RESEARCH COMPONENT AND DISTRIBUTION OF SPECIES *Amorphophallus* spp. WITH TUBERS CONTAINING GLUCOMANNAN IN THE NORTHERN MOUNTAIN PROVINCES OF VIETNAM

Tran Van Tien[1], Ha Van Huan[2], Nguyen Minh Quang[3], Nguyen Van Du[4]

[1]*National Academy of Public Administration*

[2,3]*Vietnam National University of Forestry*

[4]*Institute of Ecology and Biological Resources*

SUMMARY

In Vietnam, recent findings have recorded 25 species of the genus *Amorphophallus.* Despite some initial results of the contents of *Amorphophallus* spp. In Vietnam, th ose r esults only record the presence of species in Vietnam territory. In order to pick species with high-glucomannan content, potential to develop in Vietnam, there must be deeper research on species composition, the distrubution in areas, also ecological conditions, developing potential of *Amorphophallus* spp to become the resources of tuber used for *Amorphophallus* spp flour manufacturing. This research shows that 6 species with gluconmannan were recorded in 14 mountainous provinces in Northern Vietnam. The Konjac of *Amorphophallus* spp has the highest gluconmannan content (44.97% in tuber) and has m ost outstanding potential to grow as an industrial crop. In details, 3 years since planted, its mother tuber may reach 600 - 1000 g, including 44 - 47% gluconmannan and produce 5 - 6 tubers a year.

Keywords: Amorphophallus, glucomannan, species composition.

I. INTRODUCTION

There are about 200 *Amorphophallus* species in the world distributed mainly in the the tropical regions of Africa and Asia (Hetterscheid and Ittenbach, 1996). *Amorphophallus* species belonging to *Amorphophallus* genus, in Araceae family have been grown in many countries around the world such as Japan, China, India… to get tubers for food ingredients and functional foods.

The *Amorphophallus* species are distributed mainly in the the tropical regions of Africa and Asia (Hetterscheid and Ittenbach, 1996). They are the endemic species of the tropical rain forests in Southeast Asia. They are distributed throughout the Himalayas, Indochina (Myanmar, Thailand, Cambodia, Laos and Vietnam), Japan, Philippines, Southwest (Yunnan Province) and Northwest (Shaanxi, Ningxia, Jiangsu) China (Liu, 2004).

The above works have made research results on *Amorphophallus* species composition in the world and in Vietnam. However, the researches on composition and distribution of *Amorphophallus* spp. with tubers containing glucomannan, assessment of species containing high glucomannan content are limited and undeveloped in Northern mountainous area of Vietnam.

Derived from the above reasons, the authors undertook research on composition and distribution of species with tubers containing glucomannan in Northern mountainous area of Vietnam, in order to provide information for the conservation and development of this species in the Northern mountainous provinces of Vietnam.

II. RESEARCH METHODOLOGY

2.1. Methods of surveying and samples collecting

- Selecting information on the distribution of species to conduct site investigation:

The information on the location of the *Amorphophallus* species in the Northern mountainous provinces of Vietnam was selected through the materials on the genus *Amorphophallus* in Vietnam such as the books of Nguyen Van Du (2005), Araceae Juss, Checklist of plants of Vietnam; Dictionary of medicinal plants in Vietnam – Vo Van Chi (2012); An Illustrated Flora of Vietnam - Pham Hoang Ho (1993) and through information on plant ethnography (from residental area, market, etc.).

Sampling has been conducted in 14 mountainous provinces of Northern Vietnam. 14 surveys were conducted in 14 mountainous provinces: Hoa Binh (Tan Lac, Lac Son, Hoa Binh), Son La (Van Ho, Thuan Chau, Moc Chau), Phu Tho (Tan Son), Dien Bien Dien Bien), Lai Chau (Muong Te), Lao Cai (Bat Xat), Yen Bai (Van Chan), Tuyen Quang (Son Duong), Thai Nguyen (Dinh Hoa), Ha Giang (Quan Ba, Pho Bang), Cao Bang (Nguyen Binh, Thach An), Lang Son (Trang Dinh), Bac Giang (Luc Ngan), Bac Kan (Ngan Son).

- Sampling methods:

+ Taking pictures of life form, habitats, parts of the tree... recording information about GPS coordinates, ecological biology, etc.

+ Specimens collecting: A leave or part of a leave (has a big size) is cut then processed according to the specimen processing technique of Institute of Ecology and Biological Resources. The flowers are soaked in alcohol 70^o for the purpose of studying the classification, drawing samples.

+ Collect tubers for conservation, propagation and glucomannan content analysis.

Collecting the whole fruit cluster, if the fruit is ripe, clean the inner part and leave the seeds in a cool place and wrap it with newspaper, If the fruit is not yet ripe, collect the stalk, put it into a barrel sponge then transport to the study area.

2.2. Method used in species classification

Identifying the scientific name of *Amorphophalluss* species in in the mountainous area of Northern Vietnam, the authors have used comparative morphological method. In terms of science, this method yields reliable results and is suitable for Vietnamese research conditions.

2.3. Selection method of *Amorphophallus* spp. with tubers containing high glucomannan content and prospects of planting in some Northern mountainous provinces of Vietnam.

2.3.1. Selecting species according to high glucomannan content

Tuber specimens of species collected after species identification were sent for analysis of glucomannan content according to colour comparision method of Melinda Chua and associates from the Institute of Natural Products Chemistry - Vietnamese Academy of Science. From the results of this analysis the authors selected out the *Amorphophallus* species with high glucomannan content then recommended selecting species to plant in Northern mountainous provinces of Vietnam.

2.3.2. The method of selecting species according to the development prospects of cultivation in some mountainous provinces of Northern Vietnam

From the analyzed *Amorphophallus* species with high glucomannan content, the authors conducted evaluation, selection of the most promising species to plant in the Northern mountainous area.

Criterias for evaluation and selection:

+ Good growth;

+ Easy to multiplicate, high multiplication coefficient;

+ Suitable for ecological conditions.

III. RESULTS DISCUSSION

3.1. Species composition and glucomannan content of *Amorphophallus* species with tubers in the mountains of Northern Vietnam

Results of field survey, samples collection and glucomannan analysis of *Amorphophallus* spp. in 14 mountainous provinces of Northern Vietnam have found 6 species with tubers containing glucomannan. The results are shown in Table 3.1 as follows.

Table 3.1. Checklist of *Amorphophallus* spp. with tubers containing glucomannan in the mountainous area of Northern Vietnam

No.	Vietnamese name	Scientific name	Glucomannan content in dried *Amorphophallus* tuber (%)
1	Nưa konjac	*Amorphophallus konjac* K. Koch	44.97
2	Nưa đầu nhăn	*Amorphophallus corrugatus* N. E. Br	28.60
3	Nưa krausei	*Amorphophallus krausei* Engl. & Gehrm	29.20
4	Nưa vân nam	*Amorphophallus yunnanensis* Engl.&Gehrm	25.97
5	Nưa yuloensis	*Amorphophallus yuloensis* H. Li	30.07
6	Nưa chuông	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	6.53

The result table of the study on the species composition of *Amorphophallus* spp. with tuber containing glucomannan in northern mountainous region of Vietnam showed that among these six species, *Amorphophallus konjac* had the highest glucomannan content with glucomannan content in dried *Amorphophallus* tuber was 44.97%. Thus, the glucomannan content of the *Amorphophallus konjac* in Vietnam is nearly as high as that of the high yielding *Amorphophallus konjac* glucomannan varieties grown in China (glucomannan content is 45 - 55% of the dry weight).

The results of the fieldwork have found the *Amorphophallus yuloensis* species, the first found in Vietnam. With this finding, *Amorphophallus yuloensis* species have been recorded as a complement to the flora of Vietnam. Evaluation of glucomannan content of *Amorphophallus yuloensis* was 30.7%. This is the second highest *Amorphophallus* species in terms of glucomannan content among the six species found in the mountainous region of Northern Vietnam. Among other four remaining species, *Amorphophallus corrugatus*, *Amorphophallus krausei*, *Amorphophallus yunnanensis* had relatively similar glucomannan content with 28.6%; 29.2%; 25.97% respectively. *Amorphophallus paeoniifolius* had the lowest glucomannan content of 6.53%. Thus, to develop the planting of *Amorphophallus* species with the orientation of producing high glucomannan tubers to serve the needs of food production and functional food, 5 species of *Amorphophallus konjac*, *Amorphophallus corrugatus*, *Amorphophallus krausei*, *Amorphophallus yunnanensis*, *Amorphophallus yuloensis* all have the potential to grow if they have high growth rate, multiply quickly and adapt to ecological conditions in the Northern mountainous region of Vietnam.

A: Tubers and seedling bulbs of *Amorphophallus konjac* in Dong Van, Ha Giang province

B: *Amorphophallus konjac* investigation in Bat Xat, Lao Cai province

Figure 3.1. Pictures of *Amorphophallus konjac* K. Koch

(Source: Tran Van Tien – 2016)

3.2. Distribution characteristics of *Amorphophallus* with tubers containing glucomannan in Northern mountainous area of Vietnam.

The survey results of distribution of 6 *Amorphophallus* species with tubers containing glucomannan in the Northern mountainous region of Vietnam are shown in table 3.2:

Table 3.2. Distribution of 6 *Amorphophallus* species with tubers containing glucomannan in the Northern mountainous region of Vietnam

STT	Species name	Distribution location	Elevation (m)	Forest state and ecology	Aspect
1	*Nưa* konjac - *Amorphophallus konjac* K. Koch	Lao Cai (Bat Xat); Ha Giang (Quan Ba, Pho Bang).	800 - 1600	*Amorphophallus konjac* lives in the forest, forest edge, swidden fields, roadside, home gardens. *Amorphophallus konjac* grows under the forest canopy, in the home gardens, in the gap on the rocky mountains with less sunlight.	E-S, N-E
2	*Nưa* đầu nhăn - *Amorphophallus corrugatus* N. E. Br	Hoa Binh (Tan Lac, Lac Son); Son La (Van Ho, Thuan Chau, Moc Chau); Phu Tho (Tan Son); Tuyen Quang (Son Duong); Lang Son (Trang Dinh).	300 - 1000	*Amorphophallus corrugatus* lives in the forest, forest edge, swidden fields, roadside. *Amorphophallus corrugatus* grows under canopy of thin forest, roadside without cover of large trees, with small shrubs, in the home gardens.	E-S, N-E, S-W
3	*Nưa* krausei - *Amorphophallus krausei* Engl. & Gehrm	Son La (Van Ho, Thuan Chau, Moc Chau); Cao Bang (Nguyen Binh, Thach An).	600 - 1000	*Amorphophallus krausei* found in the average, rich forests. *Amorphophallus krausei* grows under the canopy cover with over 50 - 70%.	N-E, E-S

STT	Species name	Distribution location	Elevation (m)	Forest state and ecology	Aspect
4	*Nưa* vân nam - *Amorphophallus yunnanensis* Engl. & Gehrm	Hoa Binh (Tan Lac, Lac Son, Hoa Binh city); Son La (Van Ho, Thuan Chau, Moc Chau); Cao Bang (Nguyen Binh, Thach An); Bac Kan (Ngan Son) .	300 - 800	*Amorphophallus yunnanensis* found in the forest, forest edge, swidden fields, roadside, home gardens. *Amorphophallus yunnanensis* grows under canopy of thin forest, the roadside without cover of large trees, with small shrubs, in the home gardens.	E-S, N-E, S-W
5	*Nưa* yuloensis - *Amorphophallus yuloensis* H. Li	Son La (Van Ho, Thuan Chau, Moc Chau); Dien Bien (Tuan Giao)	800 - 1000	*Amorphophallus yuloensis* found in the average, rich forests. *Amorphophallus yuloensis* grows under the canopy cover with over 50 - 70%.	E-S, N-E
6	*Nưa* chuông - *Amorphophallus paeoniifolius* (Dennst.) Nicolson	Hoa Binh (Tan Lac, Lac Son, Hoa Binh city); Son La (Van Ho, Thuan Chau, Moc Chau); Phu Tho (Tan Son), Yen Bai (Van Chan); Tuyen Quang (Na Hang); Thai Nguyen (Dinh Hoa); Cao Bang (Nguyen Binh, Thach An); Lang Son (Trang Dinh); Bac Giang (Luc Ngan); Bac Kan (Ngan Son).	0 - 600	*Amorphophallus paeoniifolius* found in average, rich, mixed forests with some woody trees such as Erythrophleum fordii, Cinnamomum parthenoxylon, Parashorea chinensis… *Amorphophallus paeoniifolius* grows under canopy of thin forest or without cover, roadside without cover of large trees, with small shrubs, in the home gardens	E-S, N-E, S-W, N-W

From the results obtained during the fieldwork, *Amorphophallus* species with tubers containing high glucomannan content were distributed at higher altitudes than those with low glucomannan content. Five species distributed widely in elevation from 300 - 1600 m. In particular, the *Amorphophallus konjac* lived at an altitude of 800 - 1600 m, the *Amorphophallus yuloensis* species lived at an altitude of 800 - 1000 m, the *Amorphophallus krausei* species lived at an altitude of 600 - 1000 m, the *A morphophallus yunnanensis* species lived at altitudes of 300 - 800 m m, the *Amorphophallus corrugatus* species lived at altitudes of 300 - 1000 m, the *Amorphophallus paeoniifolius* distributed at the lowest elevation from 0 - 600 m above sea level. As such, it is possible to see differences in climate, terrain, ecology, etc. at different heights influence on the existence of *Amorphophallus* species with tubers containing glucomannan.

The *Amorphophallus* species are widely distributed in different habitats, they occur in the forest, roadside, shifting cultivation and home gardens. These species mainly live under canopy cover, cool climate and land drainage is not flooded. Of the six species, the *Amorphophallus Konjac* lives in the forest, along the road, in the garden, etc. with varying coverage ranges usually from 20 - 70% depending on the temperature of each region. The *Amorphophallus krausei*, found only in

areas where the canopy has a high coverage of 40 - 70% in average and high density forests. *Amorphophallus paeoniifolius*, *Amorphophallus corrugatus*, *Amorphophallus yunnanensis* live under canopy of thin forest and especially the *Amorphophallus paeoniifolius* species can develop well in areas with or without canopy cover.

According to the results of the study on directional distribution, the *Amorphophallus paeoniifolius* are distributed in many different directions, with 4 different directions: E-N, E-S, W-S, and W-N. This proves that this species adapts well to changes in temperature and intensity of sunlight. The other 5 species have more specific direction, mainly towards the direction of exposure to less sunlight. *Amorphophallus corrugatus* and *Amorphophallus yunnanensis* have the next highest direction number with 3 directions of E-S, E-N, W-S, and these three directions receive less sunlight than E-N, E-S, W-N, W-S. *Amorphophallus konjac, Amorphophallus Yuloensis, Amorphophallus krausei,* have only 2 direction of E-S, E-N, which is the direction of least exposure of the sun, so the average temperature in these areas is also the lowest.

3.3. *Amorphophallus* species with tubers containing glucomannan has potential for development in some northern mountainous provinces of Vietnam

From the field survey, study on the growth and development characteristics and glucomannan content of *Amorphophallus* species in the northern mountainous region of Vietnam, some basic characteristics are summarized in table 3.3 as follows.

Table 3.3. Growth and development characteristics of 6 *Amorphophallus* species with glucomannan in Northern mountainous region of Vietnam

No	Name of Species	Growing duration of 1 year (days)	3-year-old tubers' weight (g)	3-year-old seedling bulbs' weight	Sexual reproduction (seed)
1	*Nưa* konjac - *Amorphophallus konjac* K. Koch	158 - 175	600-100	7	0
2	*Nưa* đầu nhăn - *Amorphophallus corrugatus* N. E. Br	150 - 160	200-400	0	0
3	*Nưa* krausei - *Amorphophallus krausei* Engl. & Gehrm	153 - 162	600-800	0	0
4	*Nưa* vân nam - *Amorphophallus yunnanensis* Engl. & Gehrm	145 - 162	200-300	0	0
5	*Nưa* yuloensis - *Amorphophallus yuloensis* H. Li	147 - 158	200-300	0	0
6	*Nưa* chuông - *Amorphophallus paeoniifolius* (Dennst.) Nicolson	154 - 169	400-600	5	0

The results in Table 3.3 showed that *Amorphophallus konjac* had the best growth and development ability, after 3 years of growing the mother tubers' weight were 600 - 1000 g, the number of seedling bulbs at this age is 5 - 7. The second was the *Amorphophallus*

paeoniifolius with 400 - 600 g of tubers and the number of seedling bulbs at the same age with tubers of this species is 5 - 6. The remaining 4 species were *Amorphophallus corrugatus*, *Amorphophallus krausei*, *Amorphophallus yunnanensis*, *Amorphophallus yuloensis* with mother tubers' weight of 200 - 400 g, 600 - 800 g, 200 - 300 g, 200 - 300 g respectively and no seedling bulbs. All species have no sexual reproduction in this age group.

Thus, to select species with high content of glucomannan, promising to provide raw materials for the food industry and functional foods to contribute to the socio-economic development of some nothern mountainous provinces in Vietnam, *Amorphophallus konjac* with tuber after 3 years cultivated, the mother tubers' weight from 600 - 1000g, the number of seedling bulbs at this age is 5 - 7 and glucomannan content was 44.97%, and have the most promising development prospects of glucomannan powder supply for food production and functional foods.

IV. CONCLUSION

1) Six *Amorphophallus* species with tubers containing glucomannan distributed in the mountainous provinces of Northern Vietnam have found.

Amorphophallus konjac is distributed in Lao Cai (Bat Xat) and Ha Giang (Quan Ba, Dong Van); *Amorphophallus corrugatus* is distributed in Son La (Van Ho, Thuan Chau, Moc Chau), Hoa Binh (Tan Lac, Lac Son, Hoa Binh), Tuyen Quang (Son Duong), Lang Son (Trang Dinh), Phu Tho (Tan Son); *Amorphophallus yunnanensis* is distributed in Son La (Van Ho, Thuan Chau, Moc Chau), Hoa Binh (Tan Lac, Lac Son, Hoa Binh city), Cao Bang (Nguyen Binh, Thach An), Bac Kan (Ngan Son); *Amorphophallus yuloensis* is only distributed in Son La (Van Ho, Thuan Chau, Moc Chau), Dien Bien (Tuan Giao); *Amorphophallus corrugatus* is widely distributed in the northern mountainous provinces of Vietnam.

2) *Amorphophallus konjac* is a species having high glucomannan content, a growing prospect of planting. After 3 cultivating years, its tubers can reach to 600-1000 g weigh, with 44-47% glucomannan in dried weight and 8-10 seedling bulbs.

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NGHIÊN CỨU THÀNH PHẦN VÀ PHÂN BỐ CÁC LOÀI NƯA *(Amorphophallus* spp.) CỦ CÓ CHỨA GLUCOMANNAN Ở MỘT SỐ TỈNH MIỀN NÚI PHÍA BẮC VIỆT NAM

Trần Văn Tiến[1], Hà Văn Huân[2], Nguyễn Minh Quang[3], Nguyễn Văn Dư[4]

[1]Học viện Hành chính Quốc gia

[2,3]Trường Đại học Lâm nghiệp

[4]Viện Sinh thái và Tài nguyên sinh vật - Viện Hàn lâm KH&CN Việt Nam

TÓM TẮT

Ở Việt Nam, những thống kê gần đây đã ghi nhận ít nhất có 25 loài Nưa. Mặc dù đã có những kết quả nghiên cứu bước đầu về thành phần loài các loài Nưa (*Amorphophallus* spp.) nhưng các kết quả này mới chỉ ghi nhận sự có mặt của các loài trong lãnh thổ Việt Nam. Để có thể chọn lựa loài có hàm lượng glucomannan cao, có triển vọng phát triển ở Việt Nam, cần có các nghiên cứu sâu hơn về thành phần loài, các khu phân bố, cũng như các điều kiện về sinh học sinh thái, triển vọng phát triển các loài Nưa này thành nguồn tài nguyên thực vật cho củ làm nguyên liệu sản xuất bột Nưa. Trong bài viết này ghi nhận kết quả nghiên cứu ở 14 tỉnh miền núi phía Bắc Việt Nam có 6 loài Nưa củ chứa glucomannan. Loài Nưa konjac có hàm lượng glucomannan cao nhất (trong củ Nưa khô là 44,97%) và là loài có triển vọng nhất để phát triển thành một trong những cây nông nghiệp. Ở loài này, sau 3 năm trồng, củ mẹ đạt khối lượng 600 - 1000 g, hàm lượng glucomannan 44 - 47%, và cho 5 - 7 củ con giống/năm.

Từ khóa: *Amorphophallus*, glucomannan, thành phần loài.

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