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Phenological Changes of Wheat Cultivars with Plant Type and Plant Spacing

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ABSTRACT : The three Korean wheat cultivars with different plant types; the erect, the middle and the creeping growth habit, were studied for their utilization to solar radiation, temperature changes on the furrow and to provide optimum planting space for producing the high yield in 2003. The average solar radiation rate was lowest for creeping type (39.2%) and highest for erect type (75.8%) The correlation coefficient between the coverage rate and the solar transmission rate was r = 0.8624 which was significant at 5% level. The relative growth of the plant, tiller rate and leaf size was increased in the erect and the middle type at lower plant density, while no change on plant growth at creeping type regardless of plant density. The increase of leaf size in the lower plant density was due to longer flag and the first leaf than those of other plant types. The temperature on the furrow of growing plants was changed by the canopy. The changes in temperature pattern on the furrow according to plant types during winter season was different compared to the nonplant ground. The temperature of the nonplant ground was the lowest due to solar reduction increasing the amount of cool air flowing in the furrow.

Keywords: plant type, canopy, temperature, yield, wheat

Wheat (*Triticum aestivum* L.) and barley (*Horedeum Vulgare* L.) are grown about 60,000 ha of Korean annually. Wheat is the second most important crop next to the rice based on the per capita consumption in Korea. In the 1980s, one of the main goals of program designed to improve the wheat and barley was to increase yield (Cho *et al*, 1982). The high yield of wheat and barley depends on varieties and cultivation methods that include seeding time, seeding rate, plant spacing, weed control, and disease control.

Plant spacing of 20 × 5 cm has been the commonly recommended for drill seeding method with the middle or the creeping type for wheat and barley since 1990 (RDA, 2001; Park *et al.*, 2005).

There were only two plant types for wheat and barley, the middle and the creeping types. After the year 90's the erect wheat plant type has also been bred. However, the optimum cultivation method and the plant spacing of 20 × 5 cm for the drill seeding are not estabilished yet. The objective of this study was to identify solar transmission rate, temperature in the furrow, yield, and yield components and to know the optimum plant spacing for different plant types of wheat.

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MATERIALS AND METHODS

Plant materials

The three plant types of wheat; erect, middle, and creeping (commercial wheat cultivar, Tapdongmil, Urimil, and Kemkangmil), were planted on Oct. 10, 2003 at National Institute of Crop Science (NICS) research farm in Suwon that is located in the central region of Korea. The soil type was sandyloam.

The experimental unit consisted of 7.0 × 6.0 m (42.0 m^2) plot containing three planting density, 10 × 5 cm (60 rows with 10 cm row-space), 20 × 5 cm (30 rows with 20 cm row-space), and 30 × 5 cm (20 rows with 30 cm row-space). The experiment was laid out in a split plot design making cultivar the main plot and plant density as the split plot with three replications. The seeds were planted by drill seeder, and at a depth of 2.5 cm with a seeding rate of 150 kg · ha^1.

The coverage rate was measured with photography taken above the canopy during the entire wheat growth stage. The utilization of solar radiation was measured using Spectroradiometer (Model LI188B, LICOR, lnc.) at two points, above the top of canopy and the surface between row at the booting and heading stages. The reduced solar radiation rate was calculated by dividing the latter with the former points.

RESULTS AND DISCUSSION

The coverage rate on wheat was important because it intercepted light and influence the microclimate in the furrow. The 80% canopy rate of creeping type was achieved the earliest (April 24) at 10 cm plant space and the slowest (May 26) at 30 cm (Table 1). This result was similar to crops grown at low plant densities where green area per plant increased through increased duration of tiller production (Whaley *et al.*, 2000).

The plant canopy in the thinly sown stands remained open throughout the vegetation period and thus behaved quite dif-

Table 1. Coverage rate according to different plant types and plant spaces. plant types; erect: Topdomgmil, middle: Urimil, creeping: Kemkangmil.

Plant type	Plant space (cm)	Coverage rate (%)					
		Feb. 23	April 1	April 11	April 24	May 2	May 26
Erect	10 × 5	40	75	85	95	100	100
	20 × 5	30	40	55	75	85	98
	30 × 5	15	30	40	55	70	80
Middle	10 × 5	55	80	90	95	100	100
	20 × 5	50	55	70	80	85	98
	30 × 5	20	45	50	60	70	90
Creeping	10 × 5	55	80	90	100	100	100
	20 × 5	60	65	75	85	90	98
	30 × 5	20	40	50	60	75	90

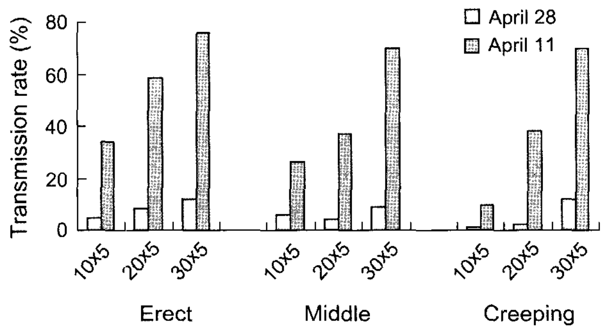

Fig. 1. Transmission rate according to plant types and plant spacing. plant types; erect: Topdomgmil, middle: Urimil, creeping: Kemkangmil.

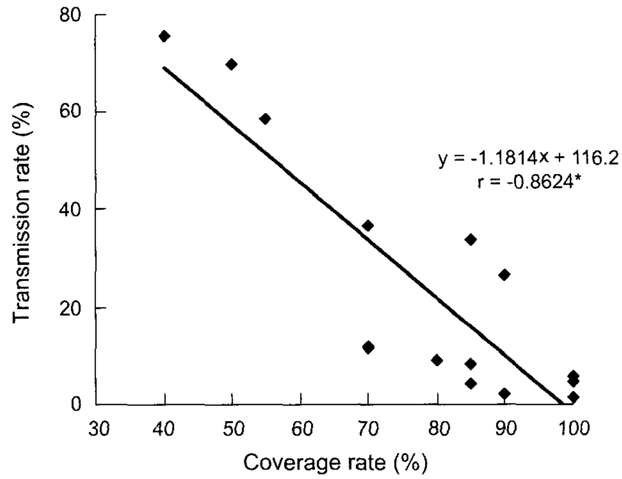

Fig. 2. Relationship between the coverage rate and the transmission rate.

ferently to the closed stands and larger transmission rate were recorded in thinly sown stands. The coverage rate affected the transmission rate, increased plant space and lowered the amount of fresh air flowing on the furrow keeping temperature high on the furrow.

The increased area of leaves affected the radiation interception and distribution in the canopy. Increased plant spacing was correlated with increased transmission rate among plant types. At the booting stage (April 11), the lowest transmission rate was 39.2% in the creeping type at 20 cm plant spacing and was highest with 75.8% in the erect type at 30 cm plant spacing. The solar transmission rate was increased with increas of plant spacing for all plant types (Fig. 1). At the heading stage (April 28), the transmission rate was low up to 1.4% at 10 cm plant spacing for the creeping type but the trend did not change.

The correlation coefficient between the coverage rate and the solar transmission rate was r = -0.8624 whice was significant at 5% level (Fig. 2). When a linear regression model was used to describe the relationship between the canopy rate and the solar transmission rate, the coefficient of transmission was $R^2 = 0.7438$. Increasing the canopy rate and the plant density lowered the amount of light reaching to the soil surface and decreased the transmission rate, resulting in a decreased efficiency in solar energy for wheat growth.

A linear regression model was developed to express the relationship of canopy interception with leaf area index and plant height (Kang *et al.*, 2005; Aristidis *et al.*, 2000) indicated that minimum of temperature and photosynthetic photon flux density were the most important factors in plant growth. Radiation use efficiency was greater at the low plant densities (Whaley *et al.*, 2000). Mathieu & Jeremy (2005) suggested that the relationship between light transmission and weed populations may be more complex.

We propose that the better solar transmission rate was based on the canopy stand. Erect type had an advantage over the other plant types since the transferred solar energy affected the temperature on the furrow and growth of the plant. The effective tiller rate was the highest in the erect

Table 2. Coverage rate according to different plant types and plant spaces. plant types; erect: Topdomgmil, middle: Urimil, creeping:Kemkangmil.

Plant type	Plant space (cm)		
	10 × 5	20 × 5	30 × 5
Erect	31.0	35.7	39.8
Middle	25.9	24.9	31.9
Creeping	23.8	24.5	29.6

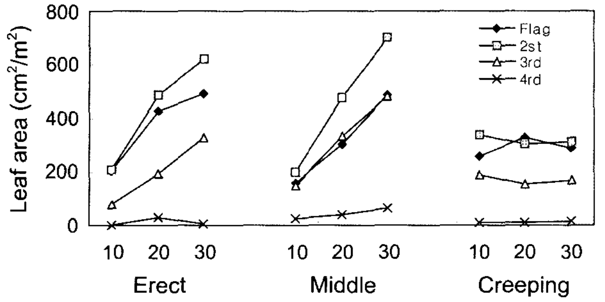

Fig. 3. Leaf area rate and plant spacing accordging to different plant types. plant types; erect: Topdomgmil, middle: Urimil, creeping:Kemkangmil.

type and the lowest in the creeping type. Also, in the erect type, the effective tiller rate was higher with increasing plant density (Table 2). Leaf areas however, was increased in the lower plant density in the erect and the middle type, but no difference was made in the creeping type (Fig. 3).

Leaf area in the erect and the middle types increased due to increase of the flag, and the second leaf length, but different result was for the creeping type where little changed with increasd plant spaces was showed. In the lower plant density, the increased leaf area was due to longer length of the flag, and the first leaf, but no change was found in the width of those leaves (Table 3).

This study was similar to the results previously reported in that an increase in plant density influenced not only the size of the leaf area, but also the distribution of the leaves at various plant heights (Anda & Loke, 2005).

During the plant growth, the temperature over the furrow was affected by the following factors such as the plant type (Fig. 4), the canopy rates, and the plant spacing (Table 1). The temperature fluctuation during the day was smaller in the creeping type than other types, causing an increased in canopy area and lowered the amount of fresh air flow through the furrow. This resulted in keeping the temperature on the furrow.

Anda & Loke (2005) reported that the low plant density allowed more energy to reach the soil, making a considerable contribution to the final temperature in the plant. Kasperbauer & Hunt (1998) also reported that mulch color

Table 3. Leaf length according to plant types and plant spaces. plant types; erect: Topdomgmil, middle: Urimil, creeping: Kemkangmil.

Plant type	Plant Space (cm)	Leaf length (cm)		
		Flag	2nd	3rd
Erect	10 × 5	16.3	21.5	19.7
	20 × 5	18.0	22.9	21.1
	30 × 5	19.5	25.7	22.9
Middle	10 × 5	13.5	19.1	19.5
	20 × 5	14.6	21.8	22.3
	30 × 5	16.9	24.0	23.4
Creeping	10 × 5	18.7	22.1	21.3
	20 × 5	19.0	23.3	20.9
	30 × 5	19.4	22.2	20.3

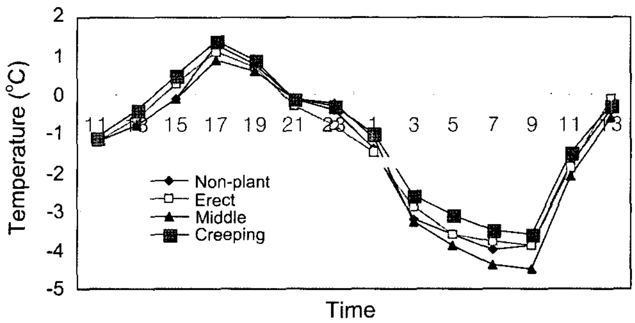

Fig. 4. Change of temperature of the furrow measured 24 hours at wintering period.

influenced tomato growth by effects on the upward reflection of light as well as effects on soil temperature. Residual transpiration rate also affect canopy temperature (Sanchez *et al.*, 2001), and yield under drought susceptibility (Rashed *et al.*, 1999).

Previous studies have indicated that soil temperature and nutrition competition were most influenced by plant space. The plant space affected the yield. The 20 × 5 cm spacing is commonly recommended for high yield in wheat (RDA, 2001; Park *et al.*, 2005). Increased plant space in the creeping type allowed a significant increase in the yield, causing an increase of panicles and spikelets. On the other hand, 20 × 5 cm space in the erect and the middle types allowed the highest increase in the yield causing an increase panicles (Table 4). This result was similar to previous result that grain yield was maintained with large reductions in plant density and the established crop densities ranged from 19 to 338 plants m^2. Gooding *et al.* (2002) indicated that the plants compensated for low population densities by increased production and survival of tillers and to a lesser extent, increased grain numbers per ear. The plant densities giving the highest yields were at least 400 to 500 plants per m^2 for

Table 4. Varietal agronomic characteristics and plant spacing.

Plant type	Plant Space (cm)	Panicles per m^2	1000 grainweight.	Spikelet Number per m^2	Yield (ton/ha)
Erect	10 × 5	1,138	30.8	31	5.55 ± 0.08
	20 × 5	881	30.8	32	5.61 ± 0.07
	30 × 5	833	32.8	31	5.35 ± 0.06
Middle	10 × 5	1,000	33.7	32	5.42 ± 0.06
	20 × 5	888	33.9	33	5.55 ± 0.08
	30 × 5	708	37.3	32	5.31 ± 0.08
Spreading	10 × 5	1,188	44.4	24	4.36 ± 0.05
	20 × 5	681	42.1	25	4.65 ± 0.05
	30 × 5	642	45.4	27	4.73 ± 0.08

most of the varieties studied (Lloveras *et al.*, 2005).

REFERENCES

Anda, A. and Z. Loke . 2005. Radiation balance components of maize hybrids grown at various plant densities. J. of Agronomy and Crop Sci. 191(3) : 202-209.

Cho, C. H., E. S. Lee, Y. W. Ha, and M. G. Shin. 1982. Changes in varieties and cultural practices of wheat and barley since 1962 in Korea. Korean J. of Crop Sci. 27(4) ; 452-461.

Gooding, M. J., A. Pinyosinwat, and R. H. Ellis. 2002. Responses of wheat grain yield and quality to seed rate. J. of Agricultural Sci.138 : 317-331.

Kang, Y. H., Q. G., Wang, and H. J. Liu. 2005. Winter wheat canopy interception and its influence factors under sprinkler irrigation. Agricultural Water Management 74(3) : 189-199.

Kasperbauer, M. J. and P. G. Hunt. 1998. Farred light affects photosynthate allocation and yield of tomato over red mulch. Crop Sci. 38 : 970-974.

Lloveras, J., J. Manent, J. Viudas, A. Lopez, and P. Santiveri. 2004. Seeding rate influence on yield and yield components of irrigated winter wheat in a Mediterranean climate. Agromony J. 96(5) : 1258-1265.

Ngouajio, M. and J. Ernest. 2004. Light transmission through colored polyethylene mulches affects weed populations. Hort. Sci. 39(6) : 1302-1304.

Matsoukis, A. S., A. G. ChronopoulouSereli, and J. K. Chronopoulos. 2003. Growth and flowering of *Lantana camara* L. subsp. camara as affected by triapenthenol and environmental factors. HortScience 38(2) : 173-175.

Park, U. H., S. N. Ryu, and C. W. Lee. 2005. Barley. Food crop II. Korea National Open University. Seoul. pp. 95-130.

RDA. 2001. Cultivation technology. Barley cultivation. Rural Development Administration. Suwon. pp. 95-149.

Rashid, A., J. C. Stark, A. Tanveer, and T. Mustafa. 1999. Use of canopy temperature measurements as a screening tool for drought tolerance in spring wheat. J. of Agronomy and Crop Sci. 182(4) : 231-237.

Sanchez, F. J., M. Manzanares, E. F. de Andres, J. L. Tenorio, and L. Ayerbe. 2001. Residual transpiration rate, epicuticular wax load and leaf colour of pea plants in drought conditions. Influence on harvest index and canopy temperature. European J. of Agronomy 15(1) : 57-70.

Whaley, J. M., D. L. Sparkes, M. J. Foulkes, J. H. Spink, T. Semere, and R. K. Scott. 2000. The physiological response of winter wheat to reductions in plant density. Annals of Applied Biology 137(2) : 165-177.