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A New Registered Cultivar "Natsuyutaka" of Guineagrass, *Panicum maximum* Jacq.

Hiroyasu SATO*1, Norihiko SHIMIZU*2, Hitoshi NAKAGAWA*3 and Hidemichi MATSUOKA*4

*1-3 Department of Grassland, Kyushu National Agricultural Experiment Station (Nishigoshi, Kikuchu, Kumamoto, 861-11 Japan)

*4 Research Team of Plant Classification and Evaluation, National Institute of Agrobiological Resources (Miyazaki, 880 Japan)

Abstract

A new guineagrass cultivar "Natsuyutaka" was released in Japan in 1988 by the Kyushu National Agricultural Experiment Station. Natsuyutaka originated from the seeds of a local ecotype of guineagrass collected in east Africa. Natsuyutaka is perennial tetraploid having a habit lf growing semi-erect. It is a medium-late maturing cultivar, i.e. 20-30 days longer than cultivar Gatton. Its plant height is slightly taller than Gatton and Petrie green panic. Its reproduction is completely based on apomixis. The growth in the early stage is not as fast as Natsukaze, being the same as Gatton and Petrie. Regrowth after cutting is however excellent. The field tests show that Natsuyutaka is much higher than Natsukaze, Gatton and Petrie in annual yield under a perennial condition. The quality as a feeding stuff, such as protein and digestability, is similar of slightly lower than that of Gatton and Petrie. It grows well under a soil condition of pH 4.8 to 6.7, but not under alkaline soils. Natsuyutaka is expected to be widely grown to grasslands as a perennial grass in the sub-tropics of Japan. It is suited for soilage and grazing as well.

Discipline: Grassland
Additional key words: apomixis, guineagrass cultivars, nutritional values, tolerance to trampling

Introduction

Guineagrass, *Panicum maximum* Jacq., is a native crop in central and southern Africa. It has recently been used in various parts of the tropics in the world. In Japan, green panic, *Panicum maximum* var. *trichoglum*, was introduced to the southern part of Kyushu as a summer annual forage grass in early 1960s. In 1985, the first guineagrass cultivar Natsukaze was released in Japan at the Kyushu National Agricultural Experiment Station. It has a tall statue, and a vigorously growing and high yielding abilities. It was introduced to arable lands in the warm regions of Japan as a summer annual grass.

In 1988, a new cultivar named Natsuyutaka was released at the above Station for the purpose of cultivation on grasslands in the non-frost regions of Japan in general, and Nansei Islands and Okinawa in particular. It is highly suited to these areas as a perennial crop with high persistency for soilage and grazing. Natsuyutaka was registered by the Ministry of Agriculture, Forestry and Fisheries in 1988. It was also registered in 1990 as a variety under

Present address:
*2 Department of Forage Production and Utilization, National Grassland Research Institute (Nishinasuno, Tochigi, 329-27 Japan)
*3 Okinawa Branch, Tropical Agriculture Research Center (Ishigaki, Okinawa, 907 Japan)

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Outlines of breeding procedures

1) Origin, materials and breeding procedures

In 1980, 760 plants from 38 strains were planted with 1 × 1 m spacing in the field of Kyushu National Agricultural Experiment Station, Japan. Those 38 strains consisted of 8 strains received from United States and Japan Conference on Natural Resources Development Seed Panel (UJNR) and 30 strains received from USA and Colombia. One strain contained 20 plants. Two plants having the heaviest plant weight were selected from each strain and their seeds were separately collected from each of those selected plants. Based on the results of the performance trial in 1981, 8 strains were selected.

In 1981, 380 plants of 19 strains of the local guineagrass collected in Africa under the support of Tropical Agriculture Research Center were newly planted, from which materials 6 strains with the highest yield were selected for further tests.

Since 1982, yield performance tests of these 14 strains had been conducted for 6 years in two places: Kyushu National Agricultural Experiment Station and Okinawa Prefectural Animal Husbandry Experiment Station. In addition, adaptation trials were undertaken at other 5 locations for 3 years. Cultivar Natsuyutaka, earlier named Kyushu No. 5, was selected for its highest yield potential and persistency among the materials tested. Natsuyutaka originated from one of the local ecotypes of guineagrass collected in Africa.

2) Reproduction mechanism

It is well known that guineagrass is reproduced through apomixis. To confirm if the reproduction mechanism of Natsuyutaka is apomictic, an embryo-sac analysis method was employed. This method was very effective for identifying the mode of reproduction of guineagrass.

Since Natsuyutaka has only 1.6% of sexual reproduction rate, as shown in Table 1, it is concluded that this cultivar is almost completely apomictic. A series of the investigations indicated that colored guineagrass, fall panic grass and GR-297 of guineagrass had a mechanism of completely sexual reproduction. On the other hand, Natsukaze showed 12.9% of sexual reproduction rate, which is likely to give an appearance of sexually reproductive plants.

Yield and other characteristics

1) Morphology

Natsuyutaka is a perennial tetraploid with chromosome number 2n = 32, having a semi-erect growing type under natural conditions. Outlines of agronomic characters are shown in Table 2.

Table 1. Sexual reproduction rates in guineagrass cultivars under the embryo sac analysis

Cultivar/strain	No. of observations	No. of plants classified[1)]				Sexual plants (%)
		S	SA	AS	A	
Guineagrass						
Natsuyutaka	63	1	1	6	55	2
Gatton	43	2	7	5	29	5
Natsukaze	70	9	0	3	58	13
GR-297	206	205	1	0	0	100
Green panic						
Petrie	36	4	0	1	31	11
Colored guineagrass						
Solai	8	8	0	0	0	100
Fall panicum						
Ezu	24	24	0	0	0	100

1): S: Sexual reproduction (8 nuclei), A: Apomictic reproduction (4 or less nuclei), SA: Mixed S and A with dominant S, AS: Mixed S and A with dominant A.
Data obtained at Kyushu Nat. Agr. Exp. Sta. (1985).

Table 2. Major characteristics of guineagrass cultivars grown in Kyushu, Japan

Characteristics[2]	Natsuyutaka			Natsukaze			Petrie[1]			Gatton		
	Mean		SD[4]	Mean		SD	Mean		SD	Mean		SD
Heading date	36.0	a[3]	1.7	21.0	b	0.0	7.7	c	5.5	16.0	b	0.0
Culm length (cm)	201.1	b	1.6	217.2	a	7.5	155.4	d	7.4	164.2	c	5.1
Panicle length (cm)	50.3	a	1.7	38.1	b	0.5	30.2	c	1.5	29.2	c	0.9
Culm diameter (mm)	6.7	a	0.3	6.7	a	0.4	4.8	b	0.1	4.8	b	0.1
No. of stems	24.9	ab	6.2	21.3	b	3.5	34.7	a	5.0	30.4	ab	3.1
No. of panicles	22.6	b	0.9	29.6	b	2.7	69.1	a	5.4	61.2	a	3.1
No. of branches	34.3	bc	1.4	45.9	a	3.7	30.1	c	3.4	38.3	ab	2.0
No. of nodes elongated	8.7	a	0.2	7.7	b	0.2	6.6	c	0.3	6.8	c	0.3
N-1 leaf length (cm)	49.3	a	3.0	51.2	a	4.2	39.1	b	4.8	41.9	b	1.1
N-1 leaf width (cm)	2.1	b	0.0	3.4	a	0.3	2.0	b	0.1	2.0	b	0.1
Hairiness: 0(glabrous)—9(hirsute)												
Node	0.0	b	0.0	1.8	a	1.4	1.4	ab	1.0	0.0	b	0.0
Sheath	0.0	b	0.0	3.0	a	0.0	2.7	a	0.6	0.0	b	0.0
Ligule	1.3	bc	0.6	3.0	a	1.0	2.3	ab	0.6	1.0	c	0.0
Blade	0.0	b	0.0	3.0	a	0.0	0.0	b	0.0	0.0	b	0.0
Plant type	6.3	b	0.6	2.0	c	0.0	7.0	a	0.0	6.0	b	0.0

1): Petrie is a cultivar of Green panic, *Panicum maximum* var. *trichoglum*.
2): Heading date: Days counted from July 1.
Culm diameter: The longest diameter in the 2nd elongated internode above the soil surface.
N-1 leaf: Just under the flag leaf.
Plant type: 1(elect)—9(prostrate).
3): The alphabets a, b and c show significant differences ($p = 0.05$) under the Duncan's multiple range test, if they are different.
4): SD: Standard deviation.
Data obtained at Kyushu Nat. Agr. Exp. Sta. (1985).

Heading time starts in mid August, when it is seeded in mid May, being 15 days later than Natsukaze and 20 days later than Gatton. Natsuyutaka belongs to the middle-late heading group under the growing condition in Kumamoto, located in the southwestern part of Japan.

Plant height at heading time is slightly shorter than Natsukaze, and much taller than Gatton and Petrie green panic. Stem diameter is the same with that of Natsukaze, and larger than Gatton and Petrie. Length of leaf is about 50 cm, which is longer than Gatton and Petrie. Leaf width is medium, being narrower than that of Natsukaze. Leaf hairiness of Natsuyutaka is the same as that of Gatton, which has glabrous stem nodes, leaf sheaths and leaf blades, except ligules. On the other hand, Natsukaze and Petrie have hairy leaf nodes, leaf sheaths and leaf blades.

2) Yield and persistency

Two types of yield performance tests were conducted: one was an annual yield potential test at 5 places, i.e. Kagoshima, Kumamoto, Miyazaki, Kouchi and Aichi for 3 years; the other was a perennial yield potential test in Okinawa Island for 6 years.

As shown in Table 3, the annual yield of Natsuyutaka is superior to that of Gatton and Petrie in all the experimental places: the average annual yield of Natsuyutaka was 14.7 t/ha in dry matter, while it was 12.4 and 11.9 t/ha in Gatton and Petrie, respectively. As compared with Natsukaze that was developed for cultivation in the warm region in Japan as an annual grass, the annual yield of Natsuyutaka was lower than that of Natsukaze by 15% on an average.

In regard to perennial cultivation in Okinawa, the total dry matter yield of Natsuyutaka during the period of 6 years amounted to 198.4 t/ha, which was much higher as compared with 177.6 t/ha of Gatton, and 156.1 t/ha of Petrie. The increment was 12 and 27%, respectively. During the same period, Natsukaze yielded only 118.8 t/ha, which accounted for 60% of the annual yield of Natsuyutaka. Its low yield was caused by poor and no

Table 3. Yearly dry matter yield of Natsuyutaka cultivated as an annual grass in Kyushu and Honshu Islands

Location	Year	Natsuyutaka		Natsukaze		Petrie		Gatton
		t/ha	%[1)]	t/ha	%	t/ha	%	t/ha
Kyushu								
Kagoshima	1983	16.2	130	17.9	144	12.5	100	12.4
	1985	21.4	118	21.1	113	16.5	88	18.7
	1986	14.7	117	15.2	121	12.5	100	12.5
	1987	13.5	109	17.6	142	10.8	87	12.4
	Mean	16.4	118	18.0	130	13.0	94	14.0
Kumamoto	1982	17.8	105	19.3	113	15.4	91	17.0
	1983	19.6	124	22.5	142	16.0	101	15.9
	1985	11.4	85	13.8	103	12.9	97	13.3
	1986	16.2	179	15.9	176	9.3	103	9.0
	1987	15.1	132	14.6	128	10.4	91	11.4
	Mean	16.0	125	17.2	133	12.8	96	13.3
Miyazaki	1983	8.1	122	9.6	144	6.7	100	6.7
Honshu								
Kagawa	1983	12.2	97	16.6	132	12.0	95	12.6
Aichi	1983	10.6	153	13.2	190	8.3	119	6.9
Grand mean		14.7	122	16.4	137	11.9	98	12.4

1): Percentages of the yields of Gatton.

Table 4. Yearly changes of dry matter yields of guineagrass cultivars cultivated as a perennial grass

Cultivar/strain	1982	1983	1984	1985	1986	1987	Total	%
Natsuyutaka	298	437	412	311	240	285	1984	112
Natsukaze	337	303	303	200	44	0	1188	67
Gatton	271	402	362	283	236	222	1776	100
Riversdale	259	376	375	298	225	195	1728	97
Hamil	274	391	334	255	181	175	1610	91
Common A	260	353	371	268	227	171	1649	93
Common J	242	355	332	272	214	138	1554	88
Petrie	251	329	331	263	214	174	1561	88

Data obtained at Okinawa Animal Hus. Res. Sta. (1982–1987).

yields obtained in the fifth and sixth years, respectively. This implies that Natsuyutaka has high persistency. Dry matter yields of the cultivars under testing are shown in Table 4.

3) Cutting frequency

Yield and quality of guineagrass are greatly affected by cutting frequencies. In 1985 and 1986, yield performance tests under varying frequencies of cutting were examined at Kyushu National Agricultural Experiment Station. The results are shown in Table 5.

Cutting frequencies of 3, 4 and 5 times were given during the growing season. Cutting 3 times/season performed the highest yield, which was followed by the decreased yields in accordance with more cutting frequencies. However, contents of nutrient components in general, and crude protein in particular,

Table 5. Dry matter yields and chemical compositions[1] of guineagrass under different cuttig frequencies

(%)

Cutting frequency	Cultivar	Dry matter (t/ha)	CP	OM	OCC	OCW	Oa	Ob	DMD	NO_3-N
3	Natsuyutaka	18.0	14.4	86.9	23.4	63.5	16.8	46.7	47.8	0.13
	Natsukaze	22.8	14.6	86.9	23.9	63.0	19.5	43.6	50.8	0.12
	Gatton	13.9	14.7	86.8	25.2	61.6	17.8	43.9	50.3	0.08
	Petrie	12.9	13.5	87.0	21.3	65.7	18.1	47.6	46.9	0.09
4	Natsuyutaka	13.8	15.5	86.2	20.6	65.6	23.2	42.3	52.0	0.20
	Natsukaze	14.9	—	—	—	—	—	—	—	—
	Gatton	11.2	16.5	86.2	22.9	63.3	24.1	39.3	55.3	0.13
	Petrie	11.1	15.8	87.2	22.3	64.9	22.2	42.8	52.6	0.14
5	Natsuyutaka	13.3	18.5	85.9	25.3	60.6	18.9	41.7	52.7	0.24
	Natsukaze	14.2	19.4	86.0	28.9	57.1	20.4	36.8	58.0	0.31
	Gatton	12.8	19.2	86.6	28.2	58.4	19.4	38.9	55.8	0.22
	Petrie	10.5	18.4	87.3	26.3	61.0	19.5	41.5	54.2	0.24
Mean	Natsuyutaka	15.0	16.0	86.3	23.1	63.2	19.6	43.6	50.8	0.19
	Natsukaze	17.3	(17.0)[2]	(86.5)	(26.4)	(60.1)	(20.0)	(40.2)	(54.4)	(0.22)
	Gatton	12.6	16.8	86.5	25.4	61.1	20.4	40.7	53.8	0.14
	Petrie	11.5	15.9	87.2	23.3	63.9	19.9	44.0	51.2	0.16

1): CP: Crude protein, OM: Organic matter, OCC: Organic cellular content, OCW: Organic cell wall, Oa: Organic matter digested by cellulase in OCW, Ob: Residual organic matter after cellulase digestion in OCW, DMD: Dry matter digestability.
2): Values in parentheses indicate means of the 3rd and 5th cuttings.
Data obtained at Kyushu Nat. Agr. Exp. Sta. (1990).

Table 6. Effects of trampling on number of tillers and yield

Cultivar		No. of tillers ($/m^2$)				Dry matter yield (t/ha)			
		Jul.11	Aug.6	Sep.10	Oct.24	Jul.11	Aug.6	Sep.10	Oct.24
Natsuyutaka	Cont.[1]	325	558	428	528	2.9	6.5	8.6	3.9
	Tra.	318	337	265	297	3.2	4.5	7.2	0.7
Natsukaze	Cont.	275	295	258	270	5.6	6.8	9.8	4.3
	Tra.	253	165	147	17	5.4	2.7	5.7	0.0
Petrie	Cont.	380	437	297	523	3.5	4.2	5.0	2.3
	Tra.	347	253	200	393	4.0	2.4	4.1	0.3
Gatton	Cont.	360	530	462	705	3.8	5.4	6.4	4.6
	Tra.	410	447	287	575	3.8	3.4	5.8	1.8
KU-9486	Cont.	285	305	258	128	5.2	4.4	6.6	1.8
	Tra.	227	63	87	0	5.5	0.5	2.3	0.0

1): Cont.: Control, Tra.: Trampling with a tractor.
Data obtained at Kyushu Nat. Agr. Exp. Sta. (1990).

increased with an increased cutting frequency. No interactions were observed between the yields and qualities of the cultivars and the cutting frequencies.

4) Regrowth after trampling and mechanical harvesting

To compare varietal differences in tolerance to trampling pressure, an examination was conducted

Table 7. Nutritional values of guineagrass cultivars

(%)[1]

Cutting date	Cultivar	CP[2]		CFa		NFE		CFi		CA	
		Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
Apr. 18	Natsuyutaka	11.4	5.2	2.7	1.4	47.5	45.1	30.4	39.0	8.0	9.4
	Natsukaze	12.3	5.7	2.9	1.5	49.9	50.5	27.9	36.1	7.0	6.2
	Petrie	9.7	4.1	2.7	1.3	49.8	48.0	29.6	38.8	8.2	7.8
	Gatton	10.4	4.1	3.0	1.2	48.8	46.0	29.4	39.8	8.4	8.9
Jun. 3	Natsuyutaka	11.5	5.1	2.6	1.1	43.9	41.6	33.3	41.9	8.7	10.4
	Natsukaze	10.1	4.4	3.4	1.2	46.9	43.2	30.4	40.0	9.1	11.3
	Petrie	12.6	4.3	3.1	1.1	44.0	40.1	31.4	44.2	8.9	10.4
	Gatton	13.1	5.8	3.4	1.1	42.7	40.7	30.9	43.1	9.9	9.3
Jul. 10	Natsuyutaka	13.8	5.5	3.1	1.5	42.0	38.8	32.7	43.6	8.4	10.7
	Natsukaze	14.1	7.4	4.1	1.6	41.7	38.9	31.4	41.1	9.1	11.0
	Petrie	14.7	5.5	3.8	1.6	41.8	40.4	31.6	43.4	8.2	9.2
	Gatton	15.0	6.3	3.9	1.4	41.6	39.1	30.8	44.5	8.8	8.6
Sep. 5	Natsuyutaka	14.9	4.7	2.7	1.1	41.5	41.4	33.9	45.3	7.1	7.6
	Natsukaze	13.1	6.2	3.6	1.4	43.2	40.9	32.4	43.1	7.7	8.4
	Petrie	13.3	5.7	3.2	1.3	45.0	42.7	31.8	43.4	6.7	6.9
	Gatton	14.0	5.6	3.1	1.2	43.2	40.9	31.8	45.4	7.8	6.9
Oct. 31	Natsuyutaka	13.9	4.5	2.8	1.2	43.1	42.5	31.2	43.7	9.1	8.1
	Natsukaze	12.6	4.1	3.5	1.4	45.1	49.5	29.2	38.2	9.5	6.9
	Petrie	13.8	3.9	3.4	1.4	45.5	43.1	28.4	44.1	8.9	7.5
	Gatton	16.7	4.6	3.7	1.5	40.6	42.4	28.4	46.6	10.6	7.9
Mean	Natsuyutaka	8.4		1.9		42.7		38.2		8.7	
	Natsukaze	7.7		2.1		45.2		36.6		8.4	
	Petrie	7.1		1.9		43.6		39.2		8.3	
	Gatton	8.4		2.1		42.5		38.5		8.6	

1): Measurements are on a dry matter basis.
2): CP: Crude protein, CFa: Crude fat, NFE: Nitrogen free extract, CFi: Crude fiber, CA: Crude ash. Data obtained at Okinawa Animal Hus. Res. Sta. (1987).

using a small tractor. The stubles just after each cutting were run over repeatedly by a tractor 2 or 3 times a day for 3 days. The results are shown in Table 6.

Natsukaze and KU-9486, both of which are of a tall, erect type with few tillers, had low tolerance to trampling. After the second cutting, tiller development and regrowth were greatly depressed, resulting in significant decrease in yield of these cultivars, while Natsuyutaka maintained a large number of tillers and yields after each cutting. Gatton showed the same level of trampling tolerance with Natsuyutaka.

5) Nutritive value

Chemical compositions were compared among Natsuyutaka and other major culivars grown at Okinawa Animal Husbandry Research Station and National Grassland Research Station in Tochigi.

Table 7 shows main nutrient components in leaves and stems of Natsuyutaka, Gatton, Petrie and Natsukaze at each cutting in Okinawa. At each of the 5 cuttings, crude protein contents of Natsuyutaka were the same with those of the other cultivars, though slightly lower in leaves in the second and third cuttings. Crude fat contents in Natsuyutaka were slightly lower than those of the other cultivars at each cutting. Natsuyutaka contained abandant crude fiber.

The nutrient components in the material of Ishigaki, as shown in Table 8, have the same tendency as the Okinawa material. Crude protein contents in Natsuyutaka were slightly lower than those

Table 8. Cellulase hydrolysis, digestability and ADF of the cultivars[1)]

Cultivar	Cutting date	CP (%)	Cellulase hydrolysis[2)] (%)	Dry matter digestability[3)] (%)	ADF[4)] (%)	Digestable dry matter yield (kg/a)
Natsuyutaka	Jun. 26	9.6	28.8	60.1	43.0	40.7
	Aug. 5	8.2	28.5	59.2	42.4	66.7
	Sep. 24	7.9	24.2	54.3	43.8	33.1
	Mean	8.6	27.2	57.9	43.1	46.8
Natsukaze	Jun. 26	10.9	32.1	63.3	39.7	32.0
	Aug. 5	9.5	31.7	62.8	39.9	47.4
	Sep. 24	8.2	24.0	54.1	45.7	15.1
	Mean	9.5	29.3	60.1	41.8	31.5
Petrie	Jun. 26	10.4	30.7	61.7	42.1	28.7
	Aug. 5	10.3	28.3	59.0	41.4	30.8
	Sep. 24	7.5	22.9	52.9	45.2	18.3
	Mean	9.4	27.3	57.9	42.9	25.9
Gatton	Jun. 26	10.8	28.9	59.7	44.8	42.6
	Aug. 5	11.2	29.2	60.0	41.1	51.8
	Sep. 24	7.8	25.7	56.0	41.6	31.5
	Mean	9.9	27.9	58.6	42.5	42.0

1): Samples were collected from the 2nd year crop (1986) at Ishigaki.
2): Cellulase hydrolysis: Rate of the cell wall constituent, solubled with 0.2% cellulase (40°C, 17.5 hr).
3): Digestability: Estimated values from *in vivo* dry matter digestability.
4): ADF: Acid detergent fiber.
Data obtained at National Grassland Res. Inst. (1987).

Table 9. Effects of soil pH values on the early growth of guineagrass[1)]

(g D.W./3 plants)

Cultivar	Texture	Fine				Fine		Coarse
	Soil type	Red soils				Red soils		Dark red soils
	Series	Nakagawa				Gushiken	Tarama	Maezato
	pH	4.7	5.3	7.1	7.8	4.3	6.7	8.0
Natsuyutaka		14.5	21.1	16.9	8.9	25.1	22.3	14.9
Natsukaze		16.6	19.2	15.2	9.1	19.2	19.6	16.6
Petrie		18.0	20.1	14.2	2.1	20.5	18.3	16.5
Gatton		19.8	20.1	16.4	8.0	27.4	20.4	16.7
Mean		17.2	20.1	15.7	7.0	23.1	20.2	16.2

1): Dry weight in 45 days after sowing.
Data obtained Okinawa Animal Hus. Res. Sta. (1987).

in Gatton and Petrie. There was a similar pattern of dry matter digestibility among the cultivars tested.

6) Influence of soil pH on the growth of Natsuyutaka

In Nansei Islands and Okinawa, there are several soil types with varying pH values. To determine the yield stability of Natsuyutaka under the different soil types, a pot trial was undertaken using soil samples collected from 4 locations: i.e. Nakagawa and

Tarama series both distributed in the northern part of Okinawa mainland, and Gushiken and Maezato series both distributed in Ishigaki. The original soil pH of the Nakagawa series was 4.7. For comparison with other soils, however, it was adjusted to higher pH values using sodium hydroxide. The responses of early growth of the cultivars tested are shown in Table 9. Growth patterns of the three cultivars, i.e. Natsuyutaka, Natsukaze and Gatton, were the same in each soil condition. In the Nakagawa series, the best growth was observed under pH 5.3, followed by pH 4.7 of the original soil and pH 7.8 in this order. Among the other 3 types of soils, i.e. Gushiken, Tarama and Maezato, growth in the Maezato series having pH 8.0 was the lowest. From these results, it is concluded that the growth of guineagrass is better in acid soils than in alkaline soils. No varietal difference was observed with an exception of Petrie, growth of which was slightly lower in the adjusted soil of pH 7.8.

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