Indian Journal of Weed Science **49**(4): 324–328, 2017
DOI: 10.5958/0974-8164.2017.00086.7

Methods of seeding and cultivars effect on weed dynamics in direct-seeded rice under rainfed upland conditions of Nagaland

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Received: 19 September 2017; Revised: 1 November 2017

ABSTRACT

Field experiments were conducted during *Kharif* season of 2009 and 2010 to study the effect of methods of seeding and rice cultivars on dynamics of weeds in direct-seeded rice under rainfed upland conditions of Nagaland. Two seeding methods *viz.*, line seeding and broadcasting and four local direct-seeded rice cultivars, *viz.* '*Kezie*', '*Chongloiman*', '*Leikhumo*' and '*Kotsala*' were evaluated under the trial in split-plot design. A total of 29 weed species were recorded, out of which *Digitaria setigera* Roth ex Roem. & Schult, *Cynodon dactylon* (L.) Pers., *Cyperus rotundus* Linn., *Borreria articularis* (L. f.) F. N. Will., *Ipomoea triloba* L. and *Mimosa pudica* L. were the dominant weed species. The line sowing was found superior over broadcasting in recording lower density, biomass and relative weed growth rate of grass, sedge and broad-leaf weeds. It also recorded significantly higher grain yield of rice. Among the cultivars ,'*Chongloiman'* and *'Kezie'* were at par with each other and recorded significantly lower density and biomass of associated grass, sedge and broad-leaved weeds. The highest grain yield during both the years was recorded by the cultivar *'Chongloiman'* which was at par with '*Kezie*'.

Key words: Cultivars, Direct-seeded rice, Sowing methods, Weed dynamics

Upland rainfed rice in Nagaland occupies an area of 94700 hectare, with a production of 181820 t while transplanted rice culture (TRC)/wet rice culture (WRC) covers an area of 94780 ha, with a production of 247820 t (DES 2014). One of the most important production constraints responsible for the production gap is the high weed pressure faced by upland direct-seeded rice. Direct-seeded rice germinates together with weeds, eliminating the 'head start' of transplanted seedlings thereby subjecting it to higher weed pressure (Rao *et al*. 2017). Chemical and manual weeding are the most popular methods among farmers, however problems of environmental pollution, rapid developing herbicide resistant weed ecotypes and cost effectiveness associated with these methods are causes for serious concern. Moreover weed populations tend to vary between environments, which makes it impossible for a single method to provide effective weed control. Therefore, it is imperative to test and develop alternative cultural weed management options such as competitive crop cultivars and sowing methods along with judicious use of direct weed control methods so as to evolve low cost, effective and eco-friendly practice for sustainable weed management. Cultivars within a crop species vary considerably in their competitiveness with weeds. Morphological and physiological traits of a strongly competitive crop will enable it to capture resources from a weed and utilize them more efficiently (Lemerle *et al.* 2001, Ramesh *et al.* 2017). The use of competitive crop cultivars may therefore be considered as an important component for integrated weed management (Ramesh *et al.* 2017). Achieving a uniform/optimum crop stand is yet another important requirement, which ensures optimum crop growth and gives the crop a competitive edge over the weeds. Hence, selection of proper sowing method is necessary to ensure crop emergence, crop stand, reduced weed growth and ultimately higher crop yield. Therefore, the present investigation was undertaken with the objective to study the effect of methods of seeding and rice cultivars on dynamics of weeds in direct-seeded rice under rainfed upland conditions of Nagaland.

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MATERIAL S AND METHODS

The investigation was carried out at the experimental farm of NU, SASRD, Medziphema, Nagaland, located at an altitude of 310 m above mean sea level, during the *Kharif* season of 2009 and 2010. The soil of the experimental site was clayey loam, well drained and acidic in reaction with low available nitrogen, medium available phosphorous and available potassium and high organic carbon content. The experiment was laid out in a split-plot design with three replications. Treatments consisted of two

sowing methods, *viz.* line sowing and broadcasting and four local rice cultivars, *viz.* '*Kezie'*, '*Chongloiman*', '*Leikhumo*' and '*Kotsala*'. Seeds 50 kg/ha at the rate of were sown in furrows at a spacing of 20 cm x 10 cm under line sowing whereas, 100 kg/ ha of seeds were broadcasted over the seedbed under broadcast method. All agronomic and cultural practices were kept standard and uniform for all the treatments. Observations on weed growth parameters were recorded at 15, 30, 45, 60 and 90 days after seeding (DAS) and at harvest. Weeds were sampled using quadrats, measuring 0.5 x 0.5 m^2. Species dominance was determined through manual counting of the different species within each quadrat. The data recorded on weed density were subjected to square root transformation before analysis. Observation on crop yield was also recorded during both the years.

RESULTS AND DISCUSSION

Effect of sowing methods on weed growth attributes

Line sowing of the crop was superior over broadcasting in reducing density, biomass and relative weed growth rate of grasses, sedges and broad-leaved weeds (**Table 1** and **2**). In dry- seeded crop, weed competition is very severe from the beginning the crop and weed seeds germinate simultaneously and weeds, being more vigorous, smother the crop. Line sowing of the crop resulted in early and uniform crop emergence and establishment, which may have given the crop a competitive edge over the weeds and better access to soil nutrients and water thereby reducing weed growth and biomass. Line sowing facilitates uniform depth of sowing resulting in uniform crop stand (Reddy and Reddy 2010). Spatially uniform crop stand establishment under line sowing results in supplementary advantage for weed control by minimizing competition within the crop population early in the growing season (Olsen and Weiner 2007), maximizing the total shade cast by the crop (Weiner *et al*. 2001) and also by providing greater selectivity between the crop and weed during weeding operations. Under broadcasting, uneven crop stand and slow emergence of the crop might have given a competitive edge to the weeds resulting in higher weed growth and competition. In broadcasting method, seeds fall at different depths resulting in uneven crop stand. Moreover, spacing available for the individual plants also varied considerably, which resulted in excess competition within the crop at certain areas and no competition at all in some areas of the field (Reddy and Reddy 2010).

Effect of cultivars on weed growth attributes

Cultivars were found to record significant differences in weed density, biomass and relative weed growth rate (**Table 1** and **2**). '*Kezie'* and '*Chongloiman'* were at par and recorded significantly lower density and biomass of grasses, sedges and broad-leaved weeds over '*Leikhumo'* which recorded the highest density and biomass of grasses, sedges and broad-leaved weeds throughout the crop season. Cultivars '*Kezie'* and '*Chongloiman'* were associated with traits like rapid tillering and increased plant height respectively early in the cropping season leading to early canopy establishment, ground cover and crop biomass accumulation and these attributes may have resulted in better weed suppression and lower weed growth. The ideal plant type that can strongly compete against weeds has shoots that spread and cover the ground rapidly during early vegetative stage (Zhao 2006). Characteristics commonly identified to make crops more competitive against weeds include rapid germination, early above ground growth, rapid canopy establishment (Lemerle *et al.* 2001), high tillering capacity (Saito *et al.* 2010), taller plants (Hucl 1998) and greater biomass accumulation early in the cropping period (Saito *et al.* 2010).

Early canopy establishment by the cultivars '*Kezie'* and '*Chongloiman'* might also have resulted in better photosynthetic photon flux density interception enhancing competitiveness of the rice cultivars. Crops with vigorous growth that reduce the quality and quantity of light beneath the crop canopy are the most competitive (Buhler 2002). Relative weed growth rate recorded at 30 to 60 DAS was found to be significantly lower for '*Kezie'* and '*Chongloiman'*, which were at par. '*Leikhumo'* and '*Kotsala'* were also at par and recorded significantly higher relative growth rate of weeds. This may be attributed to significantly lower weed biomass recorded by '*Kezie'* and '*Chongloiman'* compared to '*Leikhumo'* and '*Kotsala'*.

Effect of sowing methods and cultivars on crop yield

Significantly higher grain yields were recorded under line sowing as compared to broadcasting during both the years (**Table 1**). Comparatively superior weed suppression and reduced weed growth exhibited under line sowing as compared to broadcasting, facilitated higher uptake of nutrients by the crop resulting in better crop growth and yield attributes. Higher uptake of nutrients by the rice crop helps to achieve higher source-sink capacity, which

positively reflects in higher grain yield of rice (Choudhary 1989). Vijayakumar *et al*. (2006) also reported that higher nutrient availability subsequently results in better source to sink conversion. Lower grain yield recorded under broadcasting can be attributed to the increased nutrient removal by the weeds due to high weed competition associated with the treatment. Broadcasting produced the lowest number of effective tillers/hill, total filled grains/ panicle, 1000-grain weight and grain yield (Roy *et al.* 2009). Significant differences in grain yield were also recorded among the different cultivars (**Table 1**). During both the years '*Chongloiman*' was found to record significantly higher grain yield over *'Leikhumo'* and *'Kotsala'*, which were at par. '*Kezie*' was at par with *'Chongloiman'* and *'Kotsala'* and recorded significantly higher grain yield over the cultivar *'Leikhumo'*. The cultivars *'Chongloiman'* and*'Kezie'* exhibited superior weed suppression and reduced weed growth during the vegetative stage of the crop which facilitated efficient utilization of the various growth resources leading to luxuriant crop growth and better expression of yield attributes and grain yield. The morphology and growth rate of a cultivar can have a significant effect on both the crop and weed development. The morphological and physiological traits of a strongly competitive crop will enable it to capture resources from a weed and utilize resources more efficiently (Lemerle *et al.* 2001).

Weeds

In the present experiment, 29 weed species were identified out of which broad-leaved weeds, grasses and sedges comprised 20, 7 and 2 species. The weed flora and growth pattern of most dominant weed species belonging to each category of weeds are have been given below:

Grasses: Grass species recorded from the experimental field were *Cynodon dactylon* (L.) Pers., *Digitaria setigera* Roth ex Roem. and Schult., *Echinochloa colona* (L.) Link, *Imperata cylindrica* (L.) P. Beauv., *Eleusine indica* (L.) Gaertn., *Paspalum distichum* L. and *Setaria pumila* (Poir.) Roem. & Schult. Among the grassy weeds recorded, *Digitaria setigera* was observed to be the most dominant species throughout the crop season. The emergence, growth pattern and population density of the weed species as affected by sowing methods and cultivars are discussed below.

Digitaria setigera: The grassy weed was observed in the experimental field at 15 DAS and reached peak emergence at 90 DAS. The weed showed a slow growth during the early part of the crop growth with a faster growth during the later stages of the crop growth. The slow initial growth of the weed may be due to low temperature while, progressive increase in temperature during the later stages coupled with wider adaptability might have resulted in the faster growth of the weeds at later stages. Longchar (2000) also reported the dominance of *Digitaria setigera* in upland rice fields of Nagaland. Sowing methods exhibited considerable variations in the population density of the weed. At the peak period of emergence, broadcasting was found to record higher population of the grassy weed (47 and 42 plants/m^2 during 2009 and 2010 respectively) whereas, lower populations (33 plants/m^2 each during 2009 and 2010) were recorded under line sowing. Considerable variation in the population of this grassy weed was also recorded among the four cultivars. Maximum population (40 and 36 plants/m^2 during 2009 and 2010, respectively) at peak period of emergence was recorded by '*Leikhumo'* during both the years whereas, '*Chongloiman'* recorded the lowest population of 33

Table 1. Effect of seeding methods and cultivars on density of weeds

Treatment	Density of different weed categories (no./m^2)					
	Grasses		Sedges		Broad-leaved weeds	
	2009	2010	2009	2010	2009	2010
Sowing methods						
Broadcasting	4.45(19.3)	4.18(17.0)	2.39(5.2)	2.27(4.6)	21.14(446.4)	20.26(410.0)
Line sowing	3.68(13.0)	3.43(11.3)	2.00(3.5)	1.91(3.1)	17.46(304.3)	16.33(266.2)
LSD (p=0.05)	0.76	0.73	0.37	0.31	3.65	3.80
Cultivars						
Leikhumo	4.54(20.1)	4.26(17.6)	2.45(5.5)	2.31(4.8)	21.65(468.2)	20.76(430.5)
Kotsala	4.17(16.9)	3.94(15.0)	2.21(4.4)	2.13(4.0)	19.91(395.9)	18.97(359.4)
Kezie	3.84(14.2)	3.57(12.2)	2.11(3.9)	1.98(3.4)	18.08(326.4)	17.01(288.8)
Chongloiman	3.72(13.3)	3.45(11.4)	2.01(3.5)	1.93(3.2)	17.56(307.8)	16.45(270.1)
LSD (p=0.05)	0.47	0.52	0.25	0.22	2.35	2.52

Figures in parentheses represent original values

and 29 plants/m^2 during 2009 and 2010, respectively followed by '*Kezie'* (35 and 31 plants/m^2 during 2009 and 2010, respectively).

Sedges: The sedge species observed in the experimental field were *Cyperus iria* L. and *Cyperus rotundus* Linn. of which the later was found to be more dominant. Emergence, growth pattern and population density of the weed species are discussed below.

***Cyperus rotundus* Linn**.: The sedge species was observed to emerge at initial stage of the crop (15 DAS), attaining its peak at mid stage of the crop (60 DAS) and declining towards harvest of the crop. Dutta (1993) also reported dominance of sedges at 60 DAS to harvest in direct sown rainfed summer rice. Better adaptability and favourable microclimate conditions created by the influence of temperature, moisture and soil type under the crop canopy might have resulted in pre-dominance of the weed. Whereas, smothering effect of the rice canopy and the more competitive broad-leaf species may have resulted in reduced population of the weed species during the later stages of the crop. Predominance of *C. rotundus* in upland rice field of Nagaland was also reported by Longchar (2000). At the peak period of emergence, maximum population of the weed (26 and 24 plants/m^2 during 2009 and 2010, respectively) was recorded under broadcasting whereas, lower populations (20 and 18 plants/m^2 during 2009 and 2010, respectively) were recorded under line sowing during both the years (**Table 2**). Among the cultivars, highest population at peak period of emergence (22 and 20 plants/m^2 during 2009 and 2010, respectively) was recorded by '*Leikhumo'* during both the years whereas, the lowest population of the sedge (17 and 15 plants/m^2 during 2009 and 2010, respectively) was recorded by '*Chongloiman'* followed by 'Kezie' (18 and 16 plants/m^2 (**Table 2**) during 2009 and 2010, respectively).

Broad-leaf weeds: Broad-leaf weed species recorded from the experimental field were *Ageratum conyzoides* L., *Amaranthus viridis* L., *Borreria articularis* (L. f.) F. N. Will., *Cassia tora* L., *Cleome rutidosperma* DC., *Corchorus aestuans* L., *Commelina benghalensis* L., *Cuphea balsamina*, *Emilia sonchifolia* (L.) DC., *Eryngium foetidum* L., *Hedyotis auricularia* L., *Ipomoea triloba* L., *Ludwigia linifolia* Poir., *Melochia corchorifolia* L., *Mimosa pudica* L., *Mollugo pentaphylla* L., *Scoparia dulcis* L., *Solanum khasianum* C.B. Clarke., *Synedrella nodiflora* (L.) Gaertn., *Triumfetta rhomboids* Jacq. Among the broad-leaf species *Borreria articularis* (L.f.) F.N. Will. was found to be the most dominant species. The emergence, growth pattern and population density of the weed species as affected by sowing methods and cultivars are discussed below.

Borreria articularis: The broad-leaf weed was observed in the experimental field at 15 DAS attaining maximum population at mid stage (60 DAS) of the crop and declining slightly towards harvest. Behera and Jena (1997) also reported dominance of broad-leaf weeds at mid stages of crop growth in direct sown rice. In the present investigation, broadleaf weed species in general were found to be most dominant recording considerably higher weed density and dry weight throughout the crop season as compared to the grassy weeds and sedges. Early germination of the broad-leaf weed with vigorous early growth due to better competitive ability might have resulted in smothering of the other grassy weeds and sedges. At the peak period of emergence, broadcasting method was found to record higher population of the weed during both the years (694 and 623 plants/m^2 during 2009 and 2010, respectively)

Table 2. Effect of seeding methods and cultivars on weed growth and rice yield

Treatment	Weed biomass (g/m^2)		Relative weed growth rate 30-60 DAS (g/g/day)		Grain yield (t/ha)	
	2009	2010	2009	2010	2009	2010
Sowing methods						
Broadcasting	155.7	148.5	0.0190	0.0179	2.05	2.17
Line Sowing	132.0	123.7	0.0136	0.0116	2.85	3.00
LSD (p=0.05)	16.50	15.05	0.0029	0.0028	0.59	0.42
Cultivars						
Leikhumo	153.2	146.5	0.0176	0.0166	2.20	2.37
Kotsala	146.5	138.4	0.0176	0.0164	2.36	2.53
Kezie	139.5	131.4	0.0152	0.0133	2.50	2.61
Chongloiman	136.4	128.1	0.0148	0.0127	2.75	2.83
LSD (p=0.05)	10.98	10.62	0.0019	0.0018	0.28	0.24

whereas, line sowing recorded lower populations of the weed (479 and 455 plants/m^2 during 2009 and 2010, respectively). Variations in the population of the weed were also recorded among the four cultivars. During both the years at the peak period of emergence, '*Leikhumo*' was found to record the highest population of the weed (638 and 598 plants/m^2 during 2009 and 2010, respectively) whereas, the lowest population was recorded by '*Chongloiman*' (447 and 387 plants/m^2 during 2009 and 2010, respectively) followed by '*Kezie*' (486 and 426 plants/m^2) and '*Kotsala*' (585 and 549 plants/m^2) during 2009 and 2010, respectively.

Line sowing of the cultivars '*Chongloiman*' and '*Kezie*' was found to record significantly lower weed growth and higher grain yield of rice during both the years. Among the three categories of weeds recorded, broad-leaf weed species were found to be most dominant and recorded considerably higher weed density and biomass throughout the crop season as compared to the grasses and sedges. Sowing methods and cultivars were found to influence weed density and biomass. Further research in this area is needed to develop sustainable integrated weed management approaches with emphasis on indirect methods of control in order to alleviate the issues of low production and productivity of direct-seeded upland rice while addressing the issues of environmental pollution and food security.

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