

## Millet Seminar Q&A

(please note that the speakers reconsider how to address the questions after the seminar, thus the answers provided below may be different from those answered during the seminar).

I used to study drought tolerance of sugarcane. Like sugarcane, is it common to practice ratooning in sorghum? If ratooning is practiced, how much (%) would the sorghum harvest decrease or increase from the first harvest? Is it also common to practice ratooning with sweet sorghum?

(Dr. Subbarao)

1. For sweet sorghum, which is harvested before heading stage, as the sorghum stalks are used for crushing (similar to sugarcane), thus it may support at least one ratooning crop, though much lower yields (unlike sugarcane), but when availability of water and possibly some nitrogen fertilization is assured, this may be somewhat viable I think.

2. For grain sorghum, ratooning is not practiced in India or in Africa as the grain yields from ratooning are not economically viable. I believe it is the same in USA.

Japanese millets Variety name ?

(to Prof. Kawase)

Concerning this question, clarification is needed. "Variety name" may include various meanings. During the symposium, I answered the question as recognizing that it was asked common names in Japanese for several millets as follows;

foxtail millet, *Setaria italica*: "awa"

Japanese barnyard millet, *Echinochloa esculenta*: "hie" or "nihon-bie"

It is originally "hie", and "nihon-bie" is used to distinguish it from Indian barnyard millet ("indo-bie").

common millet, *Panicum miliaceum*: "kibi" or "ko-kibi" or "ina-kibi"

It is originally "kibi". In the words "ko-kibi" and "ina-kibi", "ko" and "ina" are adjectives meaning "small" and "rice-loke", respectively.

finger millet, *Eleusine coracana*: “shikoku-bie” or “kamoashi-bie or “chosen-bie”

Job’s tears, *Coix lacryma-jobi* var. *ma-yuen*: “hato-mugi”

pearl millet, *Pennisetum glaucum*: “tôjin-bie”

sorghum, *Sorghum bicolor*: “morokoshi” or “taka-kibi”

If the questioner would like to know officially registered “variety” names, it is completely different question. Newly registered varieties of millets are not so many, but you can obtain names of bred varieties. You can search the database of the Ministry of Agriculture, Forestry and Fisheries (MAFF). The URL is:

<https://www.hinshu2.maff.go.jp/vips/cmm/apCMM110.aspx?MOSS=1>

Regarding the definition of millet, academically, I think they are "small-grained gramineous crops" as mentioned by Dr. Sakamoto in Japan. In general, it is defined by the Zakkoku Association as “a general term for grains used by Japanese people in addition to staple foods.”

(to Prof. Kawase)

Yes, the academic definition of millet(s) is "small-grained gramineous (family Poaceae) crops". The English word millet(s) is usually translated “zakkoku” in Japan, which may provide some confusion.

The Japanese word “zakkoku” has a quite different origin from the English word “millet”, and does not always mean millet(s). As you know well, it can be used for various crops including millets, because it is generally thought as a complement set of “shukoku (major crops)”.

As I explained in the session, cultivated crops are conceptually and traditionally grouped in to four categories in Japan;

- “shukoku (主穀) ”: major staple grain crops including rice, wheat, etc.
- "zakkoku (雑穀) ": miscellaneous minor crops including various millets
- "shukukoku (菽穀) ": legumes such as soy bean, azuki bean, etc.
- "gikoku (擬穀) “: pseudocereals such as buckwheat, amaranths, chenopod, etc.

Those four categories are not always treated equally, and "zakkoku"(雑穀) can be used for a wide range of crops, because it is often thought as a complement set of "shukoku (主穀)". It sometimes includes leguminous crops and/or pseudocereals. Maize is a major crop in the world but sometimes included in zakkoku in Japan.

Please tell me why it is necessary to improve varieties even though there are many varieties. Since gene editing and genetic modification cannot be used in organic cultivation, I think this contradicts the advantages of millet grains, but what do you think?

(to Prof. Kawase)

It is an interesting question, which have been repeatedly asked. Not only millets, all the crops need improvement. Environmental conditions are always changing and human demands are different time to time and place to place. It is natural that farmers hope to grow crop varieties with higher production, disease-free, pest tolerant and good quality. They also look for crop varieties that do not need laborious management. Crop improvement has continuously been carried out to fulfil those demands.

Organic farming is an antithesis proposed against modern agriculture. A large amount of fertilizer, pesticides, herbicides, irrigation water, and so on often used in modern agriculture is actually damaging our environments and biological diversity. We should be calm and serious to think what is the most balanced point for our future.

Millets are not wild species. Like rice, wheat and maize, they have a long history of cultivation spanning thousands of years. During the history, people selected millets plants with useful traits and adaptive characters consciously and/or unconsciously. Landraces (traditional varieties) of millets have been improved for a long time. We have selected better ones. Why we have to stop here without developing millets in the future.

Some people dislike or deny transgenic plants. You are free to oppose them. It is a good attitude to examine carefully a new variety that has been bred by new technology. We should think the possibility of unexpected phenomena

Transgenic experiments are carried out in certain places in accordance with rules and guidelines. In the case of crop plants, promising varieties should be strictly checked in different aspects of safety.

Millet has not been focused on by breeders' point of view, since they did not have economic importance compared with major crops. That's why we can collect various landraces. That's why we may not have appropriate knowledge/information how to weed, how to fertilize, how to control pests or diseases and how to improve. There is a great room of improvements in millets.

Any millet variety that is grown in organic farming has been improved by our ancestors. Mutants have been selected, hybridization has occurred among cultivated plants and even between cultivated and wild plants. Repeated cultivation has naturally resulted in accumulation of genes adaptive to the environments. Such genetic modification has been accelerated and refined by means of genetics and biotechnology.

Genetic engineering and organic farming are not necessarily contradictory. When genome editing changes a single or limited number of nucleotides and no foreign nucleic acid is incorporated, it is no different from artificial or even natural mutations. In the future, a millet variety improved by genome editing to have an efficient use of nutrition and photosynthesis will be grown by organic farming under social acceptance, I believe.

As mentioned in the introductory session, millets are known to have multiple merits, but what factors have kept millets underutilized despite these merits? In particular, what aspects of millets are comparatively disadvantageous to those of rice, wheat and maize?
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(Dr. Hughes)

Millets have been relatively unknown, growing in some of the poorest regions of the world. Most research funding has traditionally gone to the crops which are of immediate interest to the wealthier countries, whether for food, feed, fodder or industrial uses. There has been underinvestment in millet research, which means that productivity was not as improved as with the big three (rice, wheat and maize) and neither were value chains strengthened to promote consumer demand and thus market 'pull'. Poor keeping quality of millet grains and flour, skills and time required to cook millet recipes and non-inclusion of millets in public food distribution systems are also some of the factors responsible for keeping millets in a disadvantageous position compared to the big three.

Could you give us any information on farming system research where millets and other crops are grown together (rotationally or intercropping)? Some millets can become weeds to other crops (ex. rice) and some farmers may be hesitant to introduce millets into their farming systems. Could you share your thoughts on this?

(Dr. Hughes)

All our agricultural production is in the context of 'farming systems', whether traditional systems or industrial systems. For the best soil management and to use good agricultural practices (GAP), millets can be, and are, grown in rotation with grain legumes such as chickpea and pigeon pea (thus enhancing soil nitrogen). Any plant in the wrong place is technically a weed. In the case of millets, however, this is not an issue. Millets are generally grown in dry or water-scarce areas and, hence, are not seen as weeds competing with crops such as rice, wheat or maize that are cultivated mainly under irrigated conditions.

(Dr. Subbarao)

In Asia and in many parts of Africa, sorghum and pearl millet are often grown as intercrops. Sorghum and pigeonpea is one of the most combination grown as an intercrop. Sorghum, being relatively faster growing habit in the early season combines very well with pigeonpea which is very slow growing initially and does not affect sorghum yields very much, and pick ups growth only after the sorghum is harvested and grows several months to produce reasonably good yields from pigeonpea. The land-equivalent ratio (LER) of sorghum-pigeonpea is often close to 1.5 to 1.7, thus is one of the extensively practiced intercrop in India and in many parts of East Africa and Southern Africa.

For West Africa, Pearl millet-Cowpea is another commonly used intercrop system, where LER are more than 1.0, indicating that such production system benefits farmers, thus extensively used and adopted. I don't have much knowledge about finger millet in an intercropping system; Other minor millets may be mostly grown as sole crops and I don't have any knowledge of their use in inter-crop systems.

Sorghum is traditionally rotated with wheat in Northern India. Similarly sorghum and groundnut is often practiced. Pearl millet is an important component of cropping systems in Central and Western India. In many West African countries, Pearl millet is an important part of cropping systems.

(Dr. Yoshihashi)

In Japan, INUBIE, the ancestor of domesticated Japanese barnyard millet, is considered the worst weed for paddy fields. As the Japanese word for millet is part of the word INUBIE, it may evoke associations with Japanese word for millet is INUBIE, the millets may be associated with this with this troublesome weed. This could be a factor in the decline of millet production.

Some start-ups of agriculture advertise and sell fonio as "super food". If those start-ups buy with appropriate value from farmers, while farmers that cultivate millets comply quality, enough amounts and delivery date, the win-win situation causes between start-ups and those farmers. I guess such a way is one of the useful methods to increase production and acceptance by consumers.

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It certainly does set up a 'win-win' situation for the consumer, the producer and the actors in the value chain. All millets are highly nutritious, with low glycaemic index and without gluten – thus could all be called “super food” though at ICRISAT we prefer to call the millets “Smart Food”. Acceptance by the consumer and the strong market demand are a sure way to make millet production sustainable and profitable.

Millets can be optimal crops for dry areas. How do you think can we possibly increase millet production in Japan? Millet production is often not economically viable and requires a lot of labour, thus there are likely few farmers who are willing to add millets into their farming business. These days, most of the existing millet producers are aging and leaving the farming farming. In view of the domestic trend of decreasing millet production, I would like to know if there are any examples from other countries that have successfully increased millet production in recent years.

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Millets are a staple food in some countries such as Niger, Nigeria, Senegal, Kenya, India etc. In some countries the millets are an important industrial crop such as for beer production (Nigeria) and blending in poultry and cattle feed ( India, Spain, US, Brazil). In these countries millet production is increasing and becoming increasingly important. For interest in millets to resurge in Japan, there would need to be supportive agricultural policies, and increased interest in their traditional roles, and a greater interest in their health properties by the consumer. It will require government and local focus to achieve this aim that will benefit consumers and perhaps indirectly help mitigate the production of greenhouse gases from rice production.

(Prof. Kawase)

Strong motivation will be needed to make breakthrough in the prevailing situation.

India has successfully improved production of millets recently. Popular millets are pearl millet, sorghum and finger millet there. Now, millets are not poor man's food. When we visited a super market in Delhi, we found different kinds of snacks, biscuits, cookies, etc. made from millets and/or pseudocereals often with a label of organic farming, non-allergenic, gluten-free, high content of protein, various vitamins, etc. have become key words there.

In Europe and US, "ancient wheat" are making comeback: einkorn, spelt wheat, Georgian emmer, emmer wheat, etc. In Japan, you can find "ancient rice" in cereal shops. They attracted intelligent and fairly wealthy health-conscious people due to their nutritional contents. Compare with the 30 year ago, food made from millets has become popular in the market.

Most of the millets can be grown adaptively in semi-dry areas. Japan of which the annual average rainfall is around 1,600-1,800 mm has a long history of millet cultivation. Japanese barnyard millet and finger millet can be well grown in paddy fields. If the many consumers are eager to use millets and accept higher price compared with imported ones, we can increase

the production inside Japan.

Milletts have been ignored for a while in Japan, only a few pesticides are registered for millets. Almost no herbicide is available for millet cultivation. We don't have effective methods to avoid birds' attack. Such agricultural infrastructure and resources are not well prepared for expanded commercial production of millets.

I don't have a special idea to promote millet cultivation in Japan. We are focusing some party and people who are trying to encourage millets production and enhance their utilization. Such steady grass roots activities will be able to develop if conditions are fulfilled.

(Dr. Subbarao)

There may be some scope for growing sorghum or Fingermillet or pearlmillet in parts of Japan (in rice-fallows, i.e. after rice harvest) in areas that are lying vacant. Though they don't have much economic value at present, it is likely to change as they are considered as functional foods or super-foods due to their mineral- and fiber-rich and slow releasing carbohydrates, make them suited for people who want to have healthy lifestyle and willing to pay a premium price for these foods. Once this happens, then the economics may drive their adoption for Japanese farmers also at some point of time.

It's great to see that millet yield has been on the rise in India. I'm curious, what do you think are the key factors driving this trend? Could it be due to climate resilience, the development of better cultivars, or perhaps even changes in farmers' preferences? Or is it due to cultivated area expansion rather than increasing yield per unit area?

(will respond later)

Q7: I am curious about the impact of biofortification on grain yield. If we aim to increase the zinc and iron content in the grain, does this affect the overall yield? I am aware that there is often a trade-off between grain quality and yield, so I would like to learn more about the potential effects of biofortification.

(will respond later)