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Guidelines for Dry Seeded *Aman* Rice (DSR) in Bangladesh

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Guidelines for Dry Seeded *Aman* Rice (DSR) in Bangladesh

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Guidelines for Dry Seeded *Aman* Rice in Bangladesh

1. Introduction

Dry seeded rice (DSR) is becoming an attractive option for farmers as it has a much lower labor requirement than manually transplanted rice. Labor for transplanting rice has become scarce and costly because laborers are shifting from agriculture to industry, public works and services, and migrating abroad. DSR can be readily adopted by small farmers as well as large farmers, provided that the required machinery is locally available (e.g., through custom hire from agricultural service providers). Best practice involves using a 2- or 4-wheel tractor-drawn drill to seed in rows into nontilled or dry tilled soil, as for wheat. Because the soil is not puddled, DSR also has a lower water requirement for crop establishment, and may require less frequent irrigation than puddled transplanted rice grown with alternate wetting and drying water management during dry spells. Where arsenic-contaminated groundwater is used, less irrigation means less arsenic brought to the soil surface. Furthermore, accumulation of arsenic in the grain and straw is much less if the soil is allowed to dry between irrigations to let air (oxygen) into the soil ("aerobic" conditions) than in continuously flooded rice.

2. Site suitability

a. Soil

DSR can be grown on the same soils as puddled transplanted rice, which typically range from sandy loam

to heavy clay. It is most suited to high and medium-high land situations.

DSR is particularly well-suited to the conditions of northern Khulna, Rajshahi, and Rangpur Divisions, and Faridpur District in Dhaka Division, where rice is grown in rotation with a wide-range of upland crops such as wheat, maize, legumes etc. The growth and yield of upland crops is improved when grown in rotation with DSR instead of conventional transplanted rice, because the soil is not puddled for DSR.

Don't grow DSR on light textured soils such as loamy sands.

Don't grow DSR on salt-affected soils.

Don't grow DSR in situations where there is a high risk of heavy rain or flooding within the first three weeks after sowing.

b. Seasons

DSR may be grown during the kharif (dry seeded aman rice) provided it is sown before the monsoon rains start. Dry seeding may also be used for the aus crop. This is a common practice in some areas, with the seed usually broadcast (traditional method). In the main boro areas (north and northwest Bangladesh), if DSR is to be grown during the dry season, seeding should be delayed until February to avoid establishment failure or serious cold damage due to low temperature in December and January. In this case, the crop is too late to be called boro, and too early to be called aus; it might thus be referred to as "braus".

These guidelines have been developed specifically for dry seeded aman rice, however, most of the recommended practices would also apply to dry seeded aus.

3. Field preparation

a. Land leveling

Key check 1.

– Fields must be accurately leveled.

Good land leveling helps ensure high yield and reliable production of DSR. This is best achieved using laser-

Land leveling using laser guidance

assisted land leveling, but it can also be achieved by careful leveling using a traditional leveler drawn by animals or a 2-wheel tractor, followed by laddering (planking). A level field allows planters/drills to place seed more precisely and enables more uniform irrigation and water depth, leading to a uniform crop stand and improved weed control and nutrient use efficiency. Leveling also helps to reduce irrigation water application by eliminating high spots. If farmers do not have access to laser land leveling equipment, a good way to judge how level a field is to measure the depth from the top of the water to soil surface when the field is flooded. If this is done in a number of locations, the high and low parts of the field can be located, which can be smoothed out by moving soil and laddering later on.

b. Tillage

DSR can be sown into soil tilled as for wheat ("conventional tillage"), into partially tilled soil using strip tillage, or into nontilled soil ("zero tillage"). The decision on whether or not to cultivate the soil depends on site-specific factors, such as the need for leveling, the availability of appropriate machinery and tools, weed pressure, crop rotation, and the risk of rodent attack.

i) Conventional tillage (CT) : The soil should be cultivated to a depth of about 5 cm to achieve a fine enough tilth for good seed-to-soil contact, as for wheat and other rabi crops. Depending on soil type, weed infestation, and field conditions, this might involve 1-3 passes of a power tiller with a 2-wheel tractor, or 2-3 passes of a tyne cultivator drawn by a 4-wheel tractor, followed by laddering. In Bangladesh, 4-wheel tractor powered rotovators are becoming more common and can also be used, though these methods are energy intensive and require more fuel and thus cost to establish the crop

compared to ZT and ST. Furthermore, they compact the soil which is deleterious for the growth of upland crops.

ii) Zero tillage (ZT) and strip tillage (ST) : For ZT-DSR and ST-DSR, existing weeds should be killed by a nonselective herbicide such as glyphosate (see Table 3 for application details). In situations where weed infestation is not uniform, the herbicide can be applied as a spot treatment rather than a blanket application, which can save farmers considerable money by reducing costly chemical application. Glyphosate should be applied at least 5 days before sowing. Apply the herbicide when weeds are actively growing and not under stress. If weeds are under moisture stress, a light irrigation should be given 5−7 days before herbicide application for a better weed kill.

Use clean water and a plastic container to make the spray solution as herbicides bind with suspended soil particles and metal surfaces (do not use iron buckets to mix the solution). Use a multiple-nozzle boom fitted with flat-fan nozzles for full coverage (see later). Where multiple nozzle booms are not available, you can still use a single boom, but it will be less effective.

Key check 2.

– All herbicides and pesticides are toxic; apply using all the safe procedures described below.

– Use clean water and a plastic container to make the spray solution.

– Use a multiple-nozzle boom fitted with flat-fan nozzles for full coverage.

Key check 3. Always use safe procedures for applying herbicides and pesticides

All herbicides and pesticides should be regarded as dangerous. Proper safety precautions should be followed. These include

- Wearing protective clothing when mixing the chemicals with water and when spraying. This includes wearing of rubber gloves, a face mask, goggles, a hat, a long-sleeved water repellent coat or apron with coat sleeves covering the gloves, rubber boots, long trousers – worn over boots.
- Protective clothing should be removed and washed after use, and operators should take a bath/shower with soap after applying chemicals.
- Operators should not smoke or eat when mixing or applying chemicals.
- Spray tanks must not be washed out in rivers or ponds as many chemicals are toxic to fish and amphibians.
- Pesticide containers should be buried at least 50 m from running water and 1 m deep, burnt well away from people/houses, or recycled where this is available.
- Empty pesticide containers should not be used to store food or drinks.

4. Cultivars

Many of the varieties bred for puddled transplanted rice are also suitable for DSR. Avoid long duration varieties to enable timely planting of rabi crops such as wheat, maize, potato, mustard, lentil, and winter vegetables after rice harvest. The use of shorter-duration varieties also helps to reduce irrigation requirement to finish the crop, which can also save farmers money by reducing pumping costs. Their higher early vigor also helps to suppress weeds. However, shorter-duration cultivars will not facilitate timely planting of rabi crops where inadequate drainage is the primary factor preventing this. In these areas, which will tend to be medium-lowland elevations, longer-duration varieties should be used because of their higher yield potential.

5. Sowing date

Key check 4.

– Medium to long duration varieties : May 20 to 31.

– Short duration varieties : June 15 to 30; earlier in this range is better if water is available.

Where irrigation is available, or timely premonsoon showers occur, the best date for sowing DSR is 10–15 days prior to the onset of the north-west monsoon rains. The optimum time of dry seeding aman rice is late May for medium- to long- duration aman rice, so that the crop matures in time for sowing of rabi crops at the optimum time. Sowing of short-duration varieties should be delayed to the second half of June to reduce the risk of heavy rain during flowering, which

results in high sterility and lower yield. However, the later the crop is sown, the greater the risk of heavy rain at sowing. Heavy rain, especially on heavy (clayey) soils, can prevent timely sowing; rain shortly after sowing can seriously impair establishment. Therefore, it is safer to sow in mid-June rather than late June. However, the earlier the crop is sown, the greater the need for irrigation to establish the crop.

6. Sowing

a. *Crop establishment*

DSR can be sown in dry or moist soil: (1) rice seeded in dry soil requires a light irrigation to germinate the seed; (2) seeding in moist soil (*joe* sowing) is done after a presowing irrigation or rainfall. In *joe* sowing, planking (laddering) after seeding helps to conserve soil moisture and improve establishment. When using conventional tillage, rice can be established by either of these two methods. However, for ZT-DSR, *joe* sowing is better as the soil is softer, especially in clay loam soils.

b. *Machinery for sowing*

For precise seeding, rice can be drilled using a seed-fertilizer drill. The most commonly available drills in Bangladesh are sometimes referred to as a “power tiller–operated seeders” (PTOS). Chinese-made seed-fertilizer drills come attachable to both Dongfeng and Sifeng 2-wheel tractors. These seed drills are becoming increasingly available in Bangladesh, and have been sold under a range of brand names including “Golden Seeder”. Sowing can be done in a single pass with full tillage or strip tillage (the latter is achieved by removing at least 50% of the rotor blades and aligning the remaining

24 rotor blades so that they till a narrow strip in front of the seeding tines). The depth of seeding needs to be adjusted by elevating the tillage blades to achieve a seeding depth of 1-2 cm. This is achieved by adjusting the roller bar that is attached to the back of the seed drill.

Because of the high speed of the rotary axle on these drills, no prior tillage is needed using either full or strip tillage. Some of these drills have an inclined-plate seeding mechanism which enables precise seeding of a range of seeds sizes (from rice and wheat to maize and chickpeas). Others have fluted roller seeding mechanisms. The Chinese seed-fertilizer drills/planters for 2-wheel tractors are an improvement on the PTOS designs that have been available for some time. The standard PTOS has a seed box but no fertilizer box, and a fluted-roller seeding mechanism.

There should be good coverage of the seed with soil to prevent desiccation and predation by rodents and birds.

Inclined-plate (left) and fluted-roller (right) seed metering systems

Crop being sown into rice stubble of the previous crop using a seed-fertilizer drill with inclined-plate seeding mechanism, using strip tillage, powered by a 2-wheel tractor. Tillage and seeding are done in a single pass. Note the crop residues from the previous crop that remain on the surface of the soil after seeding (right).

c. *Seed quality, rate, sowing depth, row spacing*

Key check 5.

- Use certified seeds.
- 20–30 kg/ha (with inclined-plate seeding mechanism).
- 35–45 kg/ha (with fluted-roller seeding mechanism).
- Seeding depth: 1–2 cm.

Seed quality greatly influences germination rate; therefore, the use of certified seeds is recommended. A seed rate of 20–30 kg/ha (using good-quality seeds with more than 85% germination) is optimal for DSR with a row spacing of 20 cm sown with an inclined plate seed metering system. Under good establishment conditions, the rate can be at the lower end of the range. However, where there is risk of reduced establishment due to factors such as suboptimal leveling, waterlogging, seed predation or sub-optimal moisture, the seed rate should be at the higher end of the range. There is no yield penalty for sowing at higher rates up to about 50 kg/ha. The seeding depth for rice is critical and the rice should be sown at 1–2 cm, and definitely not deeper than 3 cm.

d. Seed treatment

1. Priming

As DSR needs to be sown at a shallow depth (<3 cm) in advance of the monsoon rains, inadequate soil moisture can be a major constraint to rapid establishment of a good crop stand. Sowing with primed seeds into moist soil can assist rapid establishment. Priming (soaking the seeds for 10–12 hours in a gunny-bag [burlap] in water) accelerates crop emergence. After soaking, the seeds are air dried for a couple of hours, which facilitates free flow of seeds through the seed drill. Further, seeds can be incubated for an additional 8–12 hours for pregermination if sowing is to be done into moist soil (after rain or presowing irrigation) using an inclined plate seed metering system. The seeds should be sown shortly after priming and incubation. Emergence of pregerminated seeds will be adversely affected if sown into dry soil.

Don't sow primed seeds into dry soil unless you can irrigate immediately after sowing.

Don't sow pre-germinated seeds into dry soil.

Don't sow pre-germinated seeds using a fluted roller metering system

2. Seed treatment with fungicides and insecticides

Where seed-borne diseases are a concern, treatment with fungicides is recommended to manage diseases such as bakanae, loose smut, flag smut, root rot, collar rot, and stem rot. For this, a weighed quantity of seed is soaked in water treated with fungicide (tebuconazole—Raxil Easy® at 1 mL/kg seed, or carbendazim—Bavistin® at 2 g/kg) for 24 hours. The volume of water used for soaking is equivalent to the volume of seed. The seeds are then removed from the fungicide solution and dried in the shade for 1–2 hours before sowing. Where high quality, certified, and first or second generation seed is used, fungicides are less likely to be needed. However, if sowing into a field with a history of soil-borne diseases, their use is advised.

It is important to observe your fields and know what insect pests might be present. Where pests have large populations and other alternatives to control them are not feasible, the use of insecticides might be sometimes warranted. Where soil-borne insect pests (e.g., termites) are a problem, seed treatment with an insecticide is beneficial (imidacloprid—Gaucho 350® at 3 mL/kg, alone or in combination with tebuconazole—Raxil Easy® at 0.3

mL/kg seed). The combination treatment will protect the seed from both soil-borne fungi and insects. The use of imidacloprid, alone or in combination with tebuconazole, is also suitable for treating dry seeds. Mix the chemicals in 15 mL water/kg seed.

7. Fertilizer management

Key check 6.

– Avoid basal dose of urea.

– Use a minimum of three splits of N fertilizer.

a. Nitrogen (N), phosphorus (P), potassium (K), and zinc (Zn)

Fertilizer requirement varies depending on many factors including variety; soil type; residue and fertilizer management of prior crops; the number, type and yield of crops grown in the field each year; and the desired yield level. The International Rice Research Institute (IRRI), in collaboration with the Bangladesh Rice Research Institute (BRRI) and other national research organizations, has developed a nutrient management calculator for rice in Bangladesh to enable the fertiliser recommendation for each field to be determined, taking all these things into account. BRRI recommended the use of the Nutrient Manager for Rice in Bangladesh in 2013 and it has also been endorsed by the Department of Agricultural Extension (DAE). All that the farmer needs to do is to answer a few simple questions, and Nutrient Manager will indicate the amounts of each fertilizer

required, and the times when it should be applied during the growing season. Farmers can be assisted in the use of Nutrient Manager by leader farmers or extension officers. Nutrient Manager for Rice in Bangaldesh is available on the internet at the following address, in English and in Bangla: *http://webapps.irri.org/bd/nmr/*

It is also available as a smart mobile phone application at *http://webapps.irri.org/bd/nmr/*.

If you are not using Nutrient Manager, the following guidelines are suggested. The recommended N fertilizer rate for DSR varies depending on variety from 120 to 140 kg N/ha (Table 1). The requirement for other fertilizers is

Cover page of the “Nutrient Manager for Rice” in Bangladesh

P 26 kg/ha, K at 50 kg/ha, and $ZnSO_4.7H_2O$ (zinc sulfate heptahydrate) at 25 kg/ha. The nitrogen dose for CT-DSR can be reduced by 25% by green manuring—this involves growing *Sesbania* (*Dhaincha*) and incorporating it 2–3 days prior to sowing DSR. All fertilizer except urea (N) should be applied at sowing. Phosphorus fertilizer (e.g. triple super phosphate) should be placed in the soil at the time of sowing using the seed drill. Potassium (muriate of potash, MoP) and zinc sulfate should be broadcast before sowing. **MoP and zinc sulfate should not be applied by the seeder-fertilizer drill as they will not be metered out at the correct rate because they not in a granular form**. If Zn is not applied at sowing, it can be applied as a foliar spray (0.5% zinc sulfate and 1.0% urea) 30 days after sowing (DAS) and at panicle initiation (PI), which occurs approximately 3–4 weeks prior to heading. Nitrogen should be applied as urea in three or four splits, evenly spaced, starting 2–3 weeks after sowing and with the last split at PI. Apply N prior to irrigation.

Don't broadcast urea on moist soil after irrigation or rain - apply before irrigation (or rain if likely).

b. Iron (Fe)

Dry seeded rice often suffers from iron deficiency when grown on lighter soils (sandy loams and loams), and the deficiency is worse in low-rainfall seasons. The symptoms generally appear during the early vegetative stage in the form of yellowing, stunted plants, and seedling death. The crop should be sprayed with 1% ferrous sulfate

solution as soon as the symptoms appear (with repeat applications after a week if the symptoms persist). For severe symptoms, try to keep the field flooded/saturated for a few days at the time of ferrous sulfate application. If iron deficiency symptoms appear later during crop growth, they may be due to cereal cyst nematodes—check the roots for galls to determine whether this is a likely cause. If galls are present, include puddled transplanted rice (flooded) or legumes (like mungbean) in the crop rotation.

Don't grow DSR in fields with a nematode history.

Symptoms of iron deficiency (foreground)

Root galls indicating nematode infestation

8. Irrigation management

Key check 7.

- Keep the soil in the seed/root zone moist during establishment.
- Keep the soil close to saturation from the start of heading to the start of grain filling.

The goal of irrigation management is to minimise the use of irrigation water while maintaining yield because of increasing

water scarcity and/or the high cost of pumping groundwater. Rice does not need to be continuously flooded for good growth and yield. It can be grown with periodic irrigation, allowing the soil surface to dry for a few days between irrigations. However, if the soil becomes too dry too often, the rice crop will suffer and there will be a loss of yield. Therefore, irrigation needs to be managed carefully. The irrigation requirement for DSR depends very much on the weather and the soil type. The lighter (less clayey, more sandy) the soil, the more frequently it will need irrigation in the absence of adequate rain. Adding organic matter through the application of manure, compost, or retention of crop residues will improve soil water holding capacity and can reduce the required frequency of irrigation over time.

DSR needs an assured water supply for the first 2 weeks after sowing for good establishment, applying light irrigations as needed - do not allow water to pond for more than a few hours; drain the water off the field if necessary. When DSR is established in hot and dry conditions, frequent irrigation is needed to keep the soil moist in the root zone, especially on lighter soils, which may require irrigation every couple of days for good establishment. During the active tillering phase, that is, 30–45 days after seeding (DAS), and the heading to grain-filling stage, the topsoil (0–15 cm) should be kept close to saturation, with irrigation applied as needed. At other stages the topsoil can be allowed to become drier, but never to the degree that the leaves show signs of rolling (no longer flat) in the early morning. For clayey soils, the appearance of hairline cracks on the soil surface is a general indication of the need to irrigate.

9. Weed management

Weed management is usually the biggest challenge for successful production of DSR. A much larger range of

weeds occurs in DSR with alternate wetting and drying water management than in puddled transplanted rice with prolonged periods of flooding. If uncontrolled, the weed infestation in DSR can reduce rice yield to zero. There are three broad classes of weeds—grasses, broadleaves, and sedges. Table 2 lists the weeds commonly found in DSR in Bangladesh.

a. Cultural practices

Stale seedbed technique*:* This technique is highly desirable if the field has a large weed seed bank (i.e., lots of weed seeds in the soil as a result of weed infestation in the past). Weeds are germinated and encouraged to grow by giving one or two irrigations 2-4 weeks prior to sowing, and then killed by either a nonselective herbicide (e.g. glyphosate), or tillage. If the soil condition is suitable for sowing, use a nonselective herbicide to kill the weeds and sow the crop without any tillage, as tillage brings more weed seeds near the soil surface and thus promotes their germination. Note that the weeds must be actively growing at the time of herbicide application, so, if the soil is dry, irrigation will be needed prior to herbicide application. The stale seedbed technique is also helpful in managing weedy rice (*jhora dhan*), which is an emerging problem in the Eastern Gangetic Plains of India, but not yet a problem in Bangladesh.

b. Chemicals

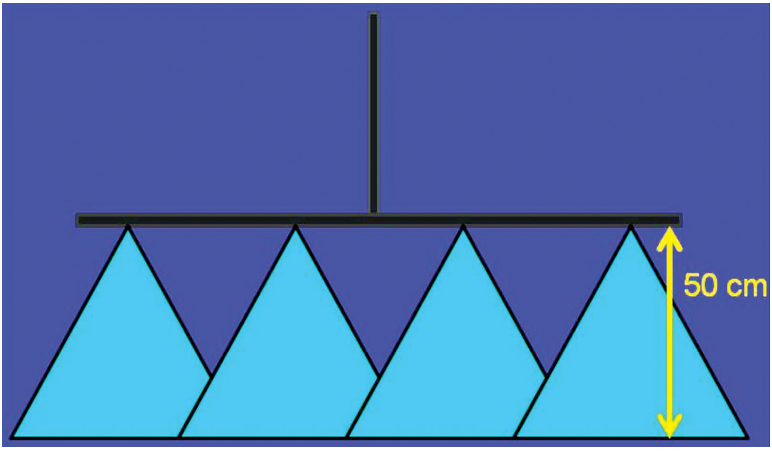
A wide range of herbicides are available for controlling weeds (Table 3). All herbicides need to be mixed with water prior to application. Clean water should be used, as muddy water reduces herbicide efficacy. Spray tanks, booms, and nozzles should be cleaned properly with clean water after use. Chemicals should not be mixed together unless recommended, as this may reduce their effectiveness on

Protective clothing for spraying

Protective clothes are made from washed fertilizer bags, which are readily available and can be made by farmers at little cost

weeds and/or be harmful to the rice plants. Chemicals should always be applied at the recommended rate following all safety procedures (see key check 3 above).

Uniform application of the spray across the entire field is needed to avoid “misses” (costly follow-up hand weeding needed) and overspraying (a waste of costly chemicals and bad for the environment). The best way of achieving this is with a multinozzle (e.g., three) boom with flat-fan nozzles and slightly overlapping spray patterns at the soil surface. The overlap is achieved by holding the boom at the right height (approximately 50 cm) above the target (for preemergence, the soil surface is the target, and for postemergence, weeds are the target, so the boom should be 50 cm above the top of the weeds). Cone nozzles should not be used for herbicide application—only flat-fan nozzles are recommended.



Boom height for desired spray pattern with slight overlap at ground level to avoid “misses”

i) Preplant/knockdown herbicides

These herbicides are used to kill existing vegetation prior to rice sowing under ZT-DSR. Glyphosate (1.0 kg a.i./ha or 1% by volume) applied at least 5 days before sowing is recommended.

ii) After crop sowing

Key check 8.

- Ensure that the soil is moist before applying preemergence herbicide.
- Apply irrigation 24 h after postemergence herbicide application if the soil is not moist.

The choice of herbicide depends on the types of weeds, and no single herbicide can control all weeds in the rice crop. In many situations, the best method for effective weed control is application of a preemergence herbicide (1–3 DAS, before the weeds and rice emerge), followed by a postemergence application 15–25 DAS. If weed pressure is low, preemergence herbicide can be followed by spot hand weeding to control weeds.

Don't apply preemergence herbicide on dry soil; irrigate first if needed.

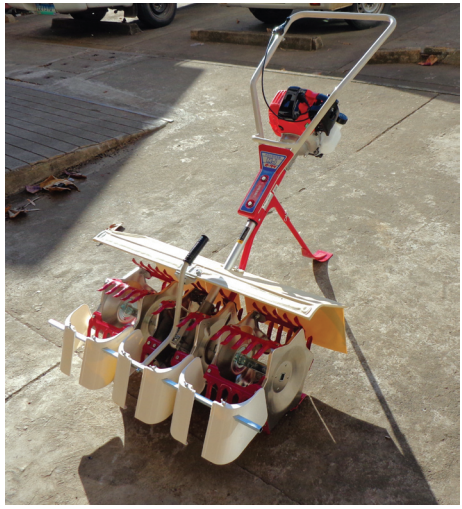
Don't allow water stress after application of post-emergence herbicide; *irrigate if needed.*

Don't apply herbicide if it is raining or likely to rain in the *next 6 hours.*

c. Physical

Physical weed control consists of removing weeds by hand (manual weeding) or by machine (mechanical weeding). It is practically and economically impossible to control weeds solely by hand weeding because of labor scarcity and rising labor wages. However, one or two spot hand weedings are strongly recommended to remove weeds that escape herbicide application, to prevent weed seed production and the accumulation of weed seeds in the soil. Mechanical weeding can be useful in reducing labor use in weeding. Motorized cono weeders and other hand weeders are available in the region and can be included as part of integrated weed management.

Hand-operated weeder for in-row weed control in DSR



Motorized weeder

d. *Surface residue retention*

Retention of crop residues on the soil surface in zero-tillage systems also helps to suppress weeds.

10. Pests and diseases

a. *Nematodes*

Cereal cyst nematodes tend to be a problem on lighter soils, more so in drier years. The problem initially appears as small patches of stunted growth, reduced tillering, and pale green-yellowish plants. The problem is likely to be exacerbated by continuing to grow non flooded DSR in the same field. It is better to avoid growing DSR in fields with a history of nematodes.

Table 1. Suitable cultivars for aman DSR in Bangladesh.

Cultivar	Duration (days)	Yield potential (t/ha)	Nitrogen requirement (kg/ha)	Days to heading	Region/situation
Inbred					
BRRI dhan 56	105	4.5-5	120	75-80 DAS	Newly released variety and gaining popularity in northern and south-west parts. Drought tolerant and better than BINA dhan7 in terms of yield and cooking quality
BU dhan 1	100-110	4-4.5	120	80-85	Northern and central parts of Bangladesh
BINA dhan 7	110-115	usually lower than BRRI dhan56, but yields up to 5.5 in farmers' fields in favorable environments in the north	120	80-90 DAS	All northern parts of Bangladesh, but popularity decreased recently due to poor cooking quality (low amylose content so rice becomes sticky after cooking). But it's a a good variety for DSR and increasing in popularity in south-western parts and farmers comment that reduced boiling time reduces the stickiness problem).
BRRI dhan 33	118	4.5	120	80- 85	Light textured drought prone rainfed area in NW of Bangladesh and some south-western parts
BRRI dhan 49	135	5	140	100-105 DAS	Central and northern parts and gaining popularity in southern parts

Table 2. Common weeds of rice in Bangladesh.

Grass		Broadleaf		Sedge	
Botanical name	**Local name**	**Botanical name**	**Local name**	**Botanical name**	**Local name**
Echinochloa colona	Khudey shyama	*Marsilea minuta*	Sushni sak	*Eclipta prostata*	Keshuti
Digitaria ciliaris	Anguli ghash	*Polygonum hydropiper*	Bishkatali	*Sphenoclea zeylanica*	
Leptochloa chinensis	Fulka ghash	*Galinsoga ciliata*		*Ludwigia octovalvis*	
Dactyloctenium aegyptium	Kak paya	*Physalis heterophylla*	Foska begun	*Portulaca oleracea*	
Cynodon dactylon	Durba	*Heliotropium indicum*	Hati-shur	*Cyperus rotundus*	Mutha, Badhalia
Echinochloa crus-galli	Boro shyama	*Phyllanthus niruri*	Chir pata	*Cyperus difformis*	Boro cechra
Eleusine indica	Chapra	*Cleome rutidosperma*	Bonnio sarisha	*Cyperus iria*	Boro cheich
Setaria viridis	Shial leza	*Murdannia nudiflora*		*Fimbristylis miliacea*	Joina
Leersia hexandra	Arail	*Lindernia anagallis*		*Scirpus maritimus*	Cechra
Ageratum conyzoides	Shialmuti	*Spilanthes paniculata*	Jirakata ful	*Scirpus juncoides*	
Amaranthus spinosus	Kanta notey	*Celosia argentea*	Murag juti		
Commelina benghalensis	Kanai bashi				

Table 3. Major knockdown and preemergence herbicides for weed control in DSR in Bangladesh (adapted from Kumar and Ladha 2011).

Herbicide (active ingredient, a.i.)	Product (trade) name*	Concentration (g a.i./ha)	Product dose (g/ha or mL/ha)	Application time (DAS)	Strengths	Weaknesses	Toxicity for human health**	Toxicity for environment**
Knockdown/nonselective								
Glyphosate	Roundup	1,000	2,500 mL		Good control of most grasses, broadleaves and sedges	Weak on *Ipomoea triloba* and *Commelina* species	Low	Low
Preemergence								
Pendimethalin	Stomp/ Stomp xtra	1,000	3,330 mL 2,580 mL	1–3	Good control of most grasses, some broadleaves and annual sedges. Has residual control.	Sufficient moisture is needed for its activity	Medium	Medium
Oxadiargyl	Topstar	90	112.5 g	1–3	Broad-spectrum weed control of grasses, broadleaves, and annual sedges. Has residual control.	Sufficient moisture is needed for its activity	No information	No information

contd...

Table contd...

Herbicide (active ingredient, a.i.)	Product (trade) name*	Concen-tration (g a.i./ha)	Product dose (g/ ha or mL/ha)	Application time (DAS)	Strengths	Weaknesses	Toxicity for human health**	Toxicity for environment**
Pyrazosulfuron		20	200	1-3	Broad-spectrum weed control of grasses, broadleaves, and annual sedges. Has residual control.	Sufficient moisture is needed for its activity	Low	No information

**Does not imply endorsement of the product*
***Classification based on review of WHO and United States Environmental Protection Agency criteria*

Table 4. Major postemergence herbicides for weed control in DSR in the Bangladesh.

Herbicide (active ingredient, a.i.)	Product (trade) name*	Concen-tration (g a.i./ ha)	Product dose (g/ ha or mL/ha)	Application time (DAS)	Strengths	Weaknesses	Toxicity for human health**	Toxicity for environment**
Postemergence								
Penoxsulam	Granite	22.5	93.75 mL	15–20	Broad-spectrum weed control of grasses, broadleaves, and annual sedges.	Poor on grasses other than *Echinochloa* species, including *L. chinensis*, *D. aegyptium*, *E. indica*, *Eragrostis species*.	No information	No information
Fenoxaprop	Whipsuper	56	622	25-30	All grasses (has a phytoxic effect on rice if used without safener)	Poor on brodleaves and sedges	Medium	No information
Ethoxysulfuron	Sunrice	24	160 g	15–20	Effective on broadleaves and annual sedges.	Does not control grasses and poor on perennial sedges.	No information	No information

**Does not imply endorsement of the product.*
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