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Use of *Scleria poaeformis* as biomaterial in etno-agricultural practice at riparian wetlands in Indonesia

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Abstract

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Local farmers grow rice only once annually at riparian wetlands in Indonesia due to unpredictable annual flooding occurrence. Farmers have to wait for floodwater to subside before planting rice seedlings but have to do the planting as early as possible for avoiding drought at reproductive growth stage. This etno-agricultural research was conducted in 2016-2017 using mixed method, started with direct and frequent field observations at five targeted villages, followed by series of dialogs with 69 local farmers and key persons based on Grounded Theory protocols for capturing key issues. One fascinating result of this study was the use of local biomaterials (*Scleria poaeformis*) in constructing floating seedbed for growing rice seedlings. Application of this grassroots innovation makes it possible for local farmers to start their rice growing season about one month earlier since seedling preparation can be started before floodwater subsided and flexibility of around two weeks in transplanting the rice seedlings from floating seedbed to paddy field.

Keywords: etno-agriculture; floating culture; *Scleria poaeformis*; inland swamp; rice cultivation

Introduction

Rice cultivation at riparian wetland is very challenging for smallholder farmers in Indonesia. Both soil and water conditions have to be managed. However, there are many workable ways to improve soil quality and improving rice yield, including application of biochar (Kartika et al., 2018a; Lakitan et al., 2018a) and designing more efficient cropping patterns (Kartika et al., 2018b). Conversely, it is almost impossible for smallholder farmers to manage unpredictable annual flooding behavior at the riparian wetland. Local farmers use floating seedbeds for rice seedling preparation as a strategy to avoid the seedlings from threat of total submersion if they are grown on land. Local farmers use *Scleria poaeformis* as main locally available biomaterial for constructing the floating seedbed.

Research on *Sclerieae* tribe especially the *S. poaeformis* has been very limited compared to other tribes within the *Cyperaceae* family (Muasya et al., 2009). The *S. poaeformis* plant was mostly considered as weed (Chandrasena, 1987) with hardly any economic value. In certain regions, *S. poaeformis* has been traditionally used as biomaterial for making mats by the locals (Kern, 1974). The use of *Scleria* for making mat is local specific, is not widely spread to other locations where *S. poaeformis* is also found.

The rural community in Sri Lanka based on their indigenous knowledge have been using *S. poaeformis* as an indicator of soil salinity (Dharmasena, 2007). At riparian wetlands in Indonesia, the same species has been recognized as a pioneer plant which grows vigorously in acidic soils. The ability of *S. poaeformis* to grow at extreme soil pH requires further evaluation. Kern (1974) indicated that *S. poaeformis* was relatively indifferent in soil preference. The species was commonly observed in distinct swamp edges and often formed tall pure stands along lake shores.

Common name of *S. poaeformis* is swamp sedge or nutrush or prue. Other Latin names or synonyms of this swamp sedge are *S. oryzoides* Presl and S. *poiformis* Retz. More information on the nomenclature of the genera and subdivisions within the *Scleria* of *Cyperaceae* family is described in Camelbeke et al. (2001). The species was originated in tropical Australia and spread to Southeast and South Asia as well as to tropical Africa (Kern, 1974). In Indonesian archipelago, this sedge is commonly found at riparian wetlands in South Sumatera, South Kalimantan, and Central Kalimantan. At riparian wetlands in South Sumatera, Indonesia, this wild sedge is known by its local name as *berondong*.

At landscape level, the swamp sedge grows vigorously and becomes a dominant species at riparian wetlands, forming a singularized patch especially at acidic soil and deep swamp in riparian wetland ecosystem. As a naturally dominant species at riparian wetlands, this species provides abundant biomaterial for floating seedbed construction. As in many species within the *Cyperaceae* family, the reproduction of *S. poaeformis* occurs by seeds or vegetative organs. In addition, *S. poaeformis* also develops lateral creeping rhizomes as other reproduction mechanism. Leck and Schütz (2005) reported that the main seed dispersal vectors were water and animals.

Scleria poaeformis has been considered as a major weed in paddy fields. This sedge has also been suspected as a potential host for insect pests of rice (Litsinger, 2007). Study on *S. poaeformis* in agriculture mainly focused on controlling this species as noxious weed (Martin et al., 2017; Ribeiro-Mesquita et al., 2015, 2016). Study on potential economic benefit of using *S. poaeformis* as biomaterial for rice production at riparian wetlands has been lacking.

The objective of the current study was to explore the socio-economic benefits of *S. poaeformis* in agricultural production at riparian wetland in South Sumatera, Indonesia. The study focused on the use of the plant as biomaterial for constructing floating raft for rice seedling production before transplanting to paddy field.

Materials and Methods

Study area

Data collections were based on field observations and dialogs with farmers and local key persons across five villages within the Pemulutan riparian wetland ecosystem. The villages included Pemulutan Ulu, Pelabuhan Dalam, Teluk Kecapi, Sukarami, and Muara Dua in the province of South Sumatera, Indonesia (Fig. 1). The major part of the lands surrounding these five villages were directly affected by seasonal flooding due to overflown water from the Ogan River during the rainy season.

Fig. 1. Study was conducted at five villages as indicated by dotted circles (*C*) in South Sumatera (*B*), Indonesia (*A*)

Procedures

Direct and frequent field observations covered typology of riparian wetland landscape, existence of river and creeks as sources of water, annual flooding pattern, agricultural land use, rice farming practiced by local farmers, availability of *S. poaeformis*, and technical aspects of constructing floating seedbed by local farmers. Grounded Research protocols were employed to objectively capture real and up-to-date issues on etno-agriculture, economic, ecological, and socio-cultural aspects associated with rice cultivation at riparian wetlands (Lakitan et al., 2018b), but later more focused on used *S. poaeformis* for constructing floating seedbed and *Urticularia vulgaris* used as growing substrate for rice seedling. Data were collected from 2016 to 2017.

Dialogs were conducted on-the-spot based on the Grounded Research protocols (Glaser and Strauss, 2009), without pre-conception, free flow, open topic with insertion of issues related to rice cultivation practices and use of *S. poaeformis* floating seedbed. Dialog partners were randomly selected among the local farmers or key persons at the village level during the seven visits to the villages. Dialogs were done by one senior researcher plus five pre-coached interviewers; each conducted the dialog with 1 to 3 individual farmers per day. Sixty nine dialogs were completed for in-depth qualitative analysis using Grounded Theory procedures.

Data analysis

Qualitative and visual data collected during direct field observations were screened, clustered, and structured for constructing current and realistic mosaic of interrelated issues within sphere of tropical riparian wetland agriculture. Intentionally, no effort was done to quantify the qualitative and visual data for avoiding loss of significant pieces of information during quantification processes. The qualitative data were extracted from collective field notes of individual researchers. Source of visual data was collection of photographs captured during field observations. Broad description of visual data by Emmison and Smith (2000) is adopted in this research. Digital camera was used as tool for freezing the moments and observable objects. Analysis of visual data is in accordance with Knoblauch et al. (2008).

There were several interesting findings from analysis of qualitative and visual data collected from direct field observations, but in this study, use of *S. poaeformis* as biomaterial in constructing floating seedbed for rice seedling production was selected as main focus of the dialogs with local farmers and key persons. The dialogs were conducted based on the Grounded Theory protocol.

Qualitative data collected from 69 dialogs were analyzed according to Corbin and Strauss (2014), starting with coding, followed by conceptualizing, categorizing, and developing theory. Methods included in the analysis are inductive, comparative, iterative, and interactive as suggested by Charmaz and Belgrave (2012).

Results and Discussion

Description of Scleria poaeformis

Based on specimen collected from the field, plant used by local farmers for construction of the raft was identified as *Scleria poaeformis* Retz. Roots, stems, leaves and reproductive organs of *S. poaeformis* plant collected from Pemulutan riparian wetland are shown in Fig. 2. Thick and hardened fibrous roots and rhizomes provide strong anchor to *S. poaeformis* plant to grow on soft muddy soil. The base of the plant is purplish red (Fig. 2A). Spongy lower leaf sheath (Fig. 2B) is very important feature of the plant. This part makes the plant float on water.

Long-and-sturdy leaf blade are suitable for use as biomaterial for construction of floating raft. Leaf blades of *S. poaeformis* plant are straight and linear with the length of more than 1 m and width of 2-4 cm. The color of the healthy blade is dark green. There are three prominent nerves in leaf blade, parallel to leaf length. The tip of the leaf blade is rather abruptly narrowed (Fig. 2C).

The inflorescence of *S. poaeformis* plants is single, compound, with long-peduncled panicle (Fig. 2 D). Spikelet is solitary and evenly distributed along the branches of the panicle. The female spikelets are located mostly at the base of branches (Fig. 2 E). The shape of the nuts is round or slightly oval, 4-5 mm in length. Nut color is white (Fig. 2F).

Availability and demand on Scleria poaeformis

At present, *S. poaeformis* is locally available in large quantity, requires no or very low extra cost to collect this

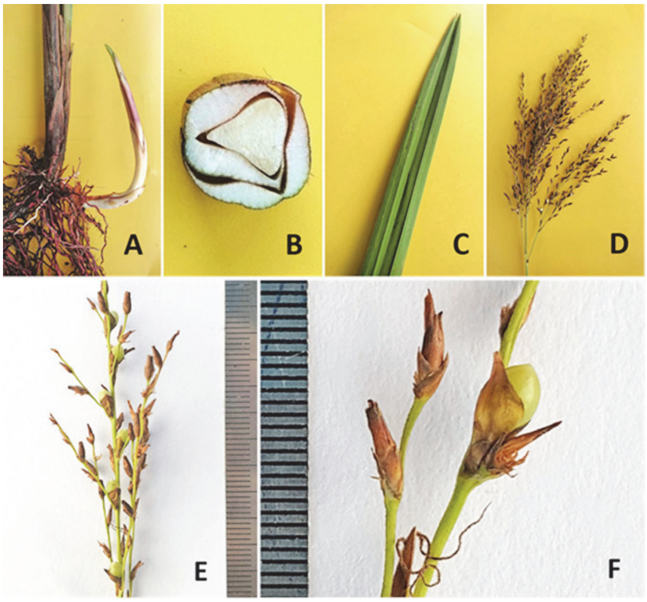

Fig. 2. ***Scleria poaeformis*** **Retz. showing roots and rhizome that grows into newly emerging shoot (*A*), cross section of spongy lower sheath (*B*), tip of leaf blade (*C*), inflorescence (*D*), female and male spikelets, scale: 1 mm/bar (*E*), and lateral view of nut, scale: 0.5 mm/bar (*F*)**

biomaterial for constructing raft required for floating rice seedling production. Therefore, *S. poaeformis* has been used by several generations of local farmers. Pure stands of *S. poaeformis* can be easily found in the riparian wetlands at the Pemulutan wetlands (Fig. 3A). The pure stands of *S. poaeformis* were mostly occupying abandoned low quality agricultural lands (acidic and low nutrient content), or lands that have been damaged due to frequent burning or mismanagement. Expenditure associated with the use of this biomaterial is only required if a farmer opted to purchase a ready-to-use raft (Fig. 3B) from other farmer.

The preferred age of rice seedlings ready for transplanting to paddy field is 3-week old. Transplanting is done if the floodwater on paddy field has subsided to a depth of 15 cm or less. Since the time at which floodwater subsides to the preferred depth is hard to predict and condition of paddy field surface is not perfectly flat, the local farmers commonly prepare rice seedlings at different ages (Fig. 3C). At some villages at Pemulutan wetland ecosystem, floating rice seedling production is practiced at large scale (Fig. 3D).

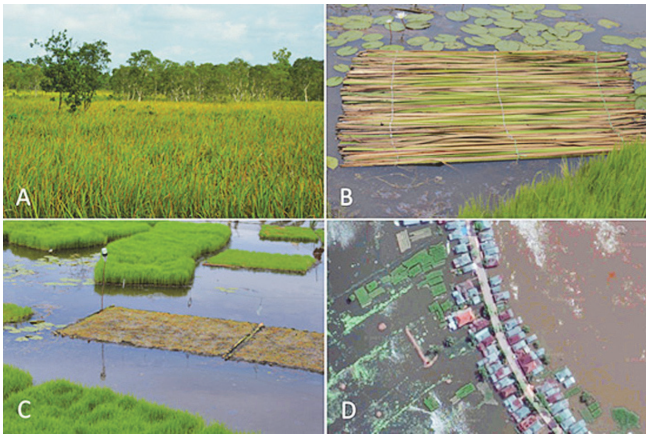

Fig. 3. Dense and pure stand of *Scleria poaeformis* at riparian wetland in South Sumatera (*A*), raft made of *S. poaeformis*, ready for use in preparing rice seedlings (*B*), floating system for rice seedlings production (*C*), and satellite image of one studied village, showing the floating rice seedlings (*D*)

Floating rice seedling production as practiced by local farmers

The raft was constructed by arranging the leaves of *S. poaeformis* in parallel position. The leaves were divided at equal portion. Half portion of the leaves was directed toward one direction and the other half was toward the opposite direction such that the spongy lower leaf sheaths were positioned equally at both sides. This practice was intended to keep the raft in balanced condition and to shape the raft in a near perfect rectangle. Several layers of leaves were stitched together to form a flat and sturdy floating raft.

The length of the raft depends on the length of the leaf blades, varies from 1.5 to 2.0 m and the width is usually less than 1.0 m. Farmers prefer smaller raft since it is easier to handle than the larger one. This traditional, biomaterial-based floating raft has been proven to be effective and widely practiced for rice seedling production at riparian wetlands in South Sumatera, Indonesia.

Prior to sowing, seeds are soaked for several hours or up to overnight in fresh water. Some farmers wait until radicle protrudes the seed coat before sowing. Farmers do not use

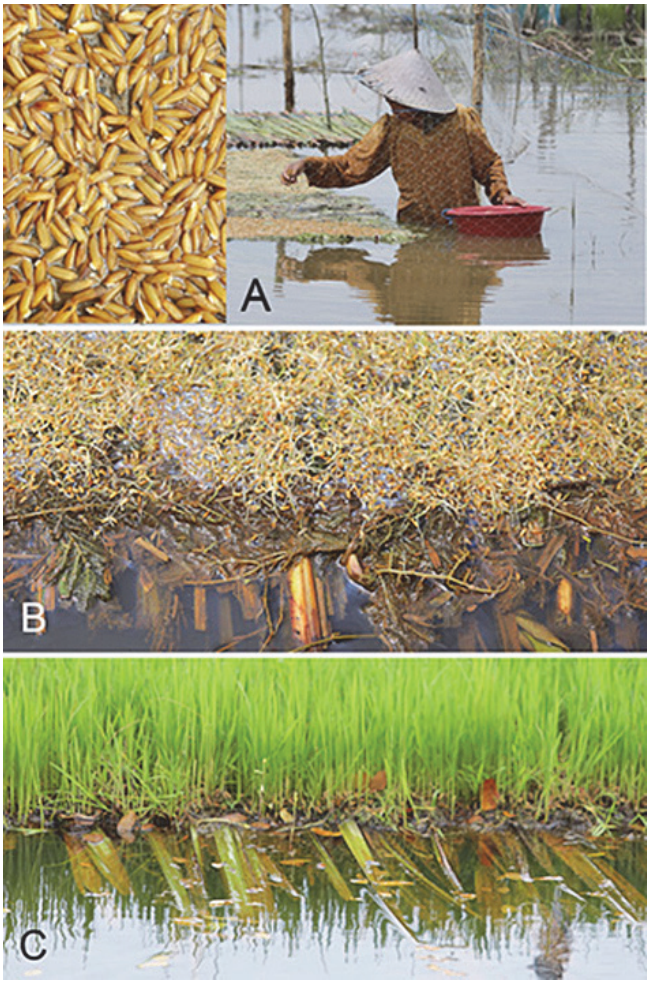

Fig. 4. Floating culture of rice seedlings as practiced by local farmers. Seed sowing on decaying aquatic plants as substrate (*A*), germinating seeds (*B*), and rice seedlings ready for transplanting (*C*)

soil as growing substrate, instead they use decomposed locally-abundant aquatic plant *Utricularia vulgaris* biomass. The seeds are densely broadcasted (3 kg m^{-2}) and evenly smeared to cover the entire surface of the organic substrate (Fig. 4A). Roots grow earlier than leaf does (Fig. 4B).

Near the end of flooding period, seedlings at age of 2 to 3-week old are transplanted to paddy field if floodwater has receded to a depth of 15 cm or less. At that time, the height of the rice seedlings normally varies from 20 to 30 cm (Fig. 4C) so that they are not fully submerged at the time of transplanting to paddy field.

Benefits of using Scleria floating seedbed

The objective of using floating seedbed for rice seedling production was to enable earlier start of rice growing season (Lakitan et al., 2018b). Transplanting could be started before floodwater completely receded. If seedlings were transplanted at the age of 3-week old and it took another 1 to 2 weeks for floodwater to fully recede. Then, rice growing season was 4 to 5 weeks earlier compared to direct seeding method. Direct seeding cannot be applied during the period when paddy field was under flooded condition.

The goal of early rice growing season is: (1) to avoid rice plants from experiencing drought stress at late generative phase at shallow riparian wetlands, or (2) being submerged before rice plants are harvested at deep riparian swamp. Drought stress during reproductive growth stage could significantly decrease rice yield (Ji et al., 2012; Trijatmiko et al., 2014). High flooding or submerging occurrence during late reproductive growth stage could cause total harvest failure (Kotera et al., 2016).

Floating seedbed made of *S. poaeformis* is very suitable for rice seedling production but it is not suitable for floating raft for vegetable production that requires longer time to harvest, since this biomaterial will decompose in less than a month (Siaga et al., 2018). The use of floating raft made of *S. poaeformis* has many advantages including available raw material at local level, easy to make, low cost, and environmentally friendly. Biomass of *S. poaeformis* will be fully decomposed after rice seedlings are transplanted to paddy field. Decomposed biomass provides extra nutrients to soil.

Floating seedbed method at Pemulutan riparian wetlands is a soil-less culture. Seeds are sown on lighter growing substrate of decaying biomass of *Utricularia vulgaris* instead of soil. The seedlings do not need watering and fertilizing because this biomaterial absorbs water from underneath the seedbed and provides moisture to roots of the seedlings, whereas decaying process of the biomass gradually releases nutrients for the growing seedlings.

Knowledge on use of floating seedbed for rice seedling production has been adopted by local farmers who has lived through common problem of unpredictable time of floodwater subsides to acceptable level for transplanting of rice seedlings to paddy field. This knowledge has been openly shared and practiced amongst local farmers and creates significant benefits to their livelihood and also significantly contributes to sustainable agricultural practices at the riparian wetland ecosystem in South Sumatra, Indonesia.

Conclusion

Scleria poaeformis plant is very important biomaterial at riparian wetland in Indonesia. It has been used for constructing floating seedbed for rice seedling production. Rice cultivation at riparian wetlands uses transplanting method; therefore, the availability of good quality seedlings at appropriate time are the key for successful rice cultivation. The challenge is to produce rice seedlings at around 3-week old at the time of floodwater has subsided to 15 cm depth or less. The only way to provide such seedlings is to sow rice seeds on floating seedbed. Starting rice growing season as earliest as possible is local farmer's strategy for avoiding drought condition during rice reproductive growth stage at shallow riparian wetland or submerging occurrence at time of harvest at deep riparian wetland.

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