

[Short Report]

## Traits of NuSun<sup>TM</sup> Varieties of Sunflower in Hokkaido, Japan

Yutaka Honda, Yuji Mukasa and Tatsuro Suzuki

(National Agricultural Research Center for Hokkaido Region, Shinsei, Memuro, Kasai, Hokkaido 082-0071, Japan)

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Sunflower is one of the most important oil crops in the world. One feature of sunflower oil is its high linoleic acid and low oleic acid, leading to its assessment as a typical high-linoleic oil (Sumita 1968, Kurokawa 1985). Research undertaken during the 1990s linked linoleic acid with cancer, high-blood pressure, allergy disease and other life-style related diseases (Okuyama et al., 2002). As a result there was a reduction in sunflower oil production not only in the USA, but also in Japan, which also affected other related industries. Consequently, the National Sunflower Association (NSA) in the USA developed varieties of sunflower, whose oil has a low linoleic and mid-oleic acid composition of similar to canola oil, through classical breeding methods. They named the mid-oleic variety 'NuSun<sup>TM</sup>', and recommended that farmers increase the cultivation of NuSun varieties. The percentage of cultivated area of NuSun in the USA has increased to 43% in 2001, 48% in 2002, and 60% in 2003 (NSA 2003). The mid-oleic acid composition is an important traits for human beings, and NuSun is becoming the major variety grown not only in USA but also in Japan.

Sunflower is cultivated as the local crop in some places in Japan (Ogihara 1987, Ishida et al., 1989, Kaneko 1992). The flowering sunflower fields attract tourists to the local area, who then buy sunflower products like oil, nuts and confections. The cultivation of sunflower reportedly increases the yields of succeeding crops (Arihara et al., 2000). Farmers use sunflower as a green manure crop, too. Sunflower seeds for oil or green manure are mainly imported from the USA, but they are very expensive and old varieties that are no longer used in the USA are imported. Japanese farmers, therefore, are now forced to use either the expensive or outdated varieties.

NuSun varieties are expected to occupy the major part of sunflower in the near future. This paper reports the adaptability for introducing NuSun varieties to the local area in Hokkaido, Japan.

### Materials and Methods

#### Varieties

Table 1 shows the varieties used in this experiment. "North Queen" and "Hokko No.4" were bred at the National Agricultural Research Center for Hokkaido Region. The former was adopted as a standard variety in Hokkaido. The latter was bred at seed companies in the USA and imported by Japanese companies or the agricultural corporative association. All of the varieties were used in both 2002 and 2003, but Hysun424, Hysun511, Hysun525, 63A21 and 63M52 were used only in 2003.

#### Culture

Each variety was sown in 17.28 m<sup>2</sup> on 8 May, 2002 and 7 May, 2003 with row and intrarow spacing of 72 and 30 cm, respectively, with three replications. Two seeds were sown per hole and thinned after germination. A single plant was grown in the per hole. After maturity the head of the sunflower was harvested and the seeds were prepared for the oil analysis.

#### Oil analysis

Oil content: sunflower's seeds were milled with a small mill (Kyoritsu Rikoh Co. Ltd. Tokyo, Japan). Then the oil was extracted from the seed powder with Sox-tech (Tecator Inc., Sweden). The oil content in percentage was calculated from the oil weight and the dried seed powder weight.

Fatty acids composition: Each 0.2 g of seed powder, placed in a 10 mL glass tube with screw cap, was esterified by 2 mL of 5% acetyl chloride in dehydrated methanol at 95 °C for 2 h. Hexane was poured into the tube and methyl fatty acids were allocated to hexane from this liquid. The methyl esters in hexane were used for analysis by gas chromatography (GC15A, Shimadzu Co. Ltd. Kyoto, Japan). The separation column used (Unisole 3000/Uniport 500, GL Sciences Inc., Tokyo, Japan) was 3 mm×3000 mm in the fluid N<sub>2</sub> gas at the column temperature of 240 °C. Detection was done by a flame ionization detection (FID) at 250°C. Data processing was performed with an integra-

Table 1. Tested varieties in this experiment.

Variety	Origin	Notes
North Queen*	Hokkaido NARC	Traditional
Hokko No.4	Hokkaido NARC	Traditional
AP 2098	AgriPro Seeds Inc.	Traditional
IS 3011	Interstate Seeds Inc.	Traditional
IS 4049	Interstate Seeds Inc.	Traditional
IS 6039	Interstate Seeds Inc.	Traditional
Hysun 424	Interstate Seeds Inc.	NuSun
Hysun 450	Interstate Seeds Inc.	NuSun
Hysun 511	Interstate Seeds Inc.	NuSun
Hysun 521	Interstate Seeds Inc.	NuSun
Hysun 525	Interstate Seeds Inc.	NuSun
Hysun 530	Interstate Seeds Inc.	NuSun
6150	Pioneer Hi-Bred International Inc.	Traditional
63A21	Pioneer Hi-Bred International Inc.	Traditional
63M02	Pioneer Hi-Bred International Inc.	NuSun
63M52	Pioneer Hi-Bred International Inc.	NuSun
63M80	Pioneer Hi-Bred International Inc.	NuSun
63M91	Pioneer Hi-Bred International Inc.	NuSun

\*: Standard Variety

Table 2. The agronomic traits in varieties (Mean value between 2002 and 2003).

Variety	Days to flowering	Days to maturity	Plant height cm	Yield kg/ha	Kernel weight g/1000	Test weight g/litter	Oil content** %
North Queen (ST)	76	110	171	1834	44.0	353	37.5
Hokko No.4	77	110	166	1571	45.2	341	40.1
AP 2098	79	110	131	1532	47.3	316	45.8
IS 3011	85	120	160	2276	44.1	352	44.1
IS 4049	86	120	141	1493	40.8	291	39.1
IS 6039	79	113	163	2233	37.6	331	43.1
Hysun 424*	95	131	170	2627	41.4	420	46.2
Hysun 450	89	124	154	2077	35.7	371	41.5
Hysun 511*	80	109	101	1319	42.3	304	39.5
Hysun 521	82	110	136	1737	41.6	361	42.7
Hysun 525*	90	123	144	2064	41.6	298	39.5
Hysun 530	85	117	151	1777	38.8	328	39.8
6150	64	99	81	1052	59.4	288	39.2
63A21*	68	98	97	1193	27.0	257	28.4
63M02	77	110	132	1662	38.8	355	44.2
63M52*	83	109	134	1220	46.3	277	35.2
63M80	81	113	113	1904	46.2	340	46.7
63M91	82	117	132	2271	45.2	379	48.6

Sowing time, 8 May in 2002 and 7 May in 2003.

\*: Tested in 2003 only.

\*\*: Dry matter basis.

Table 3. Correlation matrix in tested varieties .

Character	Maturity	Plant height	Diameter of head	Head rot	Head weight	Yield	Oil content	Test weight
Maturity	1.0000							
Plant height	0.7345**	1.0000						
Diameter of head	0.2206	0.1703	1.0000					
Head rot	-0.6348**	-0.5993**	-0.4366	1.0000				
Head weight	0.9099**	0.7193**	0.3388	-0.5976**	1.0000			
Yield	0.8925**	0.7759**	0.2953	-0.6305**	0.9299**	1.0000		
Oil content	0.5426**	0.4244	0.1860	-0.2995	0.4221	0.6432**	1.0000	
Test weight	0.6589**	0.6768**	0.1167	-0.4769*	0.6904**	0.8006**	0.7357**	1.0000

\*, \*\*: Significant at the 5% , 1% levels, respectively.

Table 4. Fatty acid composition in percentage for tested varieties (Mean value between 2002 and 2003).

Variety	Palmitic acid (16:0)	Stearic acid (18:0)	Oleic acid (18:1)	Linoleic acid (18:2)
North Queen(ST)	6.6	4.7	33.3	55.4
Hokko No.4	6.6	4.6	35.3	53.5
AP 2098	6.4	3.1	36.8	53.7
IS 3011	6.7	3.1	24.1	66.0
IS 4049	6.9	5.1	32.2	55.8
IS 6039	5.8	4.6	25.4	64.2
Hysun 424*	4.5	4.0	63.1	28.3
Hysun 450	4.8	5.2	63.3	26.7
Hysun 511*	5.1	3.6	67.0	24.4
Hysun 521	5.2	2.2	59.1	33.5
Hysun 525*	5.4	2.6	60.5	31.5
Hysun 530	5.7	1.5	66.1	26.6
6150	6.3	3.7	32.2	57.8
63A21*	6.0	3.5	44.2	46.4
63M02	4.4	2.7	68.4	24.5
63M52*	5.2	4.1	61.0	29.7
63M80	5.2	0.0	62.4	32.4
63M91	5.6	2.6	49.0	42.8

\* : Tested in 2003 only.

tor (GR4A, Shimadzu Co. Ltd.).

## Results and discussion

### 1. Agronomic traits

Table 2 shows the agronomic characteristics of the tested varieties. All varieties attained maturity before mid-September. They were harvested before winter wheat sowing in Hokkaido. Plant height varied from 81 cm to 171 cm, although two early maturity varieties were 81 cm and 97 cm in height. The highest variety was “North Queen”, which was bred from old genetic resources. Late maturity varieties harvested in September, like IS3011, IS4049, Hysun 424, Hysun 450 and 63M91, had a high yield compared with the

standard variety. Oil content varied from 35.6 to 48.6 %.

Table 3 shows the correlation matrix in agronomic characters. Both yield and oil content were related with days to maturity and plant height. As a result, oil yield also showed a correlation with both traits. These results coincided with the past data of cultivated sunflower (Kimura 1984).

### 2. Fatty acid composition

Table 4 shows fatty acid compositions in these varieties. In general, traditional varieties showed a high linoleic and low oleic acid composition. By contrast, the NuSun varieties showed a mid-oleic and low

linoleic acid composition. Linoleic acid composition is increased by cool temperatures at the maturity, therefore the high linoleic varieties are expected to show their performance in Hokkaido's climate.

The NuSun varieties showed a mid-oleic acid composition in Hokkaido, which means that the mid-oleic acid performance was unaffected by cool conditions. This experiment was conducted only in Hokkaido and not in the warmer Honshu area. Thus, the characteristics fatty acid composition of effected by warm conditions, making high oleic acid and low linoleic acid (Nagao et al., 1985, Ogihara et al., 1987). Thus, the characteristic fatty acids composition of the NuSun varieties is expected to be more evident in Honshu.

Sunflower is used as a local product in some agricultural areas in Japan (Kaneko 1992). Not only in Hokkaido, but also in Honshu area, traditional varieties are still cultivated. The local product of sunflower oilis, therefore, mainly the high linoleic type. Owing to the link between linoleic acid and various life-style related diseases (Okuyama et al., 2002), an immediate change from the traditional varieties to NuSun is needed, in order to provide safe food in Japan.

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### References

- Arihara, J. et al. 2000. *Soil Sci. Plant Nutr.* 46 : 43-51.  
Ishida, K. et al. 1989. *Agri. and Hort.* 64 : 57-62\*.  
Kaneko, K. 1992. *Hokuno* 59 : 6-22 \*.  
Kimura, M. et al. 1984. *Rep. Hokkaido br., Crop Sci. Soc. Japan* 24 : 56\*.  
Kurokawa, K. 1985. *J. Agr. Sci.* 40 : 292-298\*.  
Nagao, A. et al. 1985. *JAOCS* 60 : 1654-1658.  
National Sunflower Association, 2003. *The Sunflower* 29(6) : 14-15.  
Okuyama, H. et al. 2002. *J. Lipid Nutr.* 11 : 17-46\*.  
Ogihara, H. 1987. *Agri. and Hort.* 62 : 1087-1092\*.  
Ogihara, H. et al. 1987. *NARC Newsletter*, 4 : 13-20\*.  
Sumita, T. 1968. *Hokuno* 45 : 26-47\*.

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\* In Japanese