

Comparison of Sulfur Utilization among 10 Different Genotypes of Rape (*Brassica napus*)

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다양한 유채품종에서 황의 이용 효율 비교

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요 약

유채 품종 간의 황 이용률을 비교하기 위하여 10가지 유채 품종 (Mokpo, Tamra, Youngsan, Naehan, Saturnin, Akela, Mosa, Capitol, Pollen and Colosse)을 정상적인 황 공급 (2.0 mM) 조건하에서 재배하여 품종별로 황 흡수량을 측정하였다. 또한 유채 품종간의 생육 특성을 비교하기 위해 잎의 수, 잎의 길이, 잎의 넓이 및 뿌리의 길이를 조사하였다. 그 결과, 모든 유채품종에서 잎의 수, 잎의 길이와 넓이는 별다른 차이는 나타나지 않았다. 뿌리 길이는 Saturnin에서 36.3 cm로 가장 길게 나타났다. Saturnin, Youngsan과 Mokpo에서 SO_4^{2-} 흡수량이 대체적으로 높았고 Mosa와 Pollen에서 SO_4^{2-} 흡수량 상대적으로 낮았다. SO_4^{2-} 흡수량이 높은 Saturnin과 Mokpo에서 NO_3^- 흡수량도 높게 나타났다.

(Key words : Nitrate uptake, Rape, Sulfate uptake)

I. INTRODUCTION

Sulfur has been recognized as important nutrient for plants growth in agricultural productivity and it is required in larger amounts for most of the crop plants (Hell, 1997). In plants, sulfur is involved in numerous metabolic activities, especially in amino acid and protein synthesis (Schnug et al., 1995; Zhao et al., 1999). Sulfur is also required for the synthesis of various other compounds, such as thiols, sulpholipids and secondary sulfur compounds, which play an important role in the nutritional physiology and in the protection and adaptation of plants against stress and pests (Matsubayashi et al., 2002).

Sulfur is taken up by the roots as SO_4^{2-} , transported via the xylem to the leaves, reduced to cysteine, and either converted to methionine or incorporated into proteins and cysteine-containing peptides such as glutathione which have important functions as storage and transport form of reduced sulfur, in oxidative stress defense, regulation of sulfur assimilation (Nocter et al., 1998).

Rape species (*Brassica napus* L.) has a high demand for S during vegetative grown period with growth time (Holmes, 1980). It have relation to nitrogen utilization efficiency such as nitrate uptake and assimilation (Fismes et al., 2000). Several studies have established regulatory interactions between sulfate and nitrate assimilation.

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ation in plants (Takahashi and Saito, 1996; Kim et al., 1999; Koprivova et al., 2000).

The objectives of this study were to compare the S utilization among 10 different genotypes of rape (*Brassica napus*) and to investigate relationship between sulfur and nitrate uptake.

II. MATERIALS AND METHODS

1. Plant culture and experiment procedure

Seeds of 10 rape (*Brassica napus*) species (Naehan, Yangsan, Tamra, Mokpo, Mosa, Akela, Pollen, Capitol, Colosse and Saturnin) were used surface-sterilised. Germination of rape seeds was carried out at 25°C in the dark. After 1 day, the seeds sown into bed soil in a tray and were grown at a glasshouse with day/night mean temperatures of 27/20°C and relative humidity of 65~80% for 2 weeks. Then the seedlings were transplanted to 2.3 L pots filled with 2 L of complete nutrient solution (Kim et al., 1991). The nutrient solution was continuously aerated and renewed every 5 days. Natural light was supplemented by metal halide lamps and sodium lamps that provided a light of 200 $\mu\text{mol m}^{-2}\text{s}^{-1}$ at the canopy height for 16 h day⁻¹.

Eight-week-old plants were harvested at 3 days after the supplies of newly nutrient solution for experiment.

2. Determination of sulfate and nitrate uptake

Sulfate and nitrate uptake were estimated by depletion method, which determined the reduced concentration of specific ion in the complete nutrient solution. After 3 days, the volume of nutrient solution was corrected to 2 L with distilled water and 5 mL of well mixed solution was taken for analysis. The nutrient solutions were filtered through a 25 μM syringe filter. The concentration sulfate and nitrate in sample

solution were determined by ion chromatography (Dionex, DX-120, USA), using an isocratic $\text{Na}_2\text{CO}_3/\text{NaHCO}_3$ eluent (1.8 mM/1.7 mM), flow rate 2.3 mL min⁻¹. A sample volume of 25 μL was injected via an auto injector (AS40 Automated Sampler) into an IonPac AG4A-SC guard column and IonPac AS4A-SC analytical columns, coupled to an ASRS ULTRA II (4 mm) Anion Self-Regenerating.

III. RESULTS AND DISCUSSION

1. Growth characteristics

For comparison of SO_4^{2-} uptake among 10 cultivars, growth characteristics, leaves number, leaves length and width, root length, should have no significant differences. So the concentration of nutrient solution was increased follow growth of 10 cultivars respectively. Solution samples of 3 days after treatment were analyzed (Table 1).

Leaf number was within a range of 7 (Capitol) to 10 (Mosa and Akela). Leaf length and width in all cultivars less variable among the cultivars examined. The longest root was shown in Saturnin (36.3 cm), and follow by Colosse (33.3 cm) and Mosa (30.5 cm), while the shortest root was shown in Akela (23.5 cm). Following a sudden withdrawal of the sulfate supply there is no immediate effect on plant growth. Growth deficiency appeared after 2 or 3 days of treatment. Leaves exhibited little yellow and were lost vigor (data not shown).

2. Uptake of sulfate and nitrate

SO_4^{2-} and NO_3^- uptake of each cultivar were estimated by the depletion method. Saturnin, Youngsan and Mokpo exhibited a higher SO_4^{2-} uptake than other cultivars whereas Mosa and Pollen showed a lower SO_4^{2-} uptake (Fig. 1).

Table 1. Growth characteristics of 10 rape cultivars after 8 weeks hydroponic culture. Each value is the mean \pm S.E. for $n = 4$.

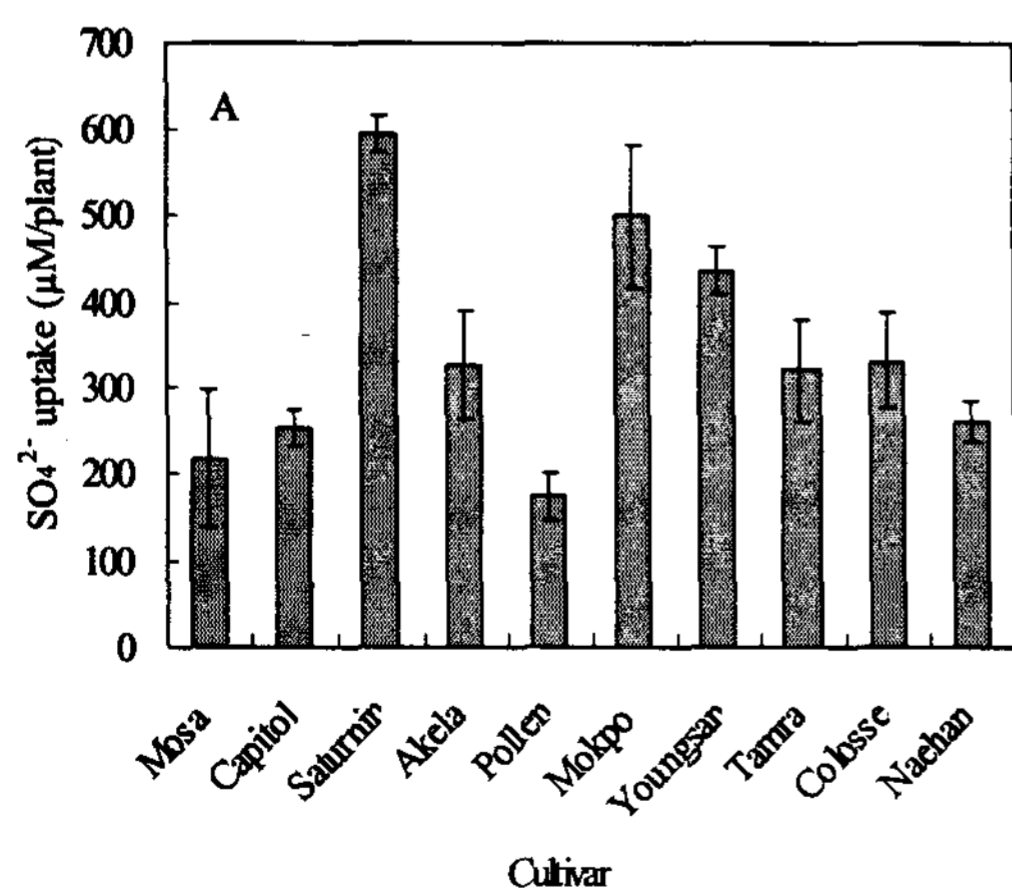
Cultivar	Leaf number	Leaf length (cm)	Leaf width (cm)	Root length (cm)
Mosa	9 \pm 1.50	16.08 \pm 1.54	11.13 \pm 0.41	30.53 \pm 5.32
Capitol	7 \pm 1.00	15.75 \pm 1.15	11.38 \pm 1.14	26.52 \pm 2.87
Saturnin	8 \pm 0.50	15.96 \pm 0.87	12.32 \pm 0.74	36.28 \pm 4.32
Tamra	9 \pm 1.92	14.82 \pm 1.03	11.86 \pm 0.89	24.31 \pm 1.92
Colosse	8 \pm 1.50	16.68 \pm 1.09	12.43 \pm 0.74	33.26 \pm 3.42
Akela	10 \pm 0.87	17.02 \pm 0.43	11.59 \pm 1.07	23.54 \pm 0.77
Pollen	8 \pm 0.43	15.78 \pm 1.47	12.01 \pm 0.54	29.32 \pm 6.98
Youngsan	9 \pm 1.73	16.13 \pm 1.35	12.04 \pm 0.61	27.58 \pm 1.92
Mokpo	8 \pm 1.00	16.39 \pm 0.31	11.97 \pm 0.74	28.36 \pm 3.00
Naehan	9 \pm 5.45	16.27 \pm 1.43	11.93 \pm 3.00	27.19 \pm 2.55

Recent study on S uptake in different *Brassica* oilseed species / cultivars (Malhi et al., 2007) showed also different S uptake capacity. When compared SO_4^{2-} concentration taken up per plant, Saturnin has about 3 times higher than Pollen (Fig. 1A). SO_4^{2-} concentration taken up per g FW also the highest in Saturnin ($1.80 \mu\text{M g}^{-1}$ FW) and the lowest in Mokpo ($0.50 \mu\text{M g}^{-1}$ FW) (Fig. 1B).

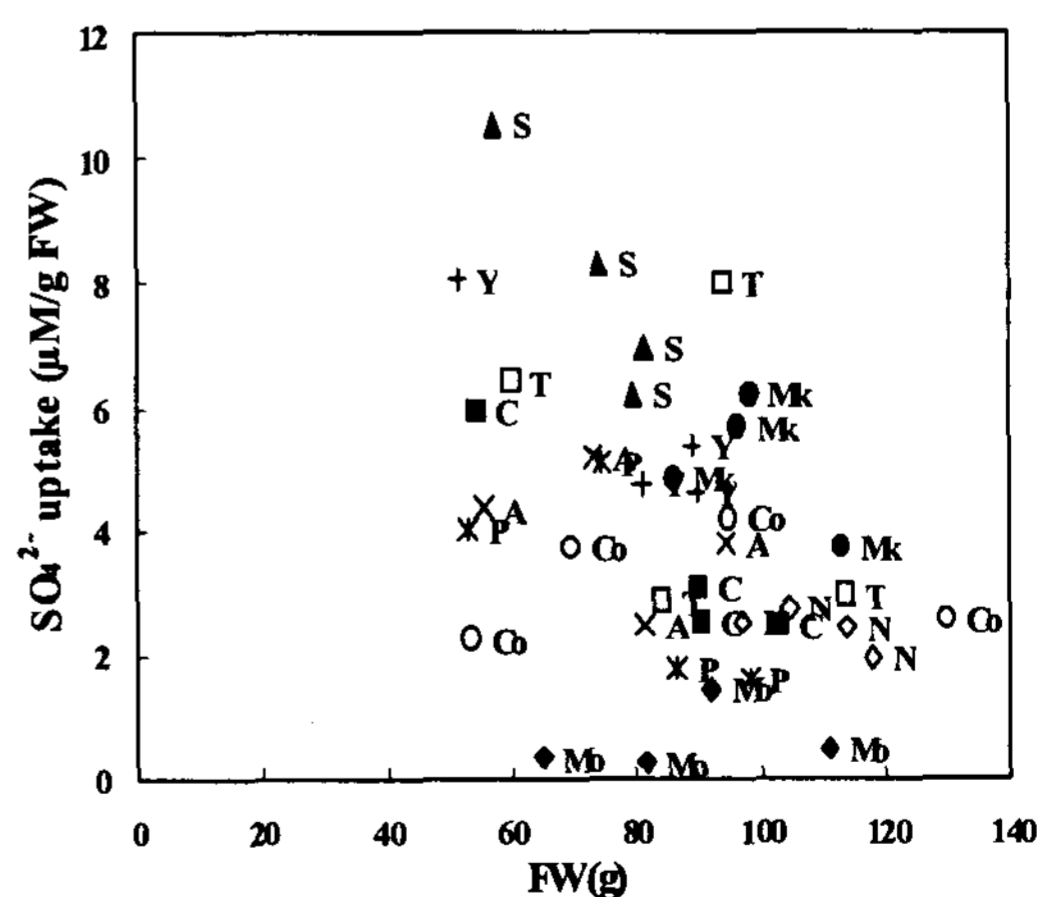
NO_3^- uptake was also measured for 10 rape cultivars to investigate the relationship between SO_4^{2-} and NO_3^- uptake (Fig. 2). Most of NO_3^-

in nutrient solution was absorbed when measured NO_3^- uptake at 3 days after SO_4^{2-} feeding with 2 mM. Thus, the data of NO_3^- uptake during 24 hours are presented in this study. Saturnin and Mokpo which have a high SO_4^{2-} uptake exhibited a high NO_3^- uptake. Relatively low NO_3^- uptake was observed in Akela and Tamra.

These results indicate that the cultivars having high capacity of SO_4^{2-} uptake also have high NO_3^- uptake.



(A)



(B)

Fig. 1. SO_4^{2-} uptake measured at 3 days after feeding of complete nutrient solution containing 2.0 mM SO_4^{2-} . SO_4^{2-} uptake was expressed by SO_4^{2-} concentration absorbed per plant (A) and per gram of fresh weight (B). Alphabets labelling each symbol indicate the cultivar examined: Mo, Mosa; Ca, Capitol; S, Saturnin; A, Akela; P, Pollen; Mk, Mokpo; Y, Youngsan; T, Tamra; Co, Colosse; N, Naehan. In Fig. 1B, the regression equation was: $y = -0.0486x + 8.2504$, $r = 0.414$; $p < 0.01$.

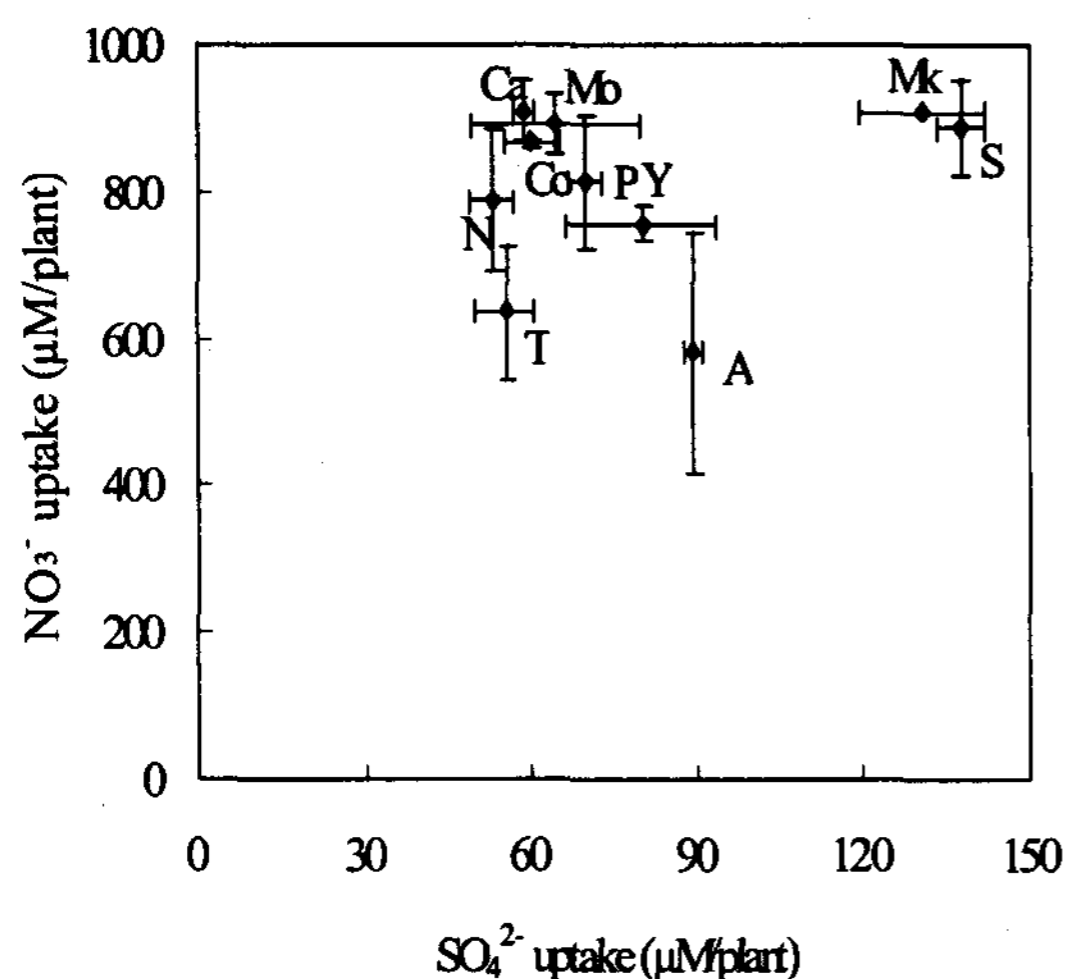


Fig. 2. NO_3^- uptake in relation to SO_4^{2-} uptake in 10 different rape cultivars. Alphabets labelling each symbol indicate the cultivar examined: Mo, Mosa; Ca, Capitol; S, Saturnin; A, Akela; P, Pollen; Mk, Mokpo; Y, Youngsan; T, Tamra; Co, Colosse; N, Naehan. Each value is the mean \pm S.E. for $n = 4$.

IV. ABSTRACT

To investigate the sulfate utilization efficiency in different rape (*Brassica napus*) cultivars, sulfate uptake are analyzed under complete S-supply level (2.0 mM SO_4^{2-}). This study used ten different genotypes of rape (Mokpo, Tamra, Youngsan, Naehan, Saturnin, Akela, Mosa, Capitol, Pollen and Colosse). For comparison of SO_4^{2-} uptake among 10 cultivars, leaf number, leaf length and width, root length was also observed. Leaf length and width in all cultivars less variable among the cultivars examined. The longest root was shown in Saturnin (36.3 cm). SO_4^{2-} uptake in Saturnin, Youngsan and Mokpo was significantly higher whereas that of Mosa and Pollen was relatively lower. Saturnin and Mokpo which have a high SO_4^{2-} uptake exhibited a high NO_3^- uptake.

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