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Effect of Phosphorus Content on the Emergence of Tillers in Wheat Cultivars

Akiko SATO*, Atsumi OYANAGI and Michihiro WADA

Department of Crop Physiology and Quality, National Agriculture Research Center (Tsukuba, Ibaraki, 305 Japan)

Abstract

Relationship between phosphorus, nitrogen and potassium contents and the emergence rate of T_1 (tiller in axils of the first leaf on main stem) in wheat cultivars differing in their adaptability to low available phosphoric acid was examined in an Andosol. Three wheat cultivars were in a field with low available phosphoric acid in soil and in a field with soil amended by the application of additional phosphoric acid and stable manure. In the case of cv. Asakazekomugi and Norin 61 which show a low adaptability to low available phosphoric acid in soil, the emergence rates of T_1 decreased when the phosphorus content of shoot was less than 0.5%. In cv. Norin 64 which shows a high adaptability to low available phosphoric acid in soil, the emergence rate of T_1 was maintained at 0.3% phosphorus content in shoot. The application of additional phosphoric acid and stable manure increased not only the phosphorus content, but also the nitrogen and potassium contents in wheat plants. Partial correlation coefficient between phosphorus, nitrogen and potassium contents and the emergence rate of T_1 indicated that the phosphorus content mainly affected the emergence of T_1. It is considered that the high emergence rate of T_1 of Norin 64 in soil with low available phosphoric acid was due to the high tillering ability in response to the low phosphorus content in plants.

Discipline: Crop production
Additional key words: Andosol, nitrogen, potassium, *Triticum aestivum* L.

Introduction

Studies on high adaptability to low available phosphoric acid in soil are important in wheat production in areas where the phosphorus fertilizer supply is insufficient. Ikeda et al.[2] who reported the presence of varietal differences in adaptability to low available phosphoric acid in soil indicated that cv. Norin 64 showed a high adaptability. We reported that Norin 64 showed a higher emergence and survival rate of T_1 (tiller in axils of the first leaf on main stem) than the other cultivars, resulting in higher yield in soil with low available phosphoric acid[5]. Tanno and Tanaka[8] reported that the crop differences in adaptation to low available phosphoric acid were due to the tolerance to low phosphorus content in plant, ability of root to absorb phosphorus or translocation of phosphorus from root to shoot. We studied the relationship between phosphorus (P), nitrogen (N) and potassium (K) contents and the emergence rate of T_1 and determined whether the high adaptability of Norin 64 to low available phosphoric acid in soil was due to a high ability to absorb phosphorus or high tillering ability in response to the low phosphorus content in plants[6]. This paper summarizes the experimental results.

Materials and methods

Norin 64 (high adaptability to low available phosphoric acid in soil) and Asakazekomugi and Norin 61 (both with a low adaptability to low available phosphoric acid in soil) were cultivated in a Light-colored Andosol. This soil had a low content of available phosphoric acid. The test fields consisted of two plots. One was the control plot to which fertilizer had been applied before planting at the rate of 70 kg/ha for N, 70 kg/ha for P_2O_5 and 70 kg/ha for K_2O. The other plot was the improved plot

*Present address: Department of Crop Breeding, Tohoku National Agricultural Experiment Station (Shimo-kuriyagawa, Morioka, 020-01 Japan)

Table 1. Grain weight and contents of P, N and K in 1000 seeds of 3 wheat cultivars

Cultivar	1000 grain weight (g)	P (mg)	N (mg)	K (mg)
Asakazekomugi	37.8	110 ± 1	881 ± 21	142 ± 1
Norin 61	39.7	126 ± 2	977 ± 16	166 ± 1
Norin 64	34.0	95 ± 5	721 ± 34	120 ± 1

Mean values ± standard deviation.

amended with N at the rate of 70 kg/ha, P_2O_5 at the rate of 310 kg/ha, K_2O at the rate of 70 kg/ha as well as with 20 t/ha of stable manure. At 4 months after fertilizer application, the content of available phosphoric acid was 2.1 mg/100 g oven-dry soil in the control plot and 9.0 mg/100 g oven-dry soil in the improved plot. The test was carried out with 4 replications. Three cultivars were sown on 25 October in 1990 at about 200/m^2 density with a row spacing of 17 cm. Grain weight and contents of P, N and K in 1,000 seeds were higher in the order of Norin 61 > Asakazekomugi > Norin 64 (Table 1).

Ten plants were sampled on 22 November (at the stage when 3–4 leaves extended on the main stem) and plant length, leaf number on the main stem, top dry weight and P, N, K contents of top and root were determined. Emergence rate of T_1 in 20 plants was investigated at the same time. Dry plants were milled using high-speed vibrating sample mill and decomposed into sulfuric acid and hydrogen peroxide at 330°C. Extracts were analyzed for P and N with an auto-analyzer (Bran + Luebbe) and for K with an atomic absorption spectrophotometer (Jarrel Ash Video 12).

Results

Plant growth and P, N, K contents of root at the 3–4 leaf stage are shown in Table 2. The plant length, leaf number of main stem, top dry weight of all cultivars in the improved plot were greater than those in the control plot. P, N, K contents of root in the improved plot were also higher than those in the control plot.

Relationship between P, N, K contents in shoots and emergence rate of T_1 is shown in Figs. 1–3. P content in shoots of the three cultivars in the improved plot was higher than that in the control plot (Fig. 1). In both Asakazekomugi and Norin 61 in the control plot, the emergence rate of T_1 decreased when the P content of shoots was less than 0.5%. In contrast, in Norin 64, the emergence rate of T_1 was not affected by 0.3% P content.

N content in shoots of the three cultivars in the improved plot was higher than that in the control plot (Fig. 2). In both Asakazekomugi and Norin 61, the emergence rate of T_1 decreased when the N content in shoots was less than 6%. In contrast, in Norin 64, the emergence rate of T_1 was not affected by 5% N content.

K content in shoots of the three cultivars in the improved plot was higher than that in the control plot (Fig. 3). In both Asakazekomugi and Norin 61, the emergence rate of T_1 decreased when the K content in shoots was less than 6%. In contrast, in Norin 64, the emergence rate of T_1 was not affected by 4.5% K content.

The application of additional phosphoric acid and stable manure increased not only the P content, but also the N and K contents in wheat plants. In both Asakazekomugi and Norin 61, the emergence rate

Table 2. Plant length, number of leaves on main stem, top dry weight and P, N, K contents of root on 22 November

P_2O_5 application	Cultivar	Plant length (cm)	Leaf no. on main stem	Top dry weight (mg/plant)	Root		
					P content (%)	N content (%)	K content (%)
70 kg/ha (Control)	Asakazekomugi	14.8 ± 0.7	3.5 ± 0.1	53.9 ± 5.9	0.16 ± 0.06	1.6 ± 0.3	1.5 ± 0.3
	Norin 61	15.8 ± 0.6	3.3 ± 0.1	55.9 ± 3.9	0.16 ± 0.02	1.9 ± 0.2	1.7 ± 0.1
	Norin 64	15.4 ± 0.6	3.4 ± 0.1	57.7 ± 5.4	0.14 ± 0.03	1.6 ± 0.2	1.5 ± 0.3
310 kg/ha + manure (Improved)	Asakazekomugi	17.0 ± 0.8	4.2 ± 0.1	103.5 ± 6.0	0.27 ± 0.02	2.1 ± 0.3	2.6 ± 0.2
	Norin 61	18.2 ± 1.0	4.0 ± 0.2	108.7 ± 15.9	0.24 ± 0.01	2.3 ± 0.2	2.8 ± 0.2
	Norin 64	17.9 ± 0.7	4.2 ± 0.2	105.8 ± 18.1	0.28 ± 0.02	2.2 ± 0.1	2.9 ± 0.3

Mean values ± standard deviation.

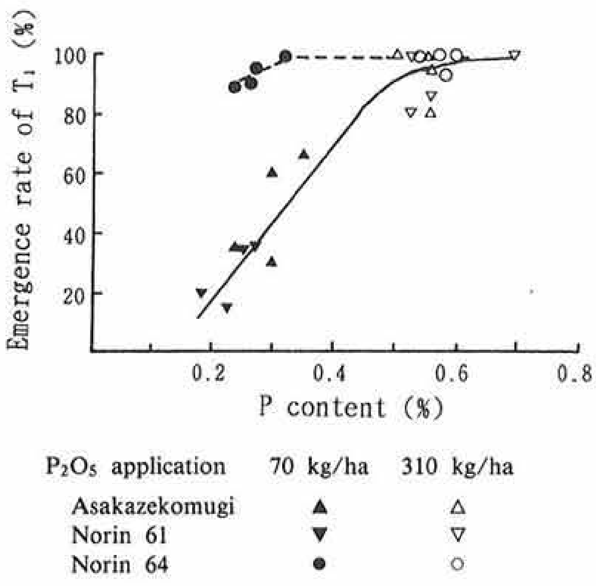

Fig. 1. Relation between P content of shoots and emergence rate of T_1 (tiller on the axil of the first leaf on the main stem)

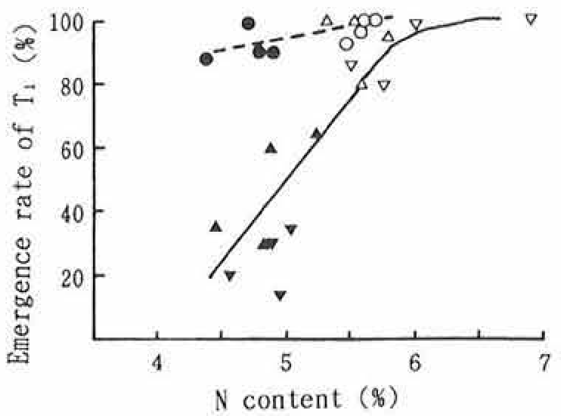

Fig. 2. Relation between N content of shoots and emergence rate of T_1
Symbols are the same as those in Fig. 1.

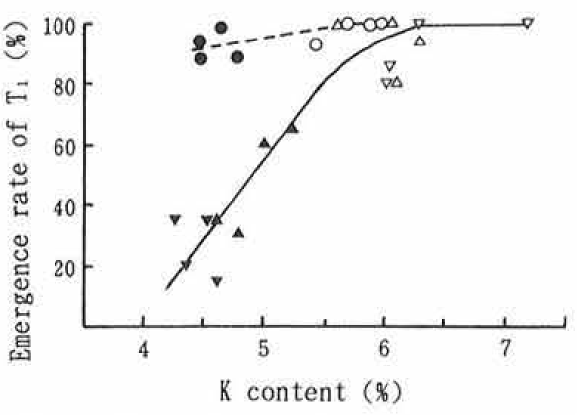

Fig. 3. Relation between K content of shoots and emergence rate of T_1
Symbols are the same as those in Fig. 1.

Table 3. Correlation matrix of P, N, K contents and the emergence rate (y) of T_1 in Asakazekomugi and Norin 61

	P	N	K	y
P	1	0.912**	0.974**	0.935**
N		1	0.932**	0.797**
K			1	0.901**
y				1

** Significant at the 1% level.

Table 4. Partial correlation coefficient between P, N, K contents and the rate (y) of emergence of T_1 in Asakazekomugi and Norin 61

$r_{Py \cdot NK}$	0.621*
$r_{Ny \cdot PK}$	− 0.375
$r_{Ky \cdot NP}$	0.075

* Significant at the 5% level.

of T_1 increased with the increase of the P, N, K contents. All the correlation coefficients of P, N, K contents and the emergence rate of T_1 were higher in both Asakazekomugi and Norin 61 (Table 3). However partial correlation coefficient between P, N and K contents and the emergence rate of T_1 indicated that only the P content was statistically significant at 5% (Table 4). This finding shows that the P content predominantly affected the emergence of T_1.

Discussion

In both cv. Asakazekomugi and Norin 61 which are characterized by a low adaptability to low available phosphoric acid in soil, the emergence rates of T_1 decreased when the shoot P content was less than 0.5%. In contrast, in cv. Norin 64 which shows a high adaptability to low available phosphoric acid in soil, the emergence rate of T_1 was not affected by 0.3% P content in shoot. Bolland et al.[1] reported that high P content in seed is related to higher rates of dry matter production. In this study, Norin 64 had smaller seeds and a lower P content in seed compared to both cv. Asakazekomugi and Norin 61. Since Norin 64 had a lower P content in shoot and root as in the case of Asakazekomugi and Norin 61 in the control plot, Norin 64 did not display a high ability to absorb P. These results suggest that the high emergence rate of T_1 of Norin 64 in soil with low available phosphoric-acid was due to the high tillering ability in response to the low P content in plants.

In general, the application of additional phosphorus to soil increases tiller production[7] and fertile tillers[4]. Reinobott et al.[3] reported that the phosphorus content in plants was affected by the absorption of magnesium and calcium. In this study, the application of additional phosphoric acid and stable manure increased not only the phosphorus content but also the nitrogen and potassium contents in wheat plants. Suppression of the absorption of phosphorus decreased the phosphorus content as well as the nitrogen and potassium contents in plants. These nutritional deficiencies suppressed tillering in wheat plants.

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