	12.4a	13.6a	10.9b	4.0a	3.8a	136.5a	79.1b	93.2a	87.9b

*The same letters in each row of every parameter are not significantly different at 0.05 level by DMRT.

upland except for asan × wx-3, cheongdo (black) × wx-3 and asan × wx-8. The highest yield in the drained-paddy field was obtained in the cultivar ks5wx × ks6wx × cheongdo (1,633.3kg · $10a^{-1}$) while the lowest was in asan × wx-8 (916.7kg · $10a^{-1}$). In upland field, the highest yield was recorded in daeyul × wx-3 (1,516.7kg · $10a^{-1}$) while the lowest was in chalok1 (848.5kg · $10a^{-1}$).

Table 3. Yield of corn hybrids in upland and drained-paddy field

Hybrids	Yield (kg · $10a^{-1}$)	
	Drained-paddy field	Upland field
pakyesa × wx-3	1,183.3a	1,122.8a
seokgul2 × wx-3	1,433.3a	1,333.3b
asan × wx-3	1,422.2b	1,512.8a
daeyul × wx-3	1,583.3a	1,516.7a
cheongdo (black) × wx-3	1,366.7b	1,488.9a
seokgul2 × wx-8	1,333.3a	1,384.6a
bugye50 × wx-8	1,466.7a	1,083.3b
asan × wx-8	916.7b	1,030.3a
hyoryeong × wx-8	1,266.7a	941.2b
cheongdo × wx-8	1,433.3a	1,087.7b
pagyesa × wx-8	1,366.7a	916.7b
cheongdoyeop × wx-8	1,166.7a	1,074.1b
daeyul × cheongdo	1,366.7a	1,055.6a
seokgul4 × cheongdo	1,400.0a	1,111.1b
hyoryeong × cheongdo	1,282.1a	1,074.3a
uswx (11a) × cheongdo	1,606.7a	1,066.7b
asan × cheongdo	1,444.4a	933.3b
ks5wx × ks6wx × cheongdo	1,633.3a	947.4b
chalok1	1,250.0a	848.5b

*The same letters in each row are not significantly different at 0.05 level by DMRT.

High yield in ks5wx × ks6wx × cheongdo can be attributed to its superior performance in all ear quality parameters except for number of ears. It obtained higher values in the drained-paddy field in ear length (20.8cm), grain setting length (19.2cm), ear diameter (4.2cm), ear weight (221.0g) and grain setting-length/ear-length ratio (92.3) compared to the upland which were 18.2, 14.3, 3.5, 118.4 and 78.6, respectively. The same case was observed in uswx (11a) × cheongdo which obtained superior performance in ear length (21.4cm), grain setting length (19.0cm), ear diameter (4.4cm) and ear weight (205.4g) in drained-paddy field compared to those in the upland which were 19.3, 17.4, 3.7 and 140.0, respectively. The cultivar asan × wx-3 obtained higher value in ear weight in upland field than drained-paddy while cheongdo (black) × wx-3 obtained higher values in grain setting length, ear weight and grain setting-length/ear-length ratio in upland field than drained-paddy. The cultivar asan × wx-3 obtained very high yield in upland compared with drained-paddy field but no ear quality parameter obtained higher values in upland field.

The highest yield among the wx-3 crosses was obtained in daeyul which was 1,583.3kg · $10a^{-1}$ and 1,516.7kg · $10a^{-1}$ in drained-paddy and upland field, respectively. For the crosses of wx-8, the highest yields were recorded in bugye50 (1,466.7kg · $10a^{-1}$) and seokgul2 (1,384.6kg · $10a^{-1}$) for drained-paddy and upland field, respectively. In the case of cheongdo, highest yields were obtained in ks5wx × ks6wx (1,633.3kg · $10a^{-1}$) and seokgul4 (1,111.1kg · $10a^{-1}$) for drained-paddy and upland field, respectively.

Physicochemical properties of soil

Table 4 showed the physicochemical properties of drained-paddy and upland soil planted with different corn hybrids. Data showed that drained-paddy (1.48~2.66g · kg^{-1}) soil had higher organic matter content than upland soil (1.16~1.98g · kg^{-1}) except for asan × wx-3 and hyoryeong × wx-8. Available soil phosphate in drained-paddy soil (216.89~542.40g · kg^{-1}) was significantly

Table 4. Soil physicochemical properties of upland and drained-paddy field planted with different corn hybrids

Hybrid	pH (1:5)		Organic matter (g · kg^{-1})		Available P_2O_5 (mg · kg^{-1})		Exchangeable cations (cmol · kg^{-1}) K^+		Ca^{2+}		Mg^{2+}	
	Drained-paddy	Upland	Drained-paddy	Upland	Drained-paddy	Upland	Drained-paddy	Upland	Drained-paddy	Upland	Drained-paddy	Upland
pakyesa × wx-3	5.69a	5.13b	2.29a	1.98b	328.26a	195.58b	0.08a	0.09a	6.67a	2.00b	2.03a	1.11b
seokgul2 × wx-3	5.71a	5.18b	2.00a	1.61b	443.75a	96.58b	0.07a	0.17a	3.97b	5.74a	1.44a	1.49a
asan × wx-3	5.58a	5.22b	1.65b	1.81a	234.76a	107.24b	0.06b	0.10a	3.90b	5.91a	1.41b	1.81a
daeyul × wx-3	5.49a	5.09b	1.71a	1.44b	216.89a	48.12b	0.14a	0.07b	4.05a	4.59a	1.26b	1.48a
cheongdo (black) × wx-3	5.51	5.08b	1.78a	1.54b	259.51a	65.30b	0.05a	0.07a	3.14a	3.26a	1.18a	1.28a
seokgul2 × wx-8	5.63	5.22b	1.48a	1.39a	248.17a	64.96b	0.08a	0.02b	1.68b	4.24a	1.02b	1.54a
bugye50 × wx-8	5.45a	5.44a	1.73a	1.69a	384.63a	78.02b	0.22a	0.05b	5.92a	4.27b	1.51a	1.49a
asan × wx-8	5.64a	5.09b	1.77a	1.57b	274.98a	89.71b	0.10a	0.03b	1.60b	4.15a	1.15b	1.57a
hyoryeong × wx-8	5.48a	5.43a	1.64b	1.82a	335.48a	40.90b	0.17a	0.02b	5.87a	2.80b	1.57a	1.21b
cheongdo × wx-8	5.69a	5.49b	1.74a	1.61b	285.63a	41.24b	0.35a	0.12b	4.89a	3.74b	1.53a	1.27b
pagyesa × wx-8	5.75a	5.35b	1.95a	1.54b	542.40a	31.27b	0.10a	0.03b	1.54b	1.75a	1.01a	1.13a
cheongdoyeop × wx-8	5.61a	5.45b	2.20a	1.52b	333.76a	30.24b	0.21a	0.18a	4.11a	1.71b	1.48a	1.13b
daeyul × cheongdo	5.79a	5.56b	2.66a	1.16b	400.10a	41.59b	0.14a	0.18a	1.98b	5.25a	1.02b	1.37a
seokgul4 × cheongdo	5.83a	5.31b	2.13a	1.48b	436.53a	24.06b	0.16a	0.08b	3.68b	5.24a	1.31a	1.40a
hyoryeong × cheongdo	5.74a	5.57b	2.14a	1.45b	392.53a	24.07b	0.21a	0.11b	2.08b	4.53a	1.22b	1.45a
uswx (11a) × cheongdo	5.94a	5.67b	2.13a	1.59b	399.07a	34.02b	0.03b	0.06a	3.62b	4.46a	1.51b	1.80a
asan × cheongdo	5.72b	6.00a	2.14a	1.36b	492.56a	25.43b	0.34a	0.26b	5.44a	5.44a	1.50a	1.38b
ks5wx × ks6wx × cheongdo	5.66b	5.93a	2.12a	1.51b	542.06a	27.15b	0.15b	0.27a	5.80a	4.11b	1.47a	1.33b
chalok1	5.70a	5.75a	2.26a	1.31b	355.76a	31.27b	0.24a	0.25a	1.90a	1.96a	1.17a	1.07a

*The same letters in each row of every parameter are not significantly different at 0.05 level by DMRT.

higher than in upland soil (24.06～195.58g · kg^{-1}). Exchangeable cations K^+, Ca^{2+} and Mg^{2+} were also generally higher in the drained-paddy soil (0.03～0.35, 1.54～6.67, 1.01～2.03cmol · kg^{-1}) than in the upland (0.06～0.27, 1.71～5.91, 1.07～1.80cmol · kg^{-1}), respectively. Also, pH, generally within acceptable limits, was higher in drained-paddy soil compared with upland.

Soil chemical properties are important factors for corn cultivation (Galdos, 2004). The result showed that the drained-paddy soil had better physicochemical properties than the upland. The relatively good performance in terms of growth parameters and yield of corn hybrids planted in the drained-paddy field is in agreement with the higher organic matter and micro-element content (Table 4) of drained-paddy field. Cultivar ks5wx × ks6wx × cheongdo obtained higher physicochemical properties in drained-paddy field compared with upland except in exchangeable K^+. Among the varieties which obtained higher yields in the upland, only asan × wx-3 had higher values in the physicochemical properties in the upland than those of drained-paddy field. The more compacted soil in the upland field could have been another reason why hybrids in upland field had poorer agronomic characteristics and lower yield (Hamblin, 1985).

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