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Differences in Productivity among Rape Varieties for Oil Seed and Forage

Byung Sun Kwon*†, June Taeg Lim*, Jeong Sik Shin, Gae Soo Ahn***, and Hee Jin Park******

*Dept. of Resources Plant Development, Sunchon Nat'l Univ. Sunchon 540-742, Korea
**Dept. of Biology, Sunchon Nat'l Univ. Sunchon 540-742, Korea
***Dept. of Animal Science, Sunchon Nat'l Univ. Sunchon 540-742, Korea
****Seokang College, Kwangju 500-742, Korea

ABSTRACT: In order to examine the possibility that oil seed rape could be used as a forage fodder crop and to select the most suitable variety of forage rape at the southern area of Korea, two varieties of oil seed rape currently grown for oil production and six introduced varieties of forage rape with relatively high yield and high nutritional value were grown at the same condition their and yield components were observed. Forage rape was superior to oil seed rape in terms of yield components, plant fresh weight and plant dry mater weight. Velox was superior to any other variety of forage rape in these characters. When plant dry matter weight of the rape was subdivided into four components such as a main stem, branch stems, main stem leaves and branch leaves, contribution of these components to plant dry matter weight was in the order of branch stems, branch leaves, the main stem and main stem leaves. Dry matter percentage of the rape ranged from 9.32 to 11.08 percent, which was somewhat low value. There was no significant difference between two groups of the rape in terms of dry matter percentage. Velox showed somewhat higher value in dry matter percentage.

Keywords: Growth habit, Plant fresh weight, Plant dry matter weight.

Based on the usage, rape can be divided into two groups, oil seed rape and forage rape. Not only forage rape but oil seed rape in known to be relatively higher in nutritional value of shoot than Gramineae forage crop or other forage fodder crops (Gupta *et al.*, 1974; Macleod, 1974; Kay 1975; Sheldrick and Lavender, 1981; Sheldrick et al., 1981; Groppel *et al.*, 1982; Jung *et al.*, 1984).

Consequently, oil seed rape as well as forage rape seems to be used for the production of forage fodder. The purpose of this study is to examine the possibility that oil seed rape can be used as a forage fodder crop and to select the most suitable variety of forage rape at the southern area of Korea. Two varieties of oil seed rape currently grown for oil production and six introduced varieties of forage rape with high yield were grown at the same environment and their yield components were observed and compared.

Forage rape has been selected for the purpose of getting high shoot dry matter yield but, in contrast. oil seed rape for high quality and quantity of seed oil. Accordingly, forage rape is considered to be greater in shoot dry matter yield than oil seed rape. Since yield of forage fodder is closely related with plant length, main stem length, stem diameter, number of branches, number of leaves and leaf area, in this study, fresh weight, dry matter weight and the yield components mentioned obove were measured and compared each character between two groups of rape.

MATERIALS AND METHODS

An experiment was conducted at the experimental farm of Sunchon National University. Field conditions before the experiment are listed in table 1.

Varieties used in this trial were eight varieties, six of which were selected from the seventeen introduced varieties of forage rape(*Brassica napus subsp. oleifera*) with relatively high yield and *in vitro* dry matter digestibility, and two from the varieties of oil seed rape (*Brassica napus L.*), Naehan yuchae and Youngsan yuchae. In order to compare the maximum productivity per the plant, each plant was grown at the spacing 1 m×1 m. Five or six seeds were sown at each spot of above spacing on September 4, and two or three poor seedlings were discarded when the first or second main stem leaf was unfolded and one healthy seedling grown uniformly was remained at the stage that the third or fourth main stem leaf was expanded. Fertilizer application rate followed the officially recommended one, that is, 10.8 and 8 kg/10 a of N, P_2O_5 and K_2O, respectively. One third of the total N fertilizer, total P_2O_5 and K_2O, fertilizer and manure of 1 MT/10 a were incorporated into the soil before sowing and the rest of N fertilizer was applied in late-February. The complete randomized block design with variety as treatment was used and treatment was randomized in each of the three blocks. The size of each experimental unit was 12.5 m^2 (2.5 m×5 m). Ten plants were randomly sampled from each

†Corresponding author: (Phone) +80-61-750-3282 (E-mail) kbs@sunchon.ac.kr <Received July 30, 2003>

Table 1. Soil properties of the experimental plot at the beginning of the experiment.

PH (1:5)	OM (%)	P_2O_5 (ppm)	Ex-(me/100 g)			CEC (me/l00 g)
			Ca	Mg	K	
6.4	4.5	382	5.1	3.9	0.74	11.2

plot at flowering stage. After plant length, main stem length, stem diameter, number of branches and number of leaves were measured, the sampled plants were harvested by cutting at 3 cm above soil level and plant fresh weight was determined. Each subsamples were separated into a main stem, branch stems, main stem leaves and branch leaves and a leaf area was measured. Dry matter of plants were weighted after drying for 30 min at 105°C, then for 72 h at 70°C in a forced-air oven.

RESULTS AND DISCUSSION

Plant length, main stem length, stem diameter and number of branches

Varietal differences of plant length, main stem length, stem diameter and number of branches are shown in table 2. Average plant length of forage rape was 161.2 cm, which was about 43 cm longer than that of oil seed rape, 118.5 cm. Forage rape cv. Velox was the longest one in plant length with 164.7 cm in this trial. It was more than 44 cm longer than Naehan yuchae which was known to be having longer plant height among oil seed rape. Average main stem length of forage and oil seed rape were 154.7 and 114.3 cm, respectively, and hence forage rape was about 40 cm longer in main stem length than oil seed rape. Velox was the longest variety of forage rape in main stem length with 156.9 cm, which was about 38 cm longer than Naehan yuchae. Average stem diameter of forage rape was 70.7 mm, which was about 3.4 mm thicker than that of oil seed rape, 67.3 mm. The thickest variety of forage rape was also Velox with 72.9 mm. It was about 5 mm thicker than Naehan yuchae. Averang number of branches for forage and oil seed rape were 39.1 and 31.6, respectively, and hence forage rape had about 7 or 8 more branches than oil seed rape. Velox had more branches than any other varieties of forage rape. i.e., it had about 8 more branches than Naehan yuchae with 34 branches. Varieties in this study showed significantly higher in plant length, main stem length, stem diameter and number of branches compared with those of oil seed rape and Velox was superior to any other variety of forage rape in terms of the above characters.

Number of leaves and leaf area.

Number of leaves and leaf area are important factors for determining yield level of forage rape because they themselves are yield components and photosynthetic organs. Average number of leaves and leaf area are presented in table 3. Number of leaves were separated into number of main stem leaves and number of branch leaves. Average number of main stem leaves was 25.7 in forage rape, and 18.4 in oil seed rape and that of branch leaves was 730 in forage rape and 578 in oil seed rape. Forage rape had significantly more leaves in the main stem and the branches than oil seed rape. Analysis of variance for the number of leaves showed significant difference among varieties of forage rape, and Velox had more leaves in the main stem and the branches than any other variety of forage rape in this experiment.

Total leaf area of plant was separated into total area of main stem and branch leaves. Total leaf area showed similar results

Table 2. The plant length, main stem length, stem diameter and number of branch of oil seed rape and forage rape.

Item / Variety	Plant length (cm)	Main stem length (cm)	Stem diameter (mm)	No. of branch
Oil seed rape; Naehan yuchae	120.0^{d}	119.0^{d}	67.4^{d}	34.1^{a}
Youngsan yuchae	117.0^{e}	109.5^{e}	67.1^{d}	29.0^{f}
Mean±SD	118.5±2.12	114.3±6.72	67.3±0.21	31.6±3.61
Forage rape; Akela	164.0^{a}	156.5^{a}	72.6^{a}	41.3^{ab}
Brassica192-4-80	158.7^{c}	152.2^{c}	68.9^{c}	36.8^{d}
Canard	160.4^{ab}	154.7^{ab}	70.2^{b}	38.1^{bc}
Emerald	159.9^{b}	154.5^{ab}	70.0^{b}	38.8^{abc}
English Giant	159.6^{b}	153.6^{bc}	69.8^{b}	37.5^{bc}
Velox	164.7^{a}	156.9^{a}	72.9^{a}	42.0^{a}
Mean±SD	161.2±2.50	154.7±1.76	70.7±1.63	39.1±2.11

Mean seperation within column by Duncan's multiple range test at 5% level

Table 3. The number of leaf, leaf area per plant and average leaf area per leaf of oil seed rape and forage rape.

Item / Variety	No. of leaf			Leaf area (cm^2/plant)			Average leaf area (cm^2/leaf)		
	Total	Main stem	Branch	Total	Main stem	Branch	Total	Main stem	Branch
Oil seed rape; Naehan yuchae	621.5^{a}	19.4^{f}	602.1	14949.3^{f}	1728.0^{a}	13221.3^{f}	24.1^{d}	68.5^{a}	22.0^{a}
Youngsan youchae	571.3^{f}	17.4^{g}	553.9^{a}	14273.4^{f}	1764.0^{a}	12509.4^{a}	25.0^{d}	101.4^{f}	22.6^{a}
Mean±SD	596.40±35.50	18.4±1.41	578.0±34.08	14611.4±477.93	1746.0±308.30	12865.4±503.39	24.6±0.64	85.0±23.26	22.32±0.42
Forage rape; Akela	816.6^{a}	27.0^{b}	789.6^{ab}	28399.1^{b}	3427.0^{b}	25972.1^{b}	34.8^{b}	126.9^{c}	31.0^{ab}
Brassica192-4-80	638.8	23.4^{a}	615.4^{cd}	21439.6^{a}	3110.1^{c}	18329.5^{a}	33.6^{b}	132.9^{b}	29.8^{bc}
Canard	814.7^{a}	25.2^{c}	789.5^{ab}	22992.2^{d}	3016.6^{cd}	19885.6^{d}	28.2^{c}	123.3^{d}	25.2^{d}
Emerald	743.5^{b}	24.8^{cd}	718.7^{b}	23741.2^{c}	3024.8^{cd}	20716.4^{c}	31.9^{b}	122.0^{d}	28.8^{c}
English Giant	699.6^{c}	24.0^{de}	675.6^{c}	22628.5^{d}	2912.1^{d}	19716.4^{d}	32.3^{b}	121.3^{a}	29.2b^{c}
Velox	822.1^{a}	29.6^{a}	792.5^{a}	31428.0^{a}	4567.0^{a}	26861.0^{a}	38.2^{a}	154.3^{a}	33.9^{a}
Mean±SD	755.9±75.58	25.7±2.29	730.2±73.78	25104.8±3917.23	3357.9±616.60	21746.8±3372.95	33.2±3.32	130.1±12.59	29.8±2.92

Mean seperation within column by Duncan's multiple range test at 5% level.

Table 4. The fresh weight plant of oil seed rape and forage rape.

Item / Variety	Fresh weight (g/plant)				
	Total	Main stem	Branch stem	Main stem leaf	Branch leaf
Oil seed rape; Naehan yuchae	3791.0^{a}	337.0^{f}	1622.0^{a}	166.0^{a}	1666.0^{d}
Youngsan yuchae	3381.0^{h}	395.0^{a}	1460.0^{f}	197.0^{d}	1329.0^{a}
Mean±SD	3586.0±289.91	366.0±41.01	1541.0±114.55	181.5±21.92	1497.5±238.29
Forage rape; Akela	5712.0^{b}	483.0^{b}	2922.0^{b}	341.0^{b}	1966.0^{a}
Brassica192-4-80	5114.0^{f}	482.0^{bc}	2732.0^{d}	294.0^{c}	1606.0^{d}
Canard	5594.0^{bc}	479.0^{bc}	2873.0^{bc}	340.0^{b}	1902.0^{b}
Emerald	5488.0^{cd}	457.0^{c}	2862.0^{c}	341.0^{b}	1828.0^{c}
English Giant	5304.0^{a}	440.0^{d}	2785.0^{d}	287.0^{c}	1792.0^{cd}
Velox	5876.6^{a}	569.0^{a}	3046.0^{a}	368.0^{a}	1893.0^{bc}
Mean±SD	5514.8^{b}±276.35	485.0±44.53	2870.0±109.56	328.5±31.36	1831.2±125.91

Mean seperation within column by Duncan's multiple range test at 5% level

Table 5. The dry matter weight per plant of oil seed rape and forage rape.

Item / Variety	Dry matter weight (g/plant)									
	Total	%*	Main stem	%	Branch stem	%	Main stem leaf	%	Branch leaf	%
Oil seed rape; Naehan yuchae	353.5	100.0	46.2^{a}	13.07	149.2	42.21	14.8^{f}	4.18	143.3	40.54
Youngsan yuchae	338.5	100.0	49.8^{a}	14.71	146.0	43.13	19.1^{a}	5.64	123.6^{a}	36.52
Mean±SD	346.0±10.61	–	48.0±2.55	13.9±1.16	147.6±2.26	42.7±0.65	17.0±3.04	4.9±1.03	133.5±13.93	38.5±2.84
Forage rape; Akela	578.8^{b}	100.0	60.4^{bc}	10.43	306.8^{b}	53.01	32.7^{abc}	5.65	178.9^{a}	30.91
Brassica192-4-80	539.5^{c}	100.0	66.5^{b}	12.33	297.8^{bc}	55.20	29.1^{bc}	5.39	146.1	27.08
Canard	549.1^{bc}	100.0	59.9^{bcd}	10.91	290.2^{c}	52.85	31.6^{bc}	5.75	167.4^{b}	30.49
Emerald	537.9^{c}	100.0	53.9^{d}	10.02	294.8^{c}	54.81	33.8^{ab}	6.28	155.4^{c}	28.89
English Giant	557.8^{b}	100.0	58.1^{cd}	10.42	306.4^{b}	54.93	28.4^{cd}	5.09	164.9^{b}	29.56
Velox	651.3^{a}	100.0	81.4^{a}	12.50	353.3^{a}	54.24	36.8^{a}	5.65	179.8^{a}	27.61
Mean±SD	569.1±42.96	–	63.4±9.73	11.1±1.06	308.22±3.03	54.2±1.01	32.1±3.11	5.6±0.40	165.4±13.16	29.1±1.53

Mean seperation within column by Duncan's multiple range test at 5% level.
*Constitutive percentage of total dry matter weight per plant.

to those of number of leaves, i.e., forage rape had significantly broader area in main stem and branch leaves than oil seed rape, and Velox had significantly broader leaf area than any other variety of forage rape. Average area of the main stem leaf was about five times as broad as that of the branch leaf. Varieties of forage rape had significantly broader individual leaf area in the main stem and the branch leaf, especially in the main stem leaf, than those of oil seed rape, Velox also had significantly larger individual leaf area in the main stem and the branch leaf than any other variety of forage rape. Since branches and branch leaves in rape are generally developed after bolting stage following expansion of main stem leaves, varietal variations in number of branches and branch leaves seems to result from the variations of total area in main stem leaves. Varieties with greater area of main stem leaves would produce more photosynthate and hence more branches and branch leaves.

Plant fresh weight

Plant fresh weight was calculated by summing fresh weight of main stem, branch stems, main stem leaves and branch leaves (Table 4). Contribution of these components to plant fresh weight was in the order of branch stems, branch leaves. main stem and main stem leaves based on the magnitude of the organs's weight. Generally, fresh weight of branch stems accounted for about 50 percent of plant fresh weight and combined with branch leaves, they occupied about 85 percent. The results indicate that forage yield of rape depends upon the quantity of fresh weight of branch stems and branch leaves. Varieties of forage rape were larger in all the components of plant fresh weight compared with varieties of oil seed rape. Differences in mean values between two groups of varieties were significant in fresh weight of branch stems and main stem leaves at the 1% level, in the main stem and branch leaves at 5% level, and in plant fresh weight at the 1% level. Velox showed significantly larger values in all the components of plant fresh weight than any other variety of forage rape in this trial.

Plant dry matter weight

Plant dry matter weight was also calculated by summing dry matter weight of the main stem, branch stems, main stem leaves and branch leaves (Table 5). Varieties of forage rape showed larger values in all the components compared with varieties of oil seed rape. Analyses of variance for the components of dry matter weight between two groups showed that differences in dry matter weight of the main stem, branch stems and main stem leaves were significant at the 1 % level, and dry matter weight of branch leaves at th 5 % level. Differences in mean values in all the components of dry matter weight among varieties of forage rape were significant, and Velox had larger values in all the components. Varieties of forage rape showed that dry matter weight of branch stems accounted for about 54 percent of plant dry matter weight, branch leaves about 29 percent, the main stem about 11 percent and main stem leaves about 6 percent. On the other hand, varieties of oil seed rape showed different proportion of the components of dry matter weight, i.e., branch stems occupied about 43 percent of plant dry matter weight, branch leaves about 39 percent, the main stem about 14 percent and main stem leaves about 5 percent. The contribution of branch leaves and the main stem to plant dry matter weight was relatively higher in oil seed rape compared with forage rape.

Dry matter percentage

Dry matter percentages expressing dry matter weight in

Table 6. The dry matter percentage per plant of oil seed rape and forage rape.

Item / Variety	Dry matter percentage(%)				
	Total	Main stem	Branch stem	Main stem leaf	Branch leaf
Oil seed rape; Naehan yuchae	9.32	13.70	9.20	8.90	8.60
Youngsan yuchae	10.01	12.60	10.00	9.70	9.30
Mean±SD	9.70±0.49	13.20±0.78	9.60±0.57	9.30±0.57	9.00±0.49
Forage rape; Akela	10.13	12.50	10.50	9.60	9.10
Brassica192-4-80	10.55	13.80	10.90	9.90	9.10
Canard	9.82	12.50	10.10	9.30	8.80
Emerald	9.80	11.80	10.30	9.90	8.50
English Giant	10.52	13.20	11.00	9.90	9.20
Velox	11.08	14.30	11.60	10.00	9.50
Mean±SD	10.30±0.50	13.00±0.93	10.70±0.55	9.80±0.27	9.00l±0.34

percent of fresh weight for plant organs are presented in table 6. Average dry matter percentages of oil seed rape were 13.2 for the main stem, 9.6 for branch stems, 9.3 for main stem leaves, 9.0 for branch leaves and 9.7 percent for the whole plant. Dry matter percentages of forage rape were more or less higher than those of oil seed rape but there was no significant difference between two groups of rape.

The percentages of Velox were 14.30 for the main stem, 11.60 for branch stems, 10.00 for main stem leaves, 9.50 for branch leaves and 11.08 percent for whole plant and they were more or less higher than the corresponding percentage of any other variety.

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