High Analysis Compound Fertilizers in Japan

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There is no clearcut definition of high analysis compound fertilizer, but it is roughly defined as "granular fertilizer containing more than 30 percent in total of at least two of the three nutrients nitrogen, phosphate, and potassium." "A granule" is usually 2-4 mm in diameter on an average but it is getting bigger.

Most of the high analysis compound fertilizers, however, contain all three plant nutrients; nitrogen, phosphate and potassium. But NP compound fertilizers that have recently occupied the largest part of fertilizer exports from Japan consist of only N and P at the ratio such as 16-20-0, while NK compound fertilizers that have recently been expanding rapidly their domestic consumption for top dressing contain only N and K at the ratio such as 17-0-17 or 18-0-16. PK compound fertilizers are also available. However, most of the high analysis compound fertilizers produced in Japan are occupied by those containing all three nutrients, in which phosphate is mainly in the form of ammonium phosphates, N in the form of urea, ammonium sulphate, ammonium chloride, and or ammonium nitrate and K in the form of potassium chloride and or potassium sulphate.

Production and consumption of High Analysis Compound Fertilizers

In 1964 fertilizer year, 22 fertilizer companies produced 1,390,000 metric tons of high analysis compound fertilizers in total which were divided into about 190 brands. They are the most rapidly developing forms of fertilizer in Japan and their production and domestic consumption are shown in comparison with other fertilizers in Table 1.

Various analysis made on the reasons of the rapid expansion in domestic consumption of this high analysis compound fertilizers are summarized below:

(1) Decrease in population engaged in ag-

Table 1. Supply and Consumption of Nitrogenous Fertilizers and High Analysis Compound Fertilizers, 1956/57～1965/66. (1,000 metric tons of N)

	Fertilizer year	1956 /57	1957 /58	1958 /59	1959 /60	1960 /61	1961 /62	1962 /63	1963 /64	1964 /65	1965 /66
Production	Total Nitrogenous Fertilizers	781	886	994	929	1065	1125	1175	1307	1393	1625
	H.A.C. Fertilizers **	23	30	37	45	66	96	121	167	198	228
	%	3.0	3.4	3.7	4.8	6.2	8.5	10.3	12.8	14.2	14.0
Domestic Consumption	Total N Fertilizers	590	592	613	681	693	*633	*660	*688	*668	*689
	H.A.C. Fertilizers	21	25	29	39	53	80	110	142	167	206
	%	3.6	4.2	4.7	5.7	7.6	12.3	16.4	20.5	25.0	29.9
Export	Total N Fertilizers	192	248	298	335	297	411	521	583	634	844
	H.A.C. Fertilizers	0	4	4	7	5	12	10	16	17	26
	%	0	1.6	1.3	2.1	1.7	2.4	1.9	2.7	2.7	3.1

* Figures exclusive of the demand from industrial and feed production.
** High analysis compound fertilizers.

riculture

(2) Advanced labor saving in crop growing as a result of increasing part time farming

(3) Availability of fertilizers with components balanced so as best suited to each crop

(4) High expectation for stable production of crops from fertilization

(5) Easy handling and transportation of fertilizers which are not bulky because of their high analysis

Responding to the changing situation of domestic demand for fertilizers, the producers have pointed out various merits of high analysis compound fertilizers other than those of the industrial rationalization, such as to reduce transportation and marketing costs, to increase carloadings (in the case of transport of 16-20-0 fertilizer, for instance, it is equivalent to a transport of 20 percent superphosphate together with the same amount of 16 percent ammonium sulphate), and to save warehouse space. Thus, they have switched their production from ammonium sulphate and superphosphate to urea and high analysis compound fertilizers to which special importance has recently been attached.

The production capacity for high analysis compound fertilizers has notably expanded in recent years in Japan and amounted to about 2,000,000 metric tons in terms of plant food contents as of April 1, 1965.

There are numerous brands representing different grades of these three plant nutrients, and it seems that no more differentia-

Table 2. Production and Exports of High Analysis Compound Fertilizer, by Brand, in 1964/65

No.	Grades $N-P_2O_5-K_2O$	Production (m/t)	Percent	Exports Order of majority	Exports Quantity (m/t)
1	14—14—14	153,792	11.1	(3)	10,840
2	16—16—16	93,979	6.8	(6)	700
3	14—10—13	91,832	6.6		
4	13—17—12	75,271	5.4		
5	16—20—0	75,197	5.4	(1)	78,978
6	13—13—13	64,794	4.7	(8)	441
7	15—15—10	52,532	3.8	(9)	100
8	11—11—11	45,711	3.3		
9	14—12—9	40,409	2.9		
10	14—17—13	38,915	2.8		
11	12—18—14	35,654	2.6		
12	10—20—20	31,093	2.2		
13	17—8—7	28,588	2.1	(5)	2,077
14	15—15—12	26,599	1.9	(4)	2,500
15	16—10—14	19,934	1.4		
16	12—16—14	19,630	1.4		
17	17—17—17	18,576	1.3		
18	15—15—15	17,956	1.3		
19	18—18—18	17,813	1.3		
20	13—10—11	17,751	1.3	(7)	500
21	18—22—0	16,664	1.2	(2)	11,302
22	18—11—11	16,604	1.2		
	Others	387,953	28.0		6,506
	Total	1,387,240	100.0		113,944

(Average analysis: 14.3—15.3—12.4)

tion in grades is necessary. Table 2 shows production and export of leading grades of high analysis compound fertilizers in 1964.

Kinds of High Analysis Compound Fertilizers

There are not only many kinds of high analysis compound fertilizers but also numerous classifications applied to them. As aforementioned, however, most of the high analysis compound fertilizers are based on ammonium phosphates, to which nitrogen and or potassium is usually added as a raw material.

The manufacturing methods and brands of products vary according to these materials and the ways of their addition. There are also many different manufacturing methods of ammonium phosphates themselves.

These materials are combined to make different kinds of high analysis compound fertilizers.

There are 6 kinds as listed below according to a classification based on different manufacturing methods:

(1) High analysis compound fertilizer of ammonium phosphate sulphate origin
(2) High analysis compound fertilizer of urea ammonium phosphate sulphate origin
(3) High analysis compound fertilizer of urea ammonium phosphate origin
(4) High analysis compound fertilizer of ammonium phosphate chloride origin
(5) High analysis compound fertilizer based on nitric phosphate
(6) High analysis compound fertilizer of magnesium ammonium phosphate origin

Main raw materials for them are shown in Table 3.

There are two types of ammonium phosphates contained in fertilizers as explained below. Both of the types usually exist in any high analysis compound fertilizer of ammonium phosphate origin.

	N(%)	P_2O_5(%)	$N:P_2O_5$
Monoammonium phosphate (MAP) $NH_4H_2PO_4$	12.2	61.7	1:5
Diammonium phosphate (DAP) $(NH_4)_2HPO_4$	21.2	53.8	1:2.5

When these two types of ammonium phosphates are separately applied to the soil, their crop responses are different but when they are used as integrated into a compound fertilizer or mixed with other fertilizer salts,

Table 3. Kinds and Main Raw Materials of High Analysis Compound Fertilizers

	Main raw materials	Total amt. of 3 nutrients(%)
Ammonium Phosphate Sulphate Fertilizer	(1) ammonia, phosphoric acid, sulphuric acid, potassium sulphate (potassium chloride)	35—38
	(2) ammonia, phosphoric acid, sulphuric acid, phosphate rock or superphosphate, potassium chloride	37—42
Urea Ammonium Phosphate Sulphate Fertilizer	(1) ammonia, urea, phosphoric acid, sulphuric acid, potassium sulphate (potassium chloride), formalin	45—47
	(2) ammonia, urea, phosphoric acid, sulphuric acid, superphosphate, potassium chloride	48—54
Urea Ammonium Phosphate Fertilizer	ammonia, urea, phosphoric acid, potassium chloride, formalin	54
Nitric Phoshate or Ammonium Phosphate Nitrate Fertilizer	ammonia, nitric acid, phosphoric, acid phosphate rock, potassium sulphate	42
Ammonium Phosphate Chloride Fertilizer	ammonia, phosphoric acid, ammonium chloride, potassium chloride	42
Magnesium Ammonium Phosphate Fertilizer	ammonia, phosphoric acid, magnesium hydroxide or surpentine, potassium chloride (ammonium sulphate, urea, ammonium nitrate, ammonium chloride)	33—42

their responses are almost the same.

Typical guaranteed grades of leading brands are shown in Table 4. These guaranteed grades are noticeably different from one another according to the forms of nitrogen and phosphate in fertilizers. Nitrogen, for instance, can be guaranteed with total nitrogen, ammonium nitrogen or nitrate nitrogen content, although they are simply shown as nitrogen in the table. Furthermore, these fertilizers often contain urea nitrogen (total nitrogen minus ammonium nitrogen) or some other forms of nitrogen, though usually high analysis compound fertilizer does not include organic materials. Therefore, Table 4 does not tell about the forms of fertilizer compounds but merely the guaranteed grades.

Even when the guaranteed components of high analysis compound fertilizers are expressed with ammonium nitrogen (AN), different kinds of ammonium salts included may not produce strictly the same fertilizer effects. The raw materials for high analysis compound fertilizers are shown in the Table 3, but each salt in them undergoes double decomposition in the production processes. For instance, the existence of NH_4Cl, $(NH_4, K)_2SO_4$ and $(NH_4, K)_2HPO_4$ is confirmed in fertilizer of ammonium potassium phosphate sulphate origin, while that of $(NH_4, K)_2HPO_4$ in fertilizer of ammonium phosphate chloride origin, and that of $(NH_4, K)_2SO_4 \cdot CaSO_4 \cdot H_2O$, ammonium potassium syngenite, and solid solution of $(NH_4, K)NO_3$ in fertilizer of nitric phosphate origin. Furthermore, in fertilizer of magnesium ammonium phosphate almost all magnesium has been confirmed to exist as magnesium ammonium phosphate, $MgNH_4PO_4$.

With these facts explained above, it can be said that the mere total of fertilizer effects of each raw material for high analysis compound fertilizers does not eventually represent the fertilizer effects of the compound fertilizers.

According to the results of fertilizer tests performed in various parts of Japan, these high analysis compound fertilizers have been

Table 4. Component of Main Fertilizers of Ammonium Phosphate Origin

Brand	Kinds	guaranteed components of leading brands (%)								Total amt. of 3 nutrients (%)	pH
		N			P_2O_5			K_2O	MgO		
		T-N	A-N	N-N	C-P	S-P	W-P	W-K	C-Mg		
1	Ammonium phosphate sulphate	—	14.0	—	—	12.0	11.0	9.0	—	35	4~5
2	〃	—	15.0	—	—	15.0	12.0	10.0	—	40	6.5~7
3	〃	—	11.0	—	11.0	—	—	11.0	5.0	33	6.5
4	Urea ammonium phosphate sulphate	16.0	8.0	—	—	16.0	13.5	16.0	—	48	4.5
5	〃	14.0	11.0	—	10.0	—	5.0	13.0	3.0	37	6.5
6	Urea ammonium phosphate	15.0	12.0	—	—	15.0	13.0	15.0	—	45	6.5~7
7	Ammonium phosphate chloride	—	14.0	—	—	14.0	11.5	14.0	—	42	4~5
8	Nitric phosphate	17.0	12.5	4.5	—	8.0	6.0	7.0	—	32	4.5
9	〃	18.0	12.0	6.0	—	6.0	4.5	16.0	5.0	40	4.5
10	Mognesium ammonium phosphate	—	11.0	—	11.0	—	3.0	11.0	4.0	33	6.5~7

Note: T-N = Total Nitrogen
A-N = Ammonium-N
N-N = nitrate-N
C-P = 2% citric acid soluble-P_2O_5
S-P = Petermann's solution soluble-P_2O_5
W-P = water soluble-P_2O_5
W-K = water soluble-K_2O
C-Mg = 2% citric acid soluble-MgO

shown to be almost the same as a combination of straight fertilizers. Tables 5, 6 and 7 show several examples of these tests.

Properties of various high analysis compound fertilizers are summarized below with reference to their crop responses.

(1) Fertilizers of ammonium phosphate sulphate origin

The accessory components of the fertilizer are 30-40 percent of sulphate and 1-15 percent of chloride on the average, these percentages varying with different potassium materials. When diammonium phosphate (DAP) is used as a material, these accessory components naturally become less in amount.

These fertilizers are usually superior to other high analysis compound fertilizers, since they are less hygroscopic and do not cake easily. Fertilizers of DAP origin are rather inferior in these two properties and they often need anti-caking agents.

Fertilizer of ammonium phosphate sulphate origin have been successfully applied to many crops.

(2) Fertilizers of urea ammonium phosphate sulphate origin

The accessory components of fertilizers of this group are less than those of fertilizers of the above (1) group, less than 30 percent

Table 6 Fertilizer Effects of Ammonium Phosphate Chloride on Paddy Rice

Prefecture	No. of tests	Yield Index		
		Average	Highest	Lowest
Iwate	4	105	112	102
Yamagata	4	105	110	103
Miyagi	4	104	106	100
Fukushima	3	115	118	108
Nagano	8	105	113	95
Saitama	5	107	114	103
Chiba	4	115	121	103
Toyama	12	104	139	95
Shiga	5	103	116	87
Kyoto	13	109	122	95
Nara	4	108	115	103
Hyogo	4	98	101	96
Okayama	16	106	117	93
Tottori	10	105	112	99
Shimane	4	101	102	100
Ehime	4	107	115	103
Yamaguchi	11	100	107	86
Fukuoka	5	116	170	100
Nagasaki	5	103	110	99
Oita	5	102	105	96
Average		105		

Table 5. Fertilizer Effects of Ammonium Phosphate Sulphate (Data from demonstration farms)

Yield Index	Crop	Paddy rice		Wheat	Rape	Onion	Tea trees	Eaily pranted paddy rice
	Year	1954	1955	1954	1954	1954	1954	1957～58
85～ 89		1	1	2	0	1	0	0
90～ 94		8	4	8	0	0	0	0
95～ 99		21	10	9	0	0	0	1
100～104		57	76	42	1	9	0	3
105～109		63	69	49	3	1	1	5
110～114		31	44	34	5	1	0	3
115～119		21	16	23	1	1	0	2
120～124		8	4	7	2	2	1	1
125～129		6	4	8	1	0	0	0
130～134		0	2	12	0	1	0	0
135～139		0	2	4	0	1	0	0
140～144		0	1	4	0	0	0	0
145～149		0	1	0	1	0	0	0
Total number		216	234	202	14	7	2	15
Average value		107	109	110	116	112	119	109

Note: 1. Tests were performed in all prefectures

2. Fertilizers tested were those which had used to be applied in respective localities, such as ammonium sulphate superphosphate, urea, fused magnesium phosphate, calcium cyanamide, complex fertilizers, mixed fertilizers, organic fertilizers, etc.

Table 7. Fertilizer Effects of Nitric Phosphate (Data from demonstration farms)

Crop	Upland rice	Wheat	Vegetable	Potatoes	Tea trees	Tobacco	Crop
100～104			3				
105～109		1	2			2	
110～114		1	10		1		1
115～119	1		5	2	1	1	
120～124		1	3				1
125～129		1	4				
130～134			1		1		
135～139							
140～144							
145～149			2				
150～159							
160～164							1
165～169			1				
Total number	1	4	33	2	3	3	3
Average value	119	116	121	116	122	111	133

Note: 1. Tests were performed in all prefectures; the period for testing ranged from 1952 to 1965.

2. Fertilizers tested were those which had used to be applied in respective localities, such as ammonium sulphate, superphosphate, urea, ammonium chloride, fused magnesium phosphate, sodium nitrate, compound fertilizers, mixed fertilizers, organic fertlizers, etc.

in total of sulphate and chloride being contained. These fertilizers contain higher amounts of the three plant nutrients than fertilizer of (1) group and require less labor input for their application. But their hygroscopicity is fairly high.

Care should be taken not to apply them too heavily to vegetable crops and care also should be taken when they are mixed with seeds.

(3) Fertilizers of urea ammonium phosphate origin

Fertilizers of this group contain 50 percent or more of three plant nutrients in total, the highest among high analysis compound fertilizers, while their accessory components are comparatively less, accounting for less than 23 per cent.

Hardness of the fertilizer granules is the same as that of the fertilizers of (1) and (2) groups, while their hygroscopicity is the highest among high analysis compound fertilizers. They are mostly applied to tangerines, beets, rapes and so forth.

They are sometimes treated with formalin to reduce their hygroscopicity, or, if not, they are coated with anti-caking agents instead.

(4) Fertilizers of ammonium phosphate chloride origin

Most of the accessory component of this group is chloride which accounts for more than 40 percent. Hardness of granules is high and their hygroscopicity is not so high at the normal relative humidity.

They are mostly used for paddy fields, especially the fields where root rot occurs frequently.

(5) Fertilizers of nitric phosphate origin

Percentages of accessory components of these fertilizers are comparatively low and usually fall within several percent, lowest among the high analysis compound fertilizers, in case where gypsum has been separated in the production process.

As these fertilizers contain nitrate nitrogen, they are exclusively used for upland crops and fruit trees, especially suitable for potatoes and beets in cold areas.

(6) Fertilizers of magnesium ammonium phosphate origin

The accessory components of these fertilizers are just the same as those mentioned in the fertilizer of (1) group and about 10 percent of nitrogen exists in the form of $MgNH_4PO_4$. Hardness of granules is the highest among high analysis compound fertilizers.

Fertilizers of this group are suitable for all kinds of crops, especially vegetables that absorbs magnesium most.

Some of those most important high analysis compound fertilizers are occasionally applied with various additives or their nitrogen is converted into some other forms.

Most important among the additives, are agricultural chemicals such as herbicide and insecticide, nitrification inhibitors to prevent reaching of nitrogen, anti-caking agents mentioned above and micronutrients such as boron and manganese. As to the conversion of nitrogen, controlled release nitrogen, which usually replaces urea, is most important. Among controlled release nitrogen sources, IB (isobutylidene diurea) and GU (guanylurea) are used for paddy rice while ureaform and CDU (crotonylidene diurea) are used for upland crops.

Further improvement in these additives and nitrogen or other nutrients are in sight in the near future.

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Shortening the Breeding Cycle of Rice

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The establishment of a method for rapid turnover in the breeding cycle would effectively result not only in shortening the breeding period itself, but also in providing an opportunity for development of a fully artificially controlled procedure of crops breeding. The low temperature in the autumn and winter seasons makes it difficult in general in Japan to have two rice crops a year under natural conditions except in a relatively small area in southern Japan. Experimental studies on the procedures of short cuts in rice breeding were started in 1932 at Aichi Prefectural Agricultural Experiment Station in Japan[5]. During the early period of the study the shortening practices were limited only in F_1 or F_1 and F_2 generations. In recent years, however, the shortening cycles have been extended to F_4 or F_5 generation in rice breeding. It is since 1950 that the rapid turnover procedures have been widely used in a practical rice breeding program. In 1967, 54 highly promising lines of rice have been released at fifteen breeding stations in this country, among which 24 lines, i.e. 44% of the total, were the resultants