



BILL & MELINDA
GATES foundation

Guidelines for Dry Seeded Rice (DSR) in the Terai and Mid Hills of Nepal



Guidelines for Dry Seeded Rice (DSR) in the Terai and Mid Hills of Nepal

**Krishna Devkota, Sudhir Yadav, Jagat D. Ranjit,
Dil Prasad Sherchan, Ananta Regmi, Mina Devkota,
Tufail Akhtar, Elizabeth Humphreys,
Bhagirath Singh Chauhan, Virender Kumar,
Andrew J. McDonald and R.K. Malik**

2014

The International Fund for Development (IFAD) is a specialized agency of the United Nations. IFAD is dedicated to eradicating rural poverty in developing countries.

The Cereals Systems Initiative for South Asia (CSISA) is mandated to enhance farm productivity and increase incomes of resource-poor farm families in South Asia through the accelerated development and inclusive deployment of new varieties, sustainable management technologies, partnerships and policies. The project is being implemented by the CGIAR institutions of IRRI, CIMMYT, IFPRI, and ILRI and supported by USAID, and the Bill & Melinda Gates Foundation.

© This publication is a joint product of the International Fund for Agricultural Development (IFAD) “Resource Conserving Technologies” project (IFAD Grant No. C-ECG-46-IRRI, Sub-project 2) and the Cereal Systems Initiative for South Asia (CSISA) and copyrighted to the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT), 2013, and is licensed for use under a Creative Commons Attribution – Non Commercial ShareAlike 3.0 License (Unported).

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Centre (CIMMYT) and the concerning the legal status of any country, person, territory, city, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. Where trade names are used, this does not constitute endorsement of or discrimination against any product by IRRI and CIMMYT.

Citation

Devkota K, Sudhir-Yadav, Ranjit JD, Sherchan DP, Regmi A, Devkota M, Akhtar T, Humphreys E, Chauhan BS, Kumar V, McDonald AJ, Malik, RK (2013). Guidelines for dry seeded rice (DSR) in the Terai and mid hills of Nepal. CSISA and IFAD joint publication. International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT). 40 p.

Contents

1. Introduction	1
2. Soil suitability	1
3. Field preparation	2
a. Land leveling	2
b. Tillage	4
4. Cultivars	7
5. Sowing date	7
6. Sowing	8
a. Crop establishment	8
b. Machinery for sowing	11
c. Seed quality, rate, sowing depth, row spacing	14
d. Seed treatment	16
7. Fertilizer management	18
a. Nitrogen (N), phosphorus (P), potassium (K), and zinc (Zn)	18
b. Iron (Fe)	20
8. Irrigation management	22
9. Weed management	23
a. Cultural practices	23
b. Chemicals	24

c. Physical	29
d. Surface residue retention	31
Table 1. Suitable cultivars for DSR in the Terai and mid hills of Nepal	32
Table 2. Common weeds of DSR rice in Nepal	34
Table 3. Major knockdown and preemergence herbicides for weed control in DSR	35
Table 4. Major postemergence herbicides for weed control in DSR in the Terai and mid hills area of Nepal	36
Contributors	38
Acknowledgements	38
For more details and queries, please contact	39
Further information	40

Guidelines for Dry Seeded Rice (DSR) in the Terai and Mid Hills of Nepal

1. Introduction

Dry seeded rice (DSR) is becoming an attractive option for farmers as it has a much lower labor requirement and establishment cost than manually transplanted rice. Labor for transplanting rice has become scarce and costly because laborers are shifting from agriculture to industry, public works, and overseas employment. 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). Best practice involves using a 2- or 4-wheel tractor-drawn drill to seed in rows in nontilled or dry tilled soil, as for wheat. Because the soil is not puddled, DSR also has a lower water requirement for crop establishment.

2. Soil suitability

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

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

Don't grow DSR on poorly drained lowland soils.

3. Field preparation

a. Land leveling

Key check 1.

- Fields must be accurately leveled.



Land leveling using laser guidance

Good land leveling helps ensure high yield and reliable production of DSR. This is best achieved using laser-assisted land leveling. If laser-land leveling equipment is not available, the ploughed land should be leveled carefully using locally available land leveling equipment – a scraper (*Raiser*) and planking. A level field allows planters/drills to place seed more precisely and enables more uniform



Land leveling using a scraper (Raiser) and planking

irrigation, leading to a uniform crop stand and improved weed control and fertilizer 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 the levelness of a field is to measure the depth of the water 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 planking later on.

b. Tillage

DSR can be sown into tilled soil as for wheat (“conventional tillage”), into partially tilled soil (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, weed infestation, crop rotation and the risk of rodent attack. In areas where *Cynodon dactylon* (“*dubo*”) is problematic, 1-3 summer ploughings are recommended to desiccate the weeds.

- i) **Conventional tillage (CT)** : For CT-DSR, the soil should be cultivated to a depth of 5–10 cm to achieve a fine enough tilth for good seed-to-soil contact as for wheat. Depending on soil type and field conditions, this might require 1–2 discings followed by 1–2 runs of a tyne cultivator and a planking. The best time for ploughing for field preparation is after harvesting of the winter crop, during the hot/dry summer. In Nepal, 4-wheel tractor powered rotovators are becoming more common and can also be used to till the soil. However, rotovators compact the soil which is deleterious for the growth of upland crops such as wheat, and therefore rotovators are not recommended.



Soil cracking due to use of a rotovator when the soil is dry in a heavy textured soil – cracking increases the rate of soil drying and the need for irrigation.

- 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 or paraquat (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, to reduce costs. Glyphosate should be applied at least 5 days before sowing, however paraquat can be applied up to 2–3 days before sowing. Apply herbicides 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 (e.g., 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, single boom with a flat fan nozzle, can be used but it will be less efficient and effective.

Don't apply paraquat if perennial weeds are present. In such situations, apply glyphosate.

Note - paraquat is much more toxic for humans than glyphosate, and is readily absorbed through the skin.

Don't grow ZT-DSR if perennial weeds are problematic – use CT-DSR.

Don't use a rotovator for field preparation in heavy clay soil.

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 spray solution.
- Use a multiple-nozzle boom fitted with flat-fan nozzles for full coverage (see later).
- Use protective clothing when applying herbicides (see later).

4. Cultivars

Many of the inbred varieties and hybrids bred for puddled transplanted rice have also been found suitable for DSR. Varieties with faster growth and better early vigour are more suitable for DSR than slower growing varieties. Shorter duration varieties or hybrids are also preferred to reduce the irrigation requirement and to enable timely planting of wheat after rice harvest. However, shorter duration cultivars are not necessarily an advantage where inadequate drainage is the primary factor preventing timely wheat planting. The inbreds and hybrids suitable for DSR in the Terai and mid hills of Nepal are given in Table 1.

5. Sowing date

Key check 3.

- Mid hill : 15-31 May.
- Terai : 20 May-30 June, the earlier the better (late May is optimum).

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 monsoon. The optimum time of dry seeding rice in the mid hills is the middle of May while in the foothills the optimum time is late May to early June. In the Terai (plains) the optimum time is late May to early June, as the later the crop is sown, the greater the risk of heavy rain shortly after sowing. The monsoon rains generally start later in the mid and far western Terai, and sowing can be done in the first week of June. Heavy rain, especially on heavy (clayey) soils, can seriously impair establishment. Therefore, it is safer to sow earlier. However, the earlier the crop is sown, the greater the need for irrigation.

6. Sowing

a. Crop establishment

Good crop establishment is the most important factor for the success of DSR. DSR can be sown in dry or moist soil: (1) rice seeded in dry soil requires a light irrigation to germinate the seed, and (2) seeding in moist soil is done after a presowing irrigation or rainfall. When seeding into moist soil, planking 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, sowing in moist soil is better as the soil is softer. However, pre-emergent herbicide needs to be applied onto the moist soil surface for a better result. If the field is too dry, give a pre sowing irrigation before spraying.



Seeding in tilled soil (CT-DSR) using a seed drill with a fluted-roller seeding mechanism.



Seeding in nontilled soil (ZT-DSR) using an inclined plate seed drill.



DSR seeding with full pass tillage into previously cultivated soil (“power tiller–operated seeder” - a seeder with a rotary tiller powered by a 2-wheel tractor).



DSR seeding with strip tillage into the nontilled soil.

b. Machinery for sowing

For precise seeding, rice should be drilled using a multicrop planter fitted with an inclined-plate seed-metering mechanism (see photo), and with the ability to drill both seed and fertilizer simultaneously. DSR can also be sown with a conventional seed-cum-fertilizer drill with a fluted-roller seed-metering mechanism; however, the seeds will not be spaced evenly and a higher seed rate is required to avoid seed breakage. The inclined-plate seed-metering mechanism also provides the opportunity to use primed seed as there is no problem of seed breakage in contrast with the use of fluted-roller seed metering. Cleaning and maintenance of machinery is also very important to reduce seed breakage and achieve uniform crop establishment.

Seed drills with inverted-T tynes are suitable for seeding into both tilled and nontilled soil.

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) metering systems.



Coverage of seeds with soil using chains or flaps.

Therefore, it may help to use chains or flaps behind the tynes.

For ZT-DSR, when no or only anchored residues of the previous crop (e.g., wheat) are retained, the same multicrop planter can be used for seeding if fitted with suitable tynes (e.g., inverted T, as commonly provided on multicrop planters made in India). However, if loose or bulky crop residues are present on the soil surface (e.g., mungbean, loose straw), the Turbo Happy Seeder should be used.

Seed-cum-fertilizer drills for 2-wheel tractors are available in Nepal, and can be used for DSR in the small farm holdings in the foot hills, inner Terai and Terai region. Sowing can be done in a single pass with full tillage or strip tillage (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 tynes, with the curved ends angled towards the sowing line). 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 attached to the back of the seed drill.



DSR being sown into residues using the Turbo Happy Seeder.

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 (Indian models) have an inclined-plate seeding mechanism which enables precise seeding of a range of seeds sizes (from rice and wheat to maize, lentil and chickpeas). Others (Chinese models) have fluted roller seeding mechanisms. The seed-fertilizer drills/planters for 2-wheel tractors are an improvement on the “power tiller–operated seeders” (PTOS) that have been available for some time. The standard PTOS has a seed box but no fertilizer box, and a fluted-roller seeding mechanism.



Crop being sown by a seed-cum-fertilizer drill with inclined-plate seeding mechanism, using full tillage, powered by a 2-wheel tractor. Tillage and seeding are done in a single pass. Note the residues remaining on the soil surface after sowing (right side of photo).

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

Key check 4.

- 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.



Inclined plate and fluted roller seed-cum-fertilizer drills for 2-wheel tractors.

Seed quality greatly influences germination rate; therefore, the use of certified seed is recommended. For inbreds, a seed rate of 20-30 kg/ha (using good-quality seeds with more than 95% germination) is optimal for DSR with a row spacing of 20 cm sown with a multicrop planter. 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, suboptimal moisture or seed predation, 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.

Don't mix seed with urea fertilizer.

d. Seed treatment

1. Priming

Seed priming (soaking the seeds for 10–12 hours in a gunny-bag [burlap] in water) is a useful practice only under assured irrigation water availability. As DSR needs to be sown at a shallow depth (<2 cm) in advance of the monsoon rains, inadequate soil moisture can be a major constraint to rapid establishment of a good crop stand. Priming accelerates crop emergence and can thus assist rapid establishment. After soaking, the seeds are air dried for a couple of hours, which facilitates free flow of seeds through the seed drill. Further, the seed 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. Incubation involves storing the seeds overnight in a gunny bag. The seeds should be sown shortly after priming or 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.

2. Seed treatment with fungicides and insecticides

Where seed-borne diseases are a concern, seed treatment with fungicides is recommended to manage diseases such as loose smut, false 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 soil-borne insect pests (e.g., termites) are a problem, seed treatment

with an insecticide is beneficial (imidacloprid—Gaucho 350 FS® 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, 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 5.

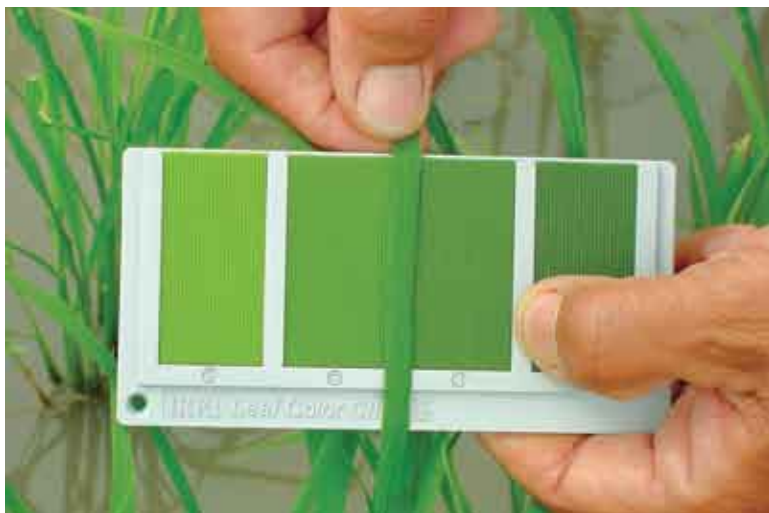
- Avoid basal dose of urea.
- Use a minimum of three splits of N fertilizer.

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

Use 100-120 kg N/ha depending upon soil fertility and variety (Table 3). Use the higher rate for hybrids. The requirement for other fertilizers is P_2O_5 at 40 kg/ha, K_2O at 30 kg/ha, and $ZnSO_4$ at 25 kg/ha (in Terai). The nitrogen dose for CT-DSR can be reduced by 25% by green manuring, i.e., growing *Sesbania* (*Dhaincha*) and incorporating it 2–3 days prior to sowing DSR using a knock down herbicide such as glyphosate then seeding into the *Sesbania* using the Turbo Happy Seeder. This will result in the DSR being seeded into a mulch.

All fertilizer except urea (N) should be applied at sowing. Compound fertilizers (DAP or NPK formulations) should

be placed in the soil at the time of sowing using the seed drill. 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. The remaining 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. Use of the leaf color chart (LCC) to determine the N fertilizer requirement enables more precise N



Leaf color chart.

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

application according to the crop requirement, and often results in a reduction in the amount applied while maintaining yield. The standardized LCC developed by IRRI (photo above) is five inches long, made of high-quality plastic, with four color shades from yellowish green (No. 2) to dark green (No. 5). For high-yielding varieties/hybrids, N application should be based on a critical LCC value of 4.

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



Symptoms of iron deficiency (foreground).

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, avoid using this field for DSR in the future.



Root galls indicating nematode infestation.

8. Irrigation management

Key check 6.

- 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 3 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 than in puddled transplanted rice, and, if uncontrolled, the degree of infestation can be great enough to 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 Nepal.

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 (glyphosate or paraquat) 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. In some locations, volunteer rice is problematic in DSR. Under such conditions, use of the stale seed bed technique and rouging of the volunteer rice before grain setting are advised. Where volunteer rice is extremely problematic, use puddling and transplanting in the next year. Note that the weeds must be actively growing at the time of herbicide application, so, if the soil is dry, an irrigation will be needed prior to herbicide application. This method has great potential for reducing weeds in DSR because of the 2-month fallow period between wheat harvest and rice sowing. This technique is also helpful in managing weedy rice, which is an emerging problem in lowland rice in the Eastern Gangetic Plains. In ZT-DSR, retention of 15-20 cm standing residues of the preceding wheat crop decreases weed infestation in DSR and improves soil quality.

b. Chemicals

A wide range of herbicides is 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 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 7 below).

Key check 7. 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 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 away 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.
- Pesticides should be stored in a locked container out of reach of children.

Uniform application of the spray across the entire field is needed to avoid “misses” (costly follow-up hand weeding needed) and overspraying (waste of costly chemicals). 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 weeds). Cone nozzles should not be used for herbicide application—only flat-fan nozzles are recommended.

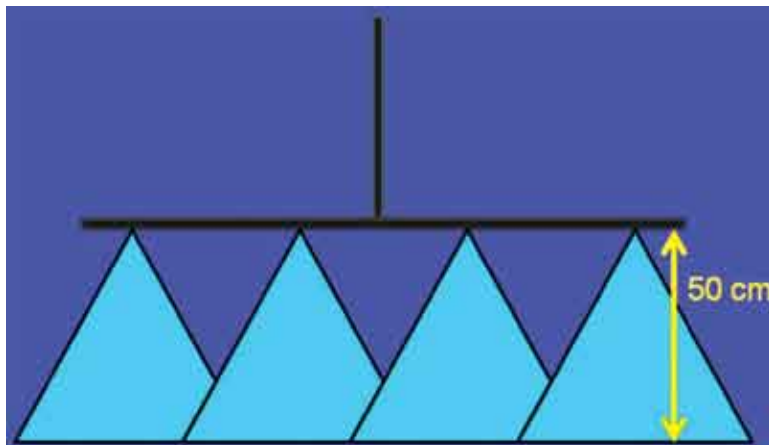


Protective clothing for spraying.



Protective clothes can be made from washed fertilizer bags.

When multiple nozzle boom sprayers are not available in the market, they can be made locally by using flat-fan nozzles, PVC pipe and bamboo stick/plastic pipe/metallic rod. For a knapsack sprayer, a 3 nozzle boom can be used, and for a foot-sprayer a 6-7 nozzle boom can be used. The longer boom provides several times the cost effectiveness and with better precision in herbicide application.



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) and paraquat (0.5 kg a.i./ha or 0.5% by volume) are recommended. If fields are infested with perennial weeds, use glyphosate, not paraquat.

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.

ii) After crop sowing

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. This will typically involve the use of pendimethalin or oxadiargyl as preemergence followed by a postemergence application of bispyribac-sodium or azimsulfuron or bispyribac-sodium plus azimsulfuron. If the field has only broadleaf weeds, 2,4-D sodium salt or 2,4-D ethyl ester can also control weeds effectively. However, in cases where the preemergence herbicide is missed (e.g., due to rain) or fails (e.g., due to management errors, such as soil too dry at the time of spraying), early herbicide application at 15 DAS should be made based on the types of weeds present.

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

Don't allow water stress after the application of postemergence 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



Hand and motorized mechanical weeders.

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, and 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 and other hand weeders can be included as part of integrated weed management.

d. Surface residue retention

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

Table 1. Suitable cultivars for DSR in the Terai and mid hills of Nepal.

Cultivar	Duration (days)	Yield potential (t/ha)	Nitrogen requirement (kg/ha)	District/Region/Situation
Inbred for Terai and inner Terai				
Hardinath-1	110-115	5.0	100	Terai and Inner Terai
Sarju -52	110-118	4.5	100	Officially not released but popular in Rupandehi, Nawalparasi, Banke and Bardia districts
Tarahara-1	115	4.2	90-92	Eastern and central Terai
Radha-4	120-25	3.2	100	Foothills and Terai region
Sukha-1	125	2.5-3.6	60	Terai and inner Terai, river basin
Sukha-2	125	3.3-3.5	60	Terai and inner Terai, river basin
Sukha-3	125	3.2-4.2	60	Terai and inner Terai, river basin
Makarkaddu	125	5.0	100	Officially not released but popular, Terai, inner Terai, irrigated and rainfed lowland
Ram Dhan	138-148	4.9	100	Chitwan
Sabitri	140-145	4.0	100	Terai and inner Terai
Samba-Sub-1	145-150	4.0	100	Officially not released but popular, Terai, inner Terai, irrigated and rainfed lowland
Sona Masuli	150-155	4.5	100	Terai (Officially not released but cover large area in Central Terai)
Inbred suitable for mid-hills				
Khumal-4	144	6.3	100	Mid hills
Khumal-8	158	9.8	100	Mid hills
Khumal-10	145	4.5	100	Mid hills
Hybrids suitable for Terai and inner Terai				
Gorakhnath	120-125	6-7	120	Terai, inner Terai, irrigated and rainfed lowland

contd...

Table contd...

Cultivar	Duration (days)	Yield potential (t/ha)	Nitrogen requirement (kg/ha)	District/Region/Situation
Arize 6444	135-140	7-8	120	Terai, inner Terai, irrigated and rainfed lowland
Bioseed 786	120-125	7-8	120	Terai, inner Terai, irrigated and rainfed lowland
RH 245	120-125	5-6	120	Terai, inner Terai, irrigated and rainfed lowland
Loknath-505	120-125	5-6	120	Terai, inner Terai, irrigated and rainfed lowland
Raja	120-125	5-6	120	Terai, inner Terai, irrigated and rainfed lowland

Table 2. Common weeds of DSR rice in Nepal.

Scientific Name	Common Name	Local Name
Grassy weed		
<i>Echinochloa colona</i>	Junglerice	Banso
<i>Echinochloa crus-galli</i>	Barnyardgrass	Sama
<i>Paspalum distichum</i>	Knot-grass	Ghode dubo
<i>Eragrostis pilosa</i>	Indian Love grass	Charako dana
<i>Leptochloa chinensis</i>	Chinese Sprangetop	
<i>Eleusine indica</i>	Goosegrass	Khode jhar
<i>Panicum dichotomiflorum</i>	False panygrass	Banso
<i>Digitaria sp</i>		Banso
<i>Cyanodon dactylon</i>	Bermuda grass	Dubo
Broad leaf weed		
<i>Ageratum conyzoides</i>	Goat grass	Gandhe
<i>Alternanthera philoxeroides</i>	Alligator weed	Patpate , maobade jhar
<i>Amaranthus spinosus</i>	Spiny pig weed	Kande lunde
<i>Caesulia axillaris</i>	Pink node flower	Thuk jhar
<i>Commelina diffusa</i>	Day flower	Kane
<i>Commelina benghalensis</i>	Tropical spider wort	Kane
<i>Cyanotis sp</i>		
<i>Eclipta prostrata</i>	False daisy	Bhingharaj
<i>Galinsoga ciliata</i>	Hairy galinsoga	Chitlange
<i>Ludwigia hyssopifolia</i>		
Sedges		
<i>Cyperus difformis</i>	Small flower umbrella plant	Mothe
<i>Cyperus iria</i>	Rice flatsedge	Chatre
<i>Cyperus rotundus</i>	Purple nutsedge	Mothe
<i>Fimbristylis littoralis</i>	Globe fringerush	Jhiruwa

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

Herbicide (active ingredient, a.i.)	Product (trade) name*	Rate (g a.i./ha)	Product dose (g/ha or mL/ha)	Application time (DAS)	Strengths	Weaknesses
<i>Knockdown/nonselective</i>						
Glyphosate	Roundup	1,000	2,500 mL		Good control of most grasses, some broadleaves and annual sedges	Weak on <i>Ipomoea trioba</i> and <i>Commelina</i> species
Paraquat	Gramoxone	500	2,000 mL		Good control of most grasses, some broadleaves and annual sedges	
<i>Preemergence</i>						
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
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

*Does not imply endorsement of the product

Table 4. Major postemergence herbicides for weed control in DSR in the Terai and mid hills area of Nepal (adapted from Kumar and Ladha 2011).

Herbicide (active ingredient, a.i.)	Product (trade name)*	Rate (g a.i./ha)	Product dose (g/ha or mL/ha)	Application time (DAS)	Strengths	Weaknesses
<i>Postemergence</i>						
Bispyribac-sodium	Nominee Gold/ Adora	25	250 mL	15–25	Broad-spectrum weed control of grasses, broadleaves and annual sedges. Good control of <i>Echinochloa</i> species.	Poor on grasses other than <i>Echinochloa</i> species, including <i>Leptochloa chinensis</i> , <i>Dactyloctenium aegyptium</i> , <i>Eleusine indica</i> , <i>Eragrostis</i> species. No residual control.
Penoxsulam	Granite	22.5	93.75 mL	15–20	Broad-spectrum weed control of grasses, broadleaves, and annual sedges.	Poor on grasses other than <i>Echinochloa</i> species, including <i>L. chinensis</i> , <i>D. aegyptium</i> , <i>E. indica</i> , <i>Eragrostis</i> species.
Fenoxaprop-ethyl + safener	Rice star	60–90	870–1,300 mL	15–20	Good control of annual grassy weeds, safe on rice at early stage.	Does not control broadleaves and sedges.
Azimsulfuron	Segment	17.5–35	35–70 g	15–20	Broad-spectrum control of grasses, broadleaves, and sedges. Good control of sedges, including <i>Cyperus rotundus</i> .	Poor on <i>Echinochloa</i> species.
Ethoxysulfuron	Sunrice	18	120 g	15–20	Effective on broadleaves and annual sedges.	Does not control grasses and poor on perennial sedges.

contd. ...

Table contd. ...

Herbicide (active ingredient, a.i.)	Product (trade name)*	Rate (g a.i./ha)	Product dose (g/ha or mL/ha)	Application time (DAS)	Strengths	Weaknesses
2,4-D ethyl ester	Weedmar	500	1,250 mL	15–25	Effective on broadleaves and annual sedges. Economical. Has no residual control	Does not control grasses.
Carfentrazone	Affinity	20	50 g	15–20	Effective on broadleaf weeds. Has no residual control.	Does not control grasses.
Chlorimuron + metsulfuron	Almix	4 (2 + 2)	20 g	15–25	Effective on broadleaves and annual sedges.	No control of grassy weeds and poor on <i>C. rotundus</i> .
Bispyribac sodium + azimsulfuron		25 + 17.5	250 mL + 35 g	15–25	Broad-spectrum weed control of grasses, broadleaves, and sedges, including <i>C. rotundus</i> .	Poor on grasses other than <i>Echinochloa</i> species.
Bispyribac sodium + pyrazosulfuron		25 + 25	250 mL + 250 g	15–20	Broad-spectrum weed control of grasses, broadleaves, and sedges, including <i>C. rotundus</i> .	Poor on grasses other than <i>Echinochloa</i> species.
Fenoxaprop + ethoxysulfuron		60 + 18	645 mL + 120 g	15–25	Broad-spectrum weed control of grasses, broadleaves, and sedges. Good control of all major grasses, including <i>L. chinensis</i> and <i>D. aegyptium</i> .	Poor on perennial sedges such as <i>C. rotundus</i> .

* Does not imply endorsement of the product.

Contributors

Krishna Devkota	International Rice Research Institute
Sudhir Yadav	International Rice Research Institute
Jagat Devi Ranjit	Nepal Agricultural Research Council
Dil Prasad Sherchan	CSISA, International Maize and Wheat Improvement Center
Ananta Regmi	CSISA, International Maize and Wheat Improvement Center
Mina Devkota	International Maize and Wheat Improvement Center
Tufail Akhtar	Nepal Agricultural Research Council
Elizabeth Humphreys	International Rice Research Institute
Bhagirath Singh Chauhan	International Rice Research Institute
Virender Kumar	International Maize and Wheat Improvement Center
Andrew McDonald	International Maize and Wheat Improvement Center
R.K. Malik	CSISA, International Maize and Wheat Improvement Center

Acknowledgements

We are grateful to Mr. Kailash Bhurer, Mitali Shah, Pradeep Shah, Mathura Yadav, Dayamani Devi Gautam, Rajendra Kumar Bhattarai, Neelam Shakya, Hira Kaji Manandhar, Anishur Rahaman Ansari, Gopal Pd. Parajuli, Ganesh Sah, Salin Acharya, Nabin Khanal, Ram Pd. Shrestha and Agronomy, Agri -Botany, Entomology, and Plant Pathology divisions of NARC Khumaltar, Lalitpur, National Wheat Research Program, Bhairahawa, Regional Agriculture Research Station, Parawanipur Nepal for their contribution during technology verification at various stages. We are also grateful to Poornima Shankar for cover design and other publication assistance.

For more details and queries, please contact

Jagat Devi Ranjit

Chief/Senior Scientist

Agronomy Division, Nepal Agricultural Research Council

Mobile: 9841293001

Email: nepaljdr@yahoo.com

Ananta Prasad Regmi

CSISA, Hub Manager

Dadeldhura, Nepal

Phone: 9847020750

Email: a.regmi@cgiar.org

Mina Devkota

Cropping Systems Agronomist

CIMMYT International, Kathmandu, Nepal

Mobile: 9847592399

Email: m.devkota@cgiar.org

Further information

<http://www.knowledgebank.irri.org/csisa/en/home/item/152-sprayersand-spray-techniques-manual.html>

<http://www.knowledgebank.irri.org/csisa/en/land-leveling-and-bunds/item/123-lazer-land-leveling-farmer-and-service-provider-interview.html>

<http://www.knowledgebank.irri.org/csisa/en/haryana-csisa-hub/item/161-operational-manual-for-multi-crop-zero-till-planter.html>

Bellinder, R.R., A.J. Miller, R.K. Mallik, J.D. Ranjit, P.R. Hobbs, L.S. Brar, G. Singh, S. Singh, and A. Yadav 2002. Improving herbicide application in South Asia. *Weed Technology* Vol. **16**: 845-850.

Kumar, V., Ladha J.K. 2011. Direct seeding of rice: recent developments and future research needs. *Advances in Agronomy* (**111**): 297-413.

Ranjit, J.D. 2011. Common weeds of rice and wheat (revised edition).

Nepal Agricultural Research Council, Agronomy Division, Lalitpur, Khumaltar, Nepal pp 40. (With pictures)

Ranjit, J.D. and R. Suwanketnikom 2005. Response of weeds and yield of dry direct seeded rice to tillage and weed management. *Kasetsart J. (Nat. Sci.)* **39**: 165-173.

Ranjit, J.D. and R. Suwanketnikom 2003. Competitive ability of rice genotypes to weeds under direct dry seeded environment. *Kasetsart J. (Nat. Sci.)* **37**: 264-283.

Ranjit, J.D., S. Sharma and D.D. Gautam 2010. Response of direct dry seeded rice (*Oryza sativa* L) to seeding dates and seed rates. *Agronomy Journal of Nepal (Agron JN)* vol. pp 16-22.

Manadhar. H. and G.P. Parajuli 2008. Dhan ma lagne pramukh rogharu (Nepali), NARC, Plant Pathology Division, Khumaltar Lalitpur, Nepal.



The DSR Series available in English and local languages:

Volume 1: Guidelines for Dry Seeded Rice (DSR) in the Eastern Gangetic Plains of India

Volume 2: Guidelines for Dry Seeded Aman Rice (DSR) in Bangladesh

Volume 3: Guidelines for Dry Seeded Rice (DSR) in the Terai and Mid Hills of Nepal

Volume 4: Guidelines for Dry Seeded Rice (DSR) in the Cauvery Delta Zone, Tamil Nadu, India

www.knowledgebank.irri.org