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An Analysis of Species of Cultivated Millet Collected in Halmahera¹⁾

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Samples of millet, 5 of *Setaria italica* P. Beauv., 3 of *Sorghum bicolor* Moench and 2 of *Coix lacryma-jobi* L. var. *ma-yuen* (Roman.) Stapf. were collected in North Halmahera by Komei Sasaki (see this volume, pp. 141-180). Several characteristics of those samples were subsequently studied and this brief report presents the results of those examinations.

Setaria italica

Five panicle samples of *Setaria italica*, known in Galelan as *bobootene*, were collected from the 4 North Halmahera villages indicated in Table 1. Thirteen other strains were used to make comparisons with those of Halmahera, 6 from Southern Formosa, 3 from the Batan Islands, 1 from Northern Thailand and 3 from Nepal. The characteristics of the strains from Formosa, the Batan Islands and Nepal have been reported elsewhere [SAKAMOTO 1977, 1978].

Fifty grains from each strain were sown in a glasshouse on April 12th, 1977. Then 5 seedlings of each strain were transplanted into the bed on May 13th, with a spacing of 11 cm between plants and 15 cm between rows. They were grown under natural temperature and photoperiodic conditions, and no fertilizer was applied.

Table 1. *Setaria italica* collected in North Halmahera

culture No.	collection locality	original No. of panicles
77178	Ngidiho, Galela Sub-district	2
77179	Loloda, Loloda Sub-district	5
77180	Limau, Galela Sub-district	3
77181	Duma, Galela Sub-district	3
77182	Duma, Galela Sub-district	3

1) Contribution No. 18 from the Plant Germ-plasm Institute, Kyoto University.

Table 2. Characteristics of *Setaria italica* collected in North Halmahera in

culture No.	collection locality	color of seedling	number of tillers	plant height (cm)	length of top internode (cm)	length of flag leaf (cm)	number of leaves
77165	Formosa	green	1.0	144.9	29.1	21.8	20.8
77166	Formosa	green	1.0	144.6	31.3	31.6	17.6
77167	Formosa	red	1.2	152.9	29.5	27.7	20.0
77168	Formosa	red	1.0	184.4	41.7	32.5	19.6
77169	Formosa	red	1.0	143.7	28.6	30.9	19.2
77170	Formosa	green	1.0	184.8	39.9	30.8	19.6
77171	Batan Islands	red	1.0	209.5	29.3	43.0	23.0
77172	Batan Islands	green	1.0	152.4	21.4	40.6	22.6
77173	Batan Islands	green	1.0	174.1	26.0	32.2	17.2
77174	Thailand	green	1.0	217.1	17.5	35.5	30.2
77175	Nepal	green	1.0	203.5	26.7	43.5	23.0
77176	Nepal	green	1.0	193.1	39.4	46.2	21.8
77177	Nepal	green	2.2	191.2	38.4	44.9	20.8
77178	Halmahera	green	1.2	191.1	18.4	41.5	29.5
77179	Halmahera	green	2.2	206.1	23.8	42.0	29.6
77180	Halmahera	green	1.8	215.9	20.5	48.8	30.2
77181	Halmahera	green	1.8	190.3	18.5	43.1	30.2
77182	Halmahera	green	2.0	204.7	11.5	39.6	34.2

Thirteen characteristics of each strain were observed and compared: Anthocyan pigmentation of seedlings, the number of tillers, plant height, length of top internode, length of flag leaf, number of leaves, number of days from sowing to heading, length of panicle, panicle shape, bristles of spikelets, lemma color of sterile and fertile florets, and the starch grain characteristics of the endosperm. The characteristics of each strain are shown in Table 2.

Compared with the strains from Formosa, the Batan Islands, Thailand and Nepal, the five strains from North Halmahera are characterized by the following common features: Green seedlings, tillered plant type, tall stature, very late heading, long-conical shape of panicle with long bristles (Photo. 1) and non-glutinous (non-waxy) endosperm. Among them the lateness of heading is clearly shown in the scatter diagram (Fig. 1), which indicates the relationship between the number of days from sowing to heading and the number of leaves. Correlation of those two characters in *Setaria italica* is highly significant [SAKAMOTO 1978]. All plants of the strain (culture No. 77182) headed very late owing to the cold autumnal weather of Kyoto. The average number of leaves of this strain was 34.1 (Table 2). When this value is plotted on the abscissa in Fig. 2, the average number of days from sowing to heading is about 170, indicating very late heading.

Among the five strains (77178-77182) from North Halmahera, strain 77178, collected at Ngidiho Village, was clearly differentiated from the other 4 by later

comparison with 13 strains from Formosa, Batan Islands, North Thailand and Nepal

number of days from sowing to heading	length of panicle (cm)	panicle shape	bristles of spikelets	lemma color of sterile florets	lemma color of fertile florets	starch grain character of endosperm
91.0	14.1	top-branched	present	yellow	yellow	glutinous
83.4	20.1	conical	present	yellow	yellow	non-glutinous
89.6	15.1	cylindrical	absent	yellow	yellow	glutinous
93.8	20.3	conical	absent	reddish purple	yellow	glutinous
85.0	16.9	top-branched	absent	reddish purple	orange	glutinous
99.3	18.7	conical	absent	yellow	yellow	glutinous
107.0	28.9	conical	present	reddish purple	yellow	non-glutinous
107.8	17.4	conical	present	yellow	yellow	non-glutinous
88.8	22.1	long conical, top-branched	present	yellow	orange	non-glutinous
150.7	22.3	conical	present	yellow	yellow	glutinous
110.6	14.9	conical	absent	greyish white	yellowish white	non-glutinous
103.0	15.5	conical	present	greyish white	yellowish white	non-glutinous
102.5	18.8	conical	absent	greyish white	yellowish white	non-glutinous
161.0	26.2	long conical	present	pale reddish purple	orange	non-glutinous
143.2	26.2	long conical	present	yellow	yellow	non-glutinous
144.0	30.2	long conical	present	yellow	yellow	non-glutinous
142.3	27.0	long conical	present	yellow	yellow	non-glutinous
—	23.1	long conical	absent	yellow	yellow	non-glutinous

heading, a pale reddish-purple lemma of sterile florets and an orange-colored lemma of fertile florets. The 4 strains were morphologically similar, but 77182 had very short bristles (Photo. 1) and, as previously discussed, is a very late variety.

The starch grain characteristics of the endosperm of all strains from North Halmahera was non-glutinous. No glutinous strains were found. In the geographic distribution of *Setaria italica* with glutinous endosperm, an obvious gap was found at the Bashi Channel, between Formosa (including the Lan Yü Islands) and the Batan Islands [SAKAMOTO 1978]. The absence of glutinous strains in Halmahera would indicate no occurrence of glutinous form of this millet in the southern Batan group.

Sorghum bicolor

Three samples of *Sorghum bicolor* were obtained from two villages in North Halmahera (Table 3). Six Japanese strains of this species, 1 from Tanegashima,

Table 3. *Sorghum bicolor* collected in North Halmahera

culture No.	collection locality	Galela name	original No. of panicles
77190	Togawa, Galela Sub-district	<i>jagun timor</i>	1
77191	Togawa, Galela Sub-district	<i>guwapo</i>	2
77192	Loce, Safu Sub-district	—	(threshed grains)

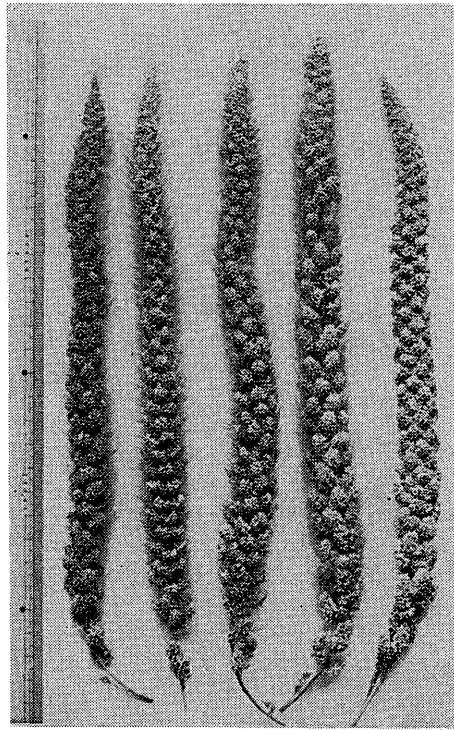


Photo. 1. Panicles of *Setaria italica* collected in North Halmahera.
From left to right: Cult. No. 77178, 77179, 77180, 77181 and 77182.

Kagoshima-ken, 2 from Saihara, Yamanashi-ken, 1 from Nishiyoshino-mura, 2 from Ooto-son, Nara-ken and 1 from Kosuge-mura, Yamanashi-ken, were also used for comparison.

Five grains of each strain were sown directly into a bed in a glasshouse on June 21st, using the same spacing and under the same environmental conditions as for *Setaria italica*.

As listed in Table 4, the number of tillers, plant height, length of top internode, length of flag leaf, number of leaves, number of days from sowing to heading, length of panicle, panicle shape, lemma and grain color, and the starch grain characteristics of the endosperm were observed. Compared with the Japanese strains, the 3 North Halmahera strains were clearly characterized by non-tillered plant type and very late heading. The correlation between the number of days from sowing to heading and the number of leaves is shown in Fig. 2. The heading date of North Halmahera strains was about 30 days later than that of the Japanese strains.

Of the 3 strains from North Halmahera, the first (77190) was characterized by tall stature, very late heading, compact panicle shape (Fig. 2), yellow lemma, brown grain and non-glutinous starch grain of the endosperm. Based on the classification of spikelet types by Harlan and de Wet [1972], this strain was identified as a *Kafir-Durra* type (Photo. 2). Judging from the spikelet type, panicle shape and the Galela

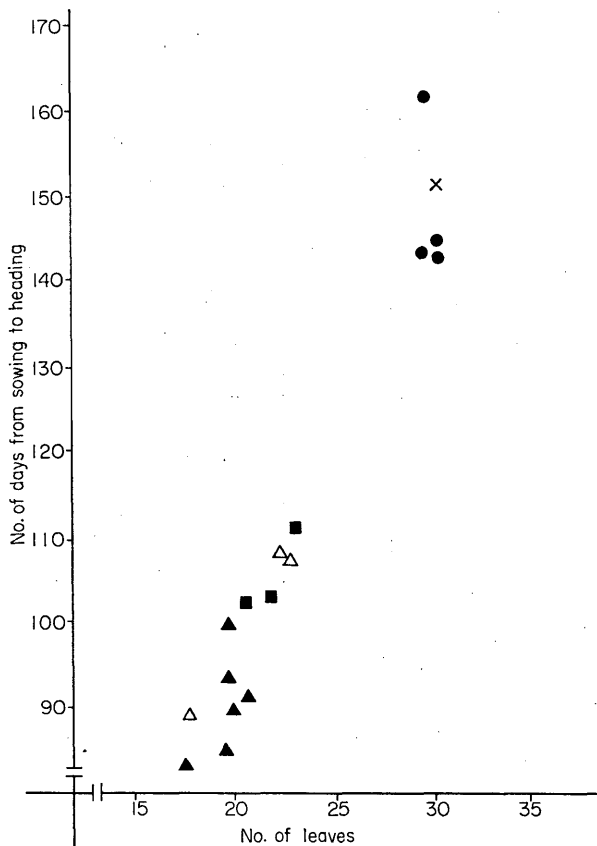


Fig. 1. Correlation between the number of days from sowing to heading and the number of leaves in *Setaria italica*.

- : North Halmahera; ▲ : Formosa;
 △ : The Batan Islands; × : Thailand;
 ■ : Nepal

name (*jagun timor*), it appears certain that this strain was introduced relatively recently to North Halmahera. The second strain (77191) is characterized by medium plant height, late heading, spreading panicle shape (Photo. 2), blackish brown lemma, grains entirely enclosed by lemmas even when mature, and a yellowish grey grain and glutinous endosperm. Based on Harlan and de Wet [1972], this strain was identified as a *Bicolor* type of spikelet. It is particularly noteworthy that the characteristics of this strain are evidently consistent with the botanical descriptions of *Sorghum splendidum* (Hack.) Snowden var. *magnum* Snowden Form 1, which was found in the Philippines [SNOWDEN 1936]. A very important characteristic of this strain is the glutinous starch grain of the endosperm. Kempton [1921] reported that a single panicle of *Andropogon sorghum* var. *negrosense* from Talim Island, Laguna del Bay, Laguna Province, Philippines, had waxy seeds only. According to Snowden [1936],

Table 4. Characteristics of *Sorghum bicolor* collected in

culture No.	collection locality	number of tillers	plant height (cm)	length of top internode (cm)	length of flag leaf (cm)	number of leaves
77183	Tanegashima, Kagoshima-ken	1.5	203.0	49.5	41.0	11.0
77184	Saihara, Yamanashi-ken	4.8	257.6	70.4	70.8	9.4
77185	Saihara, Yamanashi-ken	3.8	254.8	58.4	65.6	9.2
77186	Nishiyoshino-mura, Nara-ken	3.6	224.2	66.8	61.0	8.0
77187	Ooto-son, Nara-ken	1.6	188.4	47.6	29.0	11.2
77188	Ooto-son, Nara-ken	1.7	237.0	61.0	34.0	9.7
77189	Kosuge-mura, Yamanashi-ken	2.8	214.8	57.4	40.0	9.6
77190	Togawa, North Halmahera	1.0	306.8	35.2	24.8	15.8
77191	Togawa, North Halmahera	1.0	218.4	48.2	27.8	12.4
77192	Loce, North Halmahera	1.0	314.0	20.3	20.5	20.0

* Based on Harlan and de Wet [1972]: type 2 (spreading) – 7 (compact).

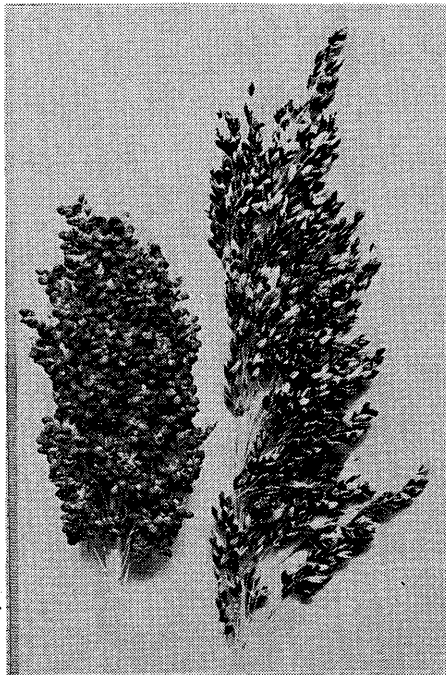


Photo. 2. Panicles of *Sorghum bicolor* collected in North Halmahera. left: 77190; right: 77191.

North Halmahera in comparison with six Japanese strains

number of days from sowing to heading	length of panicle (cm)	panicle shape*	lemma color	grain color	starch grain character of endosperm
152.0	15.5	5	brown	brown	glutinous
135.2	32.8	3	black	brown	glutinous
137.6	32.4	4	black	brown	glutinous
130.8	25.6	3	pale brown	brown	glutinous
147.0	16.0	4	yellow	brown	glutinous
144.7	20.7	4	yellow-pale brown	brown	glutinous
139.2	25.2	3	brown	brown	glutinous
192.0	14.6	6	yellow	brown	non-glutinous
186.0	26.8	2	blackish brown-purplish brown	yellowish grey	glutinous
—	21.3	6?	—	—	non-glutinous

the scientific name of this plant is a synonym of *Sorghum splendidum*. This would indicate that Snowden's *Sorghum splendidum* var. *magnum* Form 1, which has a glutinous (waxy) endosperm, is found in the Philippine Islands and at least in Halmahera as well. It is assumed that this strain, called *guwapo* in Galela, is a morphologically primitive land form introduced to North Halmahera in the fairly distant past. The third strain (77192) grew very vigorously under experimental conditions, but did not head normally prior to the onset of autumn. The average number of leaves was 20.0 (Table 4). If this value is located on abscissa in Fig. 3, the average number of days from sowing to heading of this strain can be extrapolated to about 200. Since this strain failed to produce normal panicles, owing to very late heading, classification of panicle shape and spikelet type could not be made.

Coix lacryma-jobi var. *ma-yuen*

Two grain samples of *Coix lacryma-jobi* var. *ma-yuen* were collected at Laloga Village (culture no. 77511) and Duma Village (77512), in Galela Sub-district, North Halmahera. The Galela name of the former is *rore*.

For comparison with those 2 strains, 2 strains of wild *C. lacryma-jobi* var. *lacryma-jobi*, one (76502) from Tokyo and the other (76504) from Misima, Shizuoka-ken, together with a strain (76505) of cultivated *C. lacryma-jobi* var. *ma-yuen*, obtained from the Toyama Prefectural Agricultural Station, were used.

Grains from each strain were sown in a glasshouse on April 20th, and the seedlings were transplanted to pots ($1/5 \times 10^3$ a) kept under glasshouse. The fertilizer Kasei

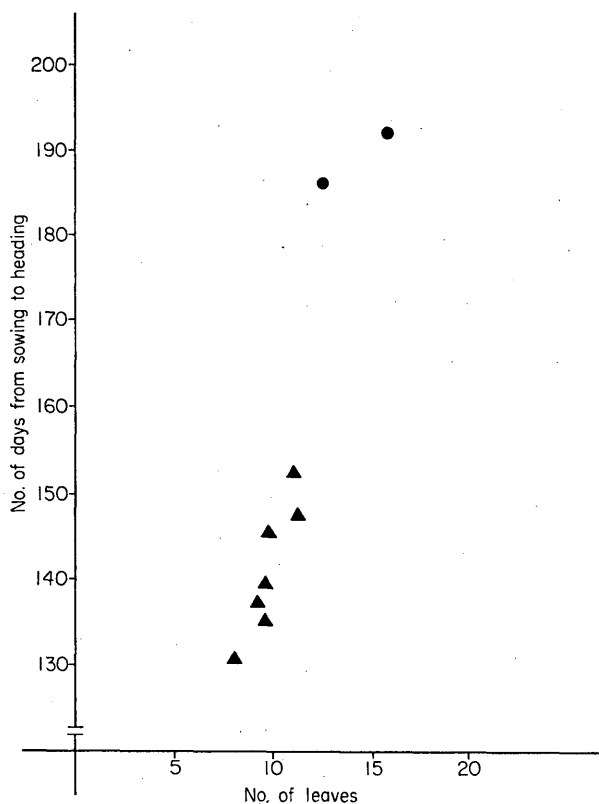


Fig. 2. Correlation between the number of days from sowing to heading and the number of leaves in *Sorghum bicolor*.

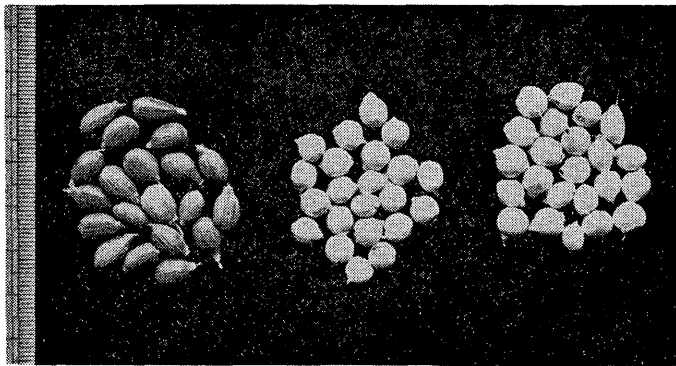
● : North Halmahera, ▲ : Japan

No. 7 (N: P₂O₅: K₂O=8:8:5) was supplied at a rate of 15 gm/pot. After September 15th, the two Halmahera strains were transferred to a greenhouse for further observation. As shown in Table 5, color of the coleoptile, number of tillers, number of nodes at heading time, plant height, length of flag leaf, number of days from sowing to heading, length of male inflorescence and lemma, color of stigma, number of spikelets per male inflorescence, length and width of involucre, color and texture of involucre, and starch grain characteristics of the endosperm were examined.

The three cultivated strains of var. *ma-yuen* were clearly distinguishable from the two wild strains of var. *lacryma-jobi* by the following characteristics: Red coleoptile, larger plant height, shorter flag leaf, smaller involucre size, soft and striate involucre, and glutinous endosperm. The two Halmahera strains of var. *ma-yuen* were very similar in many characteristics (Table 5) and were differentiated from the Japanese strain by a tallness in stature with many nodes, very late heading, red stigma, and white and round involucre (Photo. 3). Pollen fertility of vars. *lacryma-jobi* and *ma-yuen* from Japan was more than 90%, whereas that of the 2 strains of var.

Table 5. Characteristics of *Coix lacryma-jobi* var. *ma-yuen* collected in North Halmahera in comparison with two strains of var. *lacryma-jobi* and a strain of var. *ma-yuen* from Japan

culture No.	76502	76504	76505	77511	77512
collection locality	Tokyo	Misima, Shizuoka-ken	Toyama Pref. Agr. Sta.	Laloga, North Halmahera	Duma, North Halmahera
variety	<i>lacryma-jobi</i>	<i>lacryma-jobi</i>	<i>ma-yuen</i>	<i>ma-yuen</i>	<i>ma-yuen</i>
color of coleoptile	green	green	red	red	red
number of tillers	14.8	25.7	14.0	5.5	5.4
number of nodes at heading stage	15.0	17.2	16.2	26.5	26.3
plant height (cm)	78.2	81.5	108.7	188.7	193.5
length of flag leaf (cm)	13.2	10.5	6.4	6.0	6.7
number of days from sowing to heading	115.7	124.5	112.8	247.3	238.6
length of male inflorescence (mm)	20.7	24.8	17.5	22.0	22.8
number of spikelets per male inflorescence	12.2	14.7	11.2	15.4	14.3
length of the largest lemma (mm)	7.4	7.4	7.1	7.1	7.8
color of stigma	white	white	white	red	red
texture of involucre	hard, not striate	hard, not striate	soft, striate	soft, striate	soft, striate
color of involucre	brown	light brown	light brown	white	white
length of involucre (mm)	10.0	9.2	8.8	7.9	8.8
width of involucre (mm)	8.3	6.6	5.8	6.6	7.2
starch grain character of endosperm	non-glutinous	non-glutinous	glutinous	glutinous	glutinous

**Photo. 3.** Grains of *Coix lacryma-jobi* var. *ma-yuen*. left: 76505; middle: 77511; right: 77512.

ma-yuen from North-Halmahera was very low, at 0% and 37%, respectively. This resulted mainly from extremely late heading, which occurred in mid-December at very low temperatures, even in the greenhouse. The very low pollen fertility of those strains finally resulted in almost no seed setting.

The starch grain of the endosperm in the 3 strains of var. *ma-yuen* was glutinous. This accords with the view that the endosperm characteristic of var. *ma-yuen* is generally glutinous (waxy), although a non-glutinous type and a glutinous type were reported by Kempton [1921] in the collections from Burma and the Philippines. One of the most interesting findings from the *Coix* materials examined during the present study is that *C. lacryma-jobi* var. *ma-yuen* is evidently a perennial rather than an annual plant. This finding is in contrast with the diagnostic description by many floristic workers of this variety as an annual plant [e.g. MAKINO 1948]. The clones of var. *ma-yuen*, both those from Halmahera and those from Japan, used in this experiment have been maintained vegetatively in an unheated glasshouse for the past 3 years.

Setaria italica, *Sorghum bicolor* and *Coix lacryma-jobi* var. *ma-yuen* are cultivated sporadically in North Halmahera by local farmers at the margin of the cultivated lands (see Sasaki, this volume p. 161). They are sown either in February-March or in June-July, and harvested either in May-June or in September-October. Although not important food staples, they still play a significant role in Galela ritual life or in festivals. The finding, for example, of a morphologically primitive land form of *Sorghum bicolor*, such as culture No. 77191 (*guwapo* in Galela), suggests an ancient introduction and the long history of millet cultivation in Halmahera.

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