Utilization of Helicopter for Agriculture in Japan

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I. Brief History of Helicopter Utilization

1. Technology Progress of Helicopter Utilization

1953 : Aerial application (sesna) for controlling of rice blast and rice stem borer.

1954 : Started three year term research project for "agrochemical application by aircraft." Recognized the feasibility for controlling of rice blast and rice bug, etc. and the practical possibility of aircraft use.

1958 : Helicopter application of mercury compounds toward 1,045ha rice areas at Hirazuka, Kanakawa prefecture which was highly effective against rice blast.

1959 : Practical application was done for controlling of first generation of rice stem borer.

1960 : Emergency application by helicopter for controlling of strip virus disease of rice at Nagano prefecture and resulted in good efficacy. From this aerial application of pesticides, helicopter was practically applied for controlling of vector insects of virus diseases.

1961 : Aerial application of pesticides for controlling of leaf miner of apple in Nagano prefecture.

1962 : Insect control for citrus in Hiroshima and Ehime prefectures. The total area of aerial application was recorded 101,000ha in 1961.

2. Progress of Helicopter Utilization

The association of aviation for agriculture, forestry and fisheries was organized in January of 1962 to achieve low-production cost through helicopter use. Activities of this association were planning of aerial business, research and development of new area, observation of application aircraft type, apparatus and materials, education and training, economic analysis, trust of research, publications, information exchange, etc.

To improve the activity, the Ministry of Agriculture, Forestry and Fisheries released an acceleration instruction of aerial business for agriculture, forestry and fisheries in June, 1962 and application and extension guidelines for aerial business in May, 1965, respectively.

Due to the practical organization and administrative assistance, rice-based aerial application of pesticides was rapidly increased for labor-saving and low-production cost and thus resulted in about 1,107,000ha of rice areas in 44 prefectures in 1968. However, some drift problems and regulation policy of rice production caused reduction of aerial application and thus recorded about 682,000ha in 1971.

With development of new pesticides which have low toxicity and less drift incidence, improvement of application method, increased requirement of labor-saving and low-production cost, and increment of farming size the area of aerial application was extended by 1, 500, 000ha in 1977 and 1, 740, 000ha in 1988, respectively.

Beside orchards, upland crops and livestock for insect and disease control and pasture for fertilization were currently practiced the aerial application even though the area of there crops are still far behind the rice crop. Another excellent performance was also reported for controlling of fruit fly species in Okinawa prefecture.

3. Status of application

(1) Application area

The general figure of application by crop and by prefecture was given in Table 1.

The greatest area was applied for fruit fly followed by rice which is widely distributed while fruit fly was predominantly practiced only in Okinawa prefecture.

The table imply that rice crop is currently the most widely applied in aerial application practice for saving of labor and production cost.

(2) Site variation

Rice area of aerial application by prefecture was given in Table 2. About 28% of total rice area and about 29% of total farmers are currently practiced the aerial application. There was a

Table 1. Acreage of aerial application by crop and location in 1992

(unit : ha)

Prefecture	Rice	Orchard	Upland crops	Livestock	Fruit fly	Total
Hokaido	42, 211	3, 700	0	2, 031	0	47, 942
Tohoku	781, 699	35	0	414	0	782, 148
Kanto	357, 162	40	1, 847	505	0	359, 554
Hokuriku	164, 878	0	444	110	0	165, 432
Tokai	33, 185	0	0	0	0	33, 185
Kinki	44, 636	0	0	0	0	44, 636
Chukoku. Shikoku	0	0	0	0	0	0
Kyushu	54, 825	1, 998	9, 153	0	0	65, 976
Okinawa	0	0	15, 161	0	4, 537, 141	4, 552, 302
Total	1, 478, 596	5, 773	26, 605	3, 060	4, 537, 141	6, 051, 175

Table 2. Status of aerial application for controlling of rice insect and disease.

(unit : ha)

Prefecture	Aerial application (ha)			Rice area	Ratio of aerial application	Ratio of farmers to adopt aerial application
	Area	Cumulative area	Application number	(ha)	(%)	(%)
Hokaido	18, 332	42, 211	2.3	162, 200	11.3	9.2
Tohoku	225, 811	781, 699	3.5	533, 308	42.3	54.3
Kanto	198, 354	357, 162	1.8	383, 594	51.7	52.9
Hokuriku	61, 245	164, 878	2.7	258, 000	23.7	28.4
Tokai	13, 426	33, 185	2.5	79, 700	16.8	10.5
Kinki	22, 981	44, 636	1.9	145, 100	15.8	15.8
Chukoku. Shikoku	0	0		238, 100	0.0	0.0
Kyushu	27, 363	54, 825	2.0	256, 300	10.7	15.2
Total	567, 433	1, 478, 596	2.61	2, 057, 156	27.6	29.5

Table 3. Chemical formulations and their application areas in 1992

(unit : ha)

Classification	Formulation type						
	Soluble concentrate	Low volume spray	Original liquid	Micro granule	Dustable powder	Granule	Total
Hokaido	42,211	0	0	0	0	0	42,211
Tohoku	67,703	630,383	76,839	0	0	6,774	781,699
Kanto	342,725	1,743	3,205	9,489	0	0	357,162
Hokuriku	96,998	0	67,754	0	0	126	164,879
Tokai	16,101	0	13,526	3,498	0	60	33,185
Chukoku	44,516	0	0	120	0	0	44,636
Chukoku. Shikoku	0	0	0	0	0	0	0
Kyushu	54,554	0	271	0	0	0	54,825
Total	664,808	632,126	161,595	13,187	0	6,960	1,478,596
Percentage	45.0	42.8	10.9	0.9	0.0	0.5	100.0

large site variation among the locations. The average application time in a given area was about 2.6 having the greatest value of Tohoku and Kanto area (3.5 times) followed by Hokuriku, Kinki, Kyushu, Tokai, and Hokaido. Chukoku and Shikoku are not currently practiced for this technology.

Tohoku area included the largest rice area and sectioned with large farm scale and thus have a relatively high incidence of rice blast. Due to these factors, the use of helicopter in this area is more effective and efficient than any other areas.

(3) Chemical formulations

In current, there were 29 insecticides, 27 fungicides, and 18 insect-fungicides for aerial application. However, there were no available herbicides so far.

The chemical formulations and their application areas in 1992 are given in Table 3.

There are several recommendations for using this chemicals. These are as follow.

- normal liquid volume of spray solution, 30-40l/ha
- low volume of spray solution, 8l/ha
- original liquid spray, 0.8-5l/ha
- normal granule application, recommending dosase
- micro granule application, recommending dosage
- dustable powder application, recommending dosage

Application of dustable powder is currently prohibited due to drift problems even though this performed better than granule. In nationwide,

Table 4. Cost analysis for aerial application

Year	Cost (Yen/ha)			
	Aircraft use	Materials	Others	Total
1988	3,664	4,975	931	9,570
1989	3,717	5,100	951	9,848
1990	3,805	5,229	958	9,991
1991	4,031	5,531	1,042	10,604
1992	4,374	6,132	1,359	11,864

soluble concentrate is the most widely used (45%), followed by low volume spray(43%).

The granular formulations were recently registered and there will be rapidly increased due to less drift problems.

(4) Cost of application

The general economic analysis for helicopter application is given in Table 4.

The cost of aerial application was gradually increased with year in 5-year term research recording only about 12 thousand yen per hectare in 1992. This result was satisfactorily achieved in labor-and cost saving strategies.

4. Prospects

Rice crop will be the main crop in aerial chemicals applications for controlling insect and disease as before. For the time being there was no alternatives except this in solving labor shortage, being aged farm labor, decrement in number of rice farmers, abandonment of arable farm land, etc. Furthermore, the pressure of international trade liberalization required better quality and minimum production cost for rice production.

In respect to these situations the method of aerial application of chemicals will make a significant contribution to solve the confronted problems in rice crop.

With urbanize of farm village the aerial application of chemicals result in another public problems which become a significant limiting factor for this technology. The association currently focused on its activity to develop the new technology to compromise these two aspects, maximum labor-saving with minimum input and least human health hazard.

II. Sub Soil Water Seeding by Helicopter

1. Progress of Research and Business

Helicopter was firstly introduced in 1962 for direct seeding of rice and continued until 1964 as a research project. Sixteen prefectures (cumulative number) were participated for 3 years and the evaluated operations were seeding, herbicide application, disease and insect control, fertilizer application, etc. Based on these results, the package technology was evaluated in 1965 and 1973. During this period, the mechanical transplanting method was well established and settled down on farmers field. Due to this and instability of direct seeding, the water seeding by helicopter was not much paied attention by farmers.

Dry seeding method by helicopter was evaluated in 1964 at 3 prefectures. However, this had not further progress thereafter.

With development of seed coating material (CaO_2, Oxygen supplier) and new pre-emergence herbicide, pyrazolate, in early of 1980s the necessity of direct seeding was emphasized again and thus research for water seeding method by helicopter was started from 1983.

Furthermore, improvement of seed coating material (Calpa-A type) flying method allowed better seed penetration in puddled soil, uniform seed distribution, and better application of herbicide and fertilizer. Standard manual based on series of research results is currently completed and this will work on a key role for accomplishment of labor-saving with minimum input.

2. Outline of Current Helicopter Operation

Currently practiced operation procedures are as follow.

Seeding : Calpa (CaO_2) coating of water soaked seeds. The ratio of Calpa and seeds is usually 3 : 1 (sometimes 2 : 1). Seeding rate is 3kg/10a as intact seeds which is equvalent about 11-14kg by calpa coated seeds.

Flying height is about 10m high with about 40km/hr speed and the effective seeding width is about 25m. Flying is usually practiced twice to make uniform seedling establishment.

Herbicide : Granular herbicide is applied with the same way of seeding method at the rate of 3kg/10a every 20m intervals.

Insecticide and Fungicide : Insect and disease control are usually practiced with neighbor farmers as a cooperative control project.

Fertilizer Topdressing : One topdressing is practiced every 25m intervals at panicle initiation stage with the same way of seeding.

The overall procedure of this technology can be summarized as : Tillage-Flooding-Fertilization-Harrowing (1-4 days before seeding) -Drain (1 day before seeding) -Seeding (Helicopter) -Flooding (Just after seeding) -Herbicide (Pyrazolate compound granule, next day of seeding) -Drain (for seedling anchor) -Flooding -Herbicide (benzylpromethyl carbamate compound mixture, 1-2 days after flooding) -Working way setting (Tractor) -Fertilizer topdressing (before tillering, manual) -Insect and Disease control (Helicopter) -Intermediate drain (35 days before heading) -Fertilizer topdressing (at panicle initiation, Helicopter) -Insect and Disease control (Helicopter) -Harvest (Combine) -Drying-Processing (Rice center, Contry, etc.).

3. Outline of Results of Research and Business

Evaluation was made based on 9 years (1983-1991) results that were obtained from 66 research sites using helicopter.

(1) Working efficiency

Operation capacity of helicopter was given in Table 5. This data included all the necessary operations such as preparation, loading and spraying.

The results imply that the working efficiency of helicopter was increased with increase of farm size from less than 1ha to above than 10ha. In practical view point, the optimum farm size is considered as larger than 10ha.

(2) Working Accuracy

The working uniformity and drift informations are given in Table 6 and Table 7. In general, the degree of seed drift outside the target area was ralatively high having 8.7% for small size of helicopter and 17.6% for medium size of helicopter. This high value is possibly due to the fact that farm sizes of these experiments were relatively small.

Herbicide drift to outside the target area was about 8-10% while descent variation of herbicide granule to target area was 21.6% for pyrazolate

Table 5. Working efficiency of helicopter in association with farm size

(unit : ha/hr)

Farm size	Seeding (3-3.5kg/10a)	Herbicide (3kg/10a)	Fertilizer (10-20kg/10a)
<1 ha	(3) 0.90-4.80 Ave. 3.37		
1.1-5 ha	(17) 0.60-15.03 Ave. 7.25	(4) 3.49-4.71 Ave. 7.25	(5) 1.96-12.59 Ave. 7.37
5.1-10 ha	(7) 2.58-9.23 Ave. 5.53	(8) 4.82-24.10 Ave. 11.62	(5) 3.70-9.46 Ave. 6.85
>10.1 ha	(14) 3.94-14.62 Ave. 8.31	(26) 7.91-28.39 Ave. 17.64	(11) 6.30-26.83 Ave. 10.35

* ( ) : number of evaluation sites

Table 6. The degree fo seed drift and descent variation to target area in seeding operation

(unit : %)

Aircraft size	Spray apparatus	Drift outside target area	Descent variation to target area
Small	TDA-G1	(20) 3.0-20.7 Ave.8.7	(33) 14.3-50.4 Ave.33.1
Medium Ave.	206AH-14B	(5) 12.5-20.0 Ave.17.6	(10) 16.0-46.0 Ave.29.6

* ( ) : number of evaluation sites

Table 7. The degree of herbicide drift and descent variation to target area

(unit : %)

Herbicide	Spray apparatus	Drift outside target area	Descent variation to target area
Pyrazolate(G)	N-033	(5) 5.3-12.3 Ave.8.1	(5) 10.7-37.2 Ave.21.6
Dimepiperate/ Benzylpromethyl(G)	N-033	(5) 6.1-19.9 Ave.10.3	(4) 29.2-53.3 Ave.45.0

* ( ) : number of evaluation sites

Table 8. The degree of fertilizer drift and descent variation to target area

(unit : %)

Spray apparatus	Drift outside target area	Descent variation
TDA-G1	(9) 1.1-11.2 Ave.5.3	(6) 17.7-52.0 Ave.31.4

* ( ) : number of evaluation sites

and 45.0% for dimepiperate/benzylpromethyl herbicide, respectively. Further study is needed to make a general trend.

For fertilizer application, it is more difficult to collect data due to variability in fertilizer type and application rate. However, several observations indicated that the rate of fertilizer drift and descent variation were relatively small as given in Table 8.

(3) Herbicide and problems

First herbicide is usually applied either at just after seeding or at root anchor stage of seedling. Herbicides for former is mainly pyrazolate compounds, mostly pyrazolate(G) and this for latter is mainly benzylpromethyl+carbamate compound mixtures. Herbicidal efficacy of these herbicides is also significantly associated with harrowing operation and water management. In general, good water management with thorough harrowing operation satisfactorily control weeds except particular problem weeds with these herbicides.

Uneven land preparation and delayed irrigation results in enhancement of the growth of *Echinochloa* species and thus needed additional manual weeding.

In current two times of herbicide applications are basically recommended which is retrogressive event compared to transplanting method in terms of labor-saving and cost input. To solve this problem, research for new cultural technology is undertaken.

(4) Seedling emergence and standing

Due to the high variability in test site it is difficult to make general statement.

Seeding depth recorded high variability having range of 0.4mm-16.2mm(average of 4-7mm) depending on the test site. Among experimental sites Hokaido had the shallowest seeding depth where seedling was hardly emerged when seeds located greater than 5mm in seeding depth. Except Hokaido the seedlings usually emerged within 1cm soil depth. Seedling emergence rate was also highly variable having 31-100% across the experimental site and test year. The average seedling emergence among the experimental sites was about 60-80% exhibiting the least in Hokaido.

Great variations were also recorded in seedling number per unit area even though this was directly related with seeding rate. With seeding rate of 10kg/10a in Hokaido seedling number per m^2 was about 107-370(average 225). However, other areas having seeding rates of 3-4kg/10a resulted in 38-143 seedlings/m^2. The average in each site ranged from 50 to 105 seedling/m^2 that values might not affect the final rice yield.

(5) Rice yield

Rice yield was ranged 339-644kg/10a(in brown rice).

The high variation of yield was due to short rice season and double cropping with wheat in Hokaido and Saitama prefectures and high lodging incidence of good quality variety. Without lodging more than 500kg of yield is common yield level and three sites recorded more or less 600kg. This results imply that water seeding method by helicopter is as high as transplanting method in terms of yield level when appropriate management is subjected.

Lodging is the prime importance in this technology and thus selection of lodging tolerant variety is the most important.

(6) Labor hour and production cost

Labor hour requirement and economic analysis are given in Table 9 and Table 10.

Helicopter seeding method resulted in about 50% labor-saving compared to mechanical transplanting even though there was a high variations.

The primary production cost had also so high variability as the labor hour requirement due mainly to lodging problem. In broad sense, the primary production cost for 60kg rice in helicopter seeding was about 70% of the transplanted rice.

4. Problems and Solutions

There are several problems to be solved to enhance the stability of the current helicopter technology.

(1) Overall problems of sub-soil seeding

Variety : In varietal selection for direct seeding, the marketability is important factor. There are very limited choice to select good seed germinability, lodging tolerance, multi-resistance to disease and insect and good quality among current leading varieties. Breeding efforts should be focused on this aspect.

Cultivation method : Standard cultivation method should be established in each agro-environmental condition. This cultivation method included seedling establishment, growing process, and determining the yield components.

To further improve labor-saving and low production cost, reduced farm operation, better herbicide application and water management techniques will be the target research areas. The

Table 9. Labor requirement of helicopter seeding

Classification	Labor hour (hr/10a)
Helicopter	
· Seeding	(6) 7.90-14.35 Ave.11.03
· Seeding, Herbicide, Fertilizer	(25) 4.64-18.73 Ave.12.75
Mechanical transplanting	(12) 13.86-44.5 Ave.25.7

* ( ) : number of evaluation sites

Table 10. The primary production cost of helicoptor seeding

Classification	Production cost(¥/10a)	¥/60kg rice
Helicopter		
· Seeding	(3) 79,648-109,064 Ave.91,866	(2) 8,099-17,128 Ave.12,613
· Seeding, Herbicide, Fertilizer	(23) 59,816-122,959 Ave.84,303	(20) 7,486-22,356 Ave.11,279
Mechanical transplanting	(12) 113,847-145,683 Ave.130,775	(12) 14,687-18,596 Ave.16,581

* ( ) : number of evlauation sites

package technology based on above researches will make a significant contribution to enhance the stability.

Herbicide : Herbicides that currently used in direct seeding are introduced from herbicides of transplanted rice. In fact, requirements for herbicidal development are different between direct seeding and transplanting methods. New type of herbicide and better application method needed to be developed for better herbicidal efficacy and labor-saving.

Weed flora and weed biomass are usually changed with shifting cultivation method from transplanting to direct seeding methods. Research on weed biology of troublesome weeds is also emphasized.

(2) Problems of helicopter seeding(sub-soil seeding)

Working efficiency, farming size and distribution, and production organization : Currently, working acreage of helicopter is about 30-50ha per day in seeding operation while this for chemical application is higher than seeding operation. The average farm size is less than 1ha and practically difficult to make large size of farm. Due to this variable sizes of farm, locations and owners it is also difficult to organize the production system effectively. These problems must be solved before disseminate further this technology.

Terrestrial operation for helicopter work : For helicopter seeding operation, proper terrestrial operation before seeding such as irrigation, tillage and harrowing operations are very important. This might also be affected by soil types. Current working acreage for mechanical harrowing was about 2-3ha/day. Before harrowing, irrigation and basal fertilizer application must be completed. The accuracy of these operations is directly correlated with seedling establishment. Seed disinfection and water soaking are additional labor consuming process. To maximize the labor-saving and cost-saving effect development of better simplified technology must be paied attention.

Drift to non-target area : As mentioned early the degree of drifts of seed, herbicide and fertilizer to non-target area were more than 10% in current farm sizes. This drift problem is directly related to farm size and circumference situation for flying. Herbicide drift among drift problems might arise serious problems in neighboring farm fields other than rice field. Therefore, with improvement of spraying technique and chemicals, well planned crop arrangement is also desired.

Registration of chemicals : Chemicals for aerial application need particular registration. Only those chemicals that officially resistered can be used for aerial application. In this view point, there is no herbicides that allowed to be applied for helicopter so far. On the other hand, chemicals for disease and insect are well established in application method and no particular problems arised so far. However, it will not be easy to obtain official permission due to several fastidious requirements for registration.

Chemicals for remote controlled helicopter application is another possibility to reduce chemical drift to non-target area even though working efficiency is a little lower than manual controlled helicopter.

III. Agricultural Use of Remote Controlled Helicopter

1. Technology Progress

Since 1980 association of aviation for agriculture, forestry and fisheries has developed remote controlled helicopter to extend the areial application area that difficult by manual controlled helicopter. Two types of helicopter were tested with various spray apparatus mainly for rice crop. Further development can be summarized as

Table 11. Content of two types of remote controlled helicopters

Type	Total length (mm)	Main rotor diameter (mm)	Total height (mm)	Width (mm)	Maximum take-off weight(kg)	Weight (kg)	Loading weight (kg)	Flying time (min)	Effective distance (m)	Applying apparatus	
										Liquid	Granule
R-50	3580	3070	1080	700	67	44	20	30	100	nozule	imfera
KG-135	3825	3250	1060	870	83	63	20	30	100	automizer	-

follows.

1980 : Organized the group of research and development

1987 : Completed test helicopter(RC)

1988 : Conducted field experiment in rice crop

1989 : Insect and Disease control of rice crop by RC(330ha)

Researches on upland crop, orchard and other crops

1990 : Test working efficiency(27 prefectures, 2,600ha)

1991 : Standardized the technical directions and chemical registration Test area 6,155ha

Organized the national RC association

In current, there are two types of remote controlled helicopter, R-50(Yamaha) and KG-135(Japan air and electric) as given in Table 11.

Both types had 20kg in loading capacity. However, due to additional apparatus to be attached during operation the actual loading capacity is about 10kg. In practical working, KG-135 performed better in terms of working efficiency and safety than R-50 due to larger size and heavy weight.

Applying apparatus, on the other hand, had two kinds in R-50, liquid and granule. while KG-135 developed only one for liquid application. In aircraft price, KG-135 is much more expensive than R-50.

2. Current Technology for Applying

Currently available technology is given in Table 12. There is no particular difference between low volume liquid spray and granular application in terms of application method. In both types of chemical, the flying method is the same as flying speed of 10-20km/hr, flying height of 3-4m(from the top of crop canopy), flying interval of 5cm, and flying of less than 3cm/sec in wind speed.

The number of chemicals registered for this technology in rice crop was 10 for insecticide, 19 for fungicide and 2 for insect-fungicide which is less chemicals compared to manual controlled helicopter method. Besides, on insecticide for aphid in wheat and two insecticides in soybean,

Table 12. Current technology of remote controlled helicopter

Crop	Target operation	Applying method	Dosage		Flying speed (km/ha)	Flying height (m)	Flying interval (m)	Wind speed (m/sec)	Applying helicopter	Applying apparatus
			l/ha	kg/ha						
Rice	Disease Insect	Low volume liquid	8	-	10-20	3-4	5	3	KG-135 R-50	automizer nozule
		Granule	-	10-15	10-20	3-4	5	3	R-50	impera
Wheat	Disease Insect	Low volume liquid	8	-	10-20	3-4	5	3	KG-135 R-50	automizer nozule
soybean	Disease Insect	Low volume liquid	8	-	10-20	3-4	5	3	KG-135 R-50	automizer nozule
Lotus root	Disease Insect	Granule	-	40-60	10-20	3-4	5	3	R-50	impera

Table 13. Utilization status of remote comtrolled helicopter

Prefecture	Acreage (ha)							1992	
	1989	1990	1991	1992 October				Helicopter	Crew
				Rice	Wheat	Soybean	Total	number	number
Hokaido	195.7	718.7	1,817.0	6,188.4	-	20.0	6,208.4	29	191
Tohoku	22.7	753.3	1,010.5	5,939.2	20.0	18.0	5,977.2	27	129
Kanto	28.5	183.5	1,328.6	2,599.0	-	33.6	2,632.6	36	189
Hokuriku	6.0	59.3	206.7	310.1	-	-	310.1	18	52
Tokai	38.0	525.7	668.6	501.1	-	1.4	502.5	6	49
Kinki	12.7	170.3	382.2	544.2	-	15.9	560.1	14	47
Chukoku. Shikoku	15.5	71.6	369.7	1,075.4	-	-	1,075.4	17	119
Kyushu	11.8	120.1	371.6	1,189.1	-	13.0	1,202.1	20	176
Total	330.8	2,602.5	6,154.9	18,346.5	20.0	101.9	18,468.4	167	952

one for several insects and the other of plant hopper are currently available.

Working efficiency of the remote controlled helicopter was about 35-70sec/10a which is much higher than manual controlled helicopter. Lower loading capacity and frequent engine stop for loading are another limiting factor for this technology.

3. Status of utilization

In nationwide, about 330ha was practiced in this method in 1989. Since then, the area was rapidly increased and reached about 18,000ha in 1992 (Table 13) mainly in rice crop for insect and disease control.

The number of helicopter used in nationwide for this technology was 162 in 1992. Areas of Kanto, Hokaido, and Tohoku recorded relatively high number while area of Tokaikinki had the least number, respectively. About 48% of total helicopter was owned by company or related organization (association).

Personal owner was about 19%. The number of helicopter in June, 1993 was 264.

4. Prospects

The basic idea of the remote controlled helicopter is the complimentary method of manual controlled helicopter particulary, on small farm size and some limited areas to apply. Current applying apparatus is relatively expensive and thus needed to develop multi-purpose apparatus to reduce expenditure.

Extension of applying area to upland crops, vegetables and orchard crops and to herbicides is another alternative to increase the remote controlled helicopter utilization. Remote controlled helicopter can be used from seeding to pest control for water seeded rice and pest control for transplanted rice, respectively. Due to this, the association of aviation for agriculture, forestry and fisheries is currently actively studied on these areas to extend the applying area.

Herbicide formulation research is one of these researches. This year, the possibility of bentazon liquid to control of *Eleocharis kuroguwai* was tested.

Due to the limited loading capacity of remote controlled helicopter (effective loading capacity, 10kg) large volume requirement for spraying is less effective in cost saving. Therfore, technical improvements such as flying method and drift-less chemicals are needed. Herbicide, for example, new types of granules (1kg/10a) and flowables (500ml/10a) are under evaluating.