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GROWTH & YIELD RESPONSE OF DIRECT-SEEDED RICE (*ORYZA SATIVA* L.) CULTIVARS UNDER DIFFERENT SOWING METHODS AND WEED MANAGEMENT METHODS

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Abstract- Field experiments were conducted during *kharif* season of 2009 and 2010 at SASRD, NU, Medziphema Campus, Nagaland, to study the response of direct-seeded rice (*Oryza sativa* L.) cultivars towards different sowing and weed management methods. The dominant weed species were *Digitaria setigera* Roth ex Roem. & Schult, *Cynadon dactylon* (L.) Pers., *Cyperus rotundus* L., *Borreria articularis* (L. f.) F. N. Will. and *Ipomoea triloba* L. Line sowing was found superior over broadcasting in reducing weed growth and exhibited better crop growth attributes and yield attributes and also recorded higher grain yield (2.85 t/ha during 2009 & 3.00 t/ha during 2010). The cultivar '*Kezie'* was found to effectively suppress weed growth and recorded significantly higher tillers/m^2, panicles/m^2 and filled grains/panicle and grain yield (2.50 t/ha during 2009 & 2.61 t/ha during 2010) over '*Leikhumo*'. Weed management treatment hand weeding at 20 and 40 DAS (Days after sowing) effectively minimized weed population and dry weight and recorded the highest the weed control efficiency (92.57% during 2009 & 94.64% during 2010) as well as grain yield (3.42 t/ha during 2009 & 3.57 t/ha during 2010). The highest gross return/ha and net return/ha (Rs.22265/ha during 2009 & Rs.24360/ha during 2010) and also the highest BCR (benefit cost ratio) (2.26 during 2009 & 2.38 during 2010) was recorded by the cultivar '*Kezie*' in combination with line sowing and hand weeding at 20 & 40 DAS.

Keywords- Direct-seeded rice, Cultivars, Planting methods, Line sowing, Weed management, Hand weeding, Net returns, BCR.

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Introduction

Sowing method is a very important factor that determines the crop stand and ultimately the crop yield. Maintaining uniform depth and spacing during sowing not only reduces the seed rate but also results in early and uniform crop emergence and establishment, which allows the crop to be more competitive with weed for growth resources *viz*., space, light, nutrients and water leading to higher crop yields. The way a crop is grown also gives the crop subsequent advantages by widening the weeding window or increases flexibility during subsequent weeding. Thus, selection of proper sowing method is necessary to ensure optimum plant population, synchronization of tillering, flowering and maturity and reaping a bumper harvest.

The morphology and growth rate of a cultivar is yet another important aspect, which can significantly affect the development of both the crop and weed. In order to get the greatest advantage from weed control methods the cultivar itself must have the ability to compete against weed. Many researchers have reported that in cereals choice of cultivar can be useful in suppressing weed and thereby minimize weed control inputs. Competitive cultivars can therefore be considered as one of the important components for integrated weed management strategies**.** Weed problem is one of the major yield-limiting constraints in direct seeded upland rice because, in case of direct-seeded rice, the crop and weed germinates simultaneously, eliminating the head start advantage in case of transplanted seedlings.

Weed control has always been one of the major inputs in rice production. Without effective weed control, even the best rice variety will not produce its potential yield. Chemical weed control has become popular among the farmers being the most efficient means of reducing weed competition with minimum labor cost however, the use of excessive herbicides causes environmental pollution and proliferates resistant weed biotypes. Hand weeding though effective, is tedious, time consuming and less cost effective. Weed populations tend to differ for different environments wherein applying a single weed control method are not effective also recurring use of a particular method may lead to build up weed resistance. These risks prompt for environmentally safe and labor efficient methods of weed management. The combination of direct weed control methods such as herbicide with subsequent hand weeding would prove to be more environment-friendly and cost effective and can result in improved yields. Therefore, the present investigation was undertaken to evaluate the effect of sowing methods and weed management methods on weed growth and growth and yield of local direct-seeded upland rice cultivars in order to evolve feasible and economical cultivation practices.

MaterialsandMethods

Field experiments were conducted during the *kharif* season of 2009 and 2010 in the experimental farm of SASRD, NU, Medziphema Campus, Nagaland. The soil of the experimental field was clayey loam and well drained with a pH of 5.0. The soil was low in available nitrogen, medium in available phosphorous and available potassium and had high organic carbon content. The experiment was conducted in split-split plot design with three replications comprising of two sowing methods *viz.,* broadcasting and line sowing, two local upland rice cultivars *viz*., '*Leikhumo*' and '*Kezie*' and two weed management methods *viz*., hand weeding at 20 & 40 DAS and pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS. Primary and secondary tillage was done during the last week of April and May respectively during both the years. FYM (Farm yard manure) @ 10 t/ha was uniformly broadcasted over the field and incorporated thoroughly during the final land preparation and NPK (Nitrogen, phosphorus and potassium) @ 40: 20: 20 kg/ha in the form of Urea, Single Super Phosphate and Murite of Potash were applied in all the experimental plots. Both the cultivars were sown during the first week of June with a seed rate of 100kg/ha (broadcasting) and 50kg/ha (line sowing). For broadcasting method the seeds were broadcasted on

the seedbeds then covered with soil using local plough whereas, in line sowing the seeds were sown in furrows 20 cm apart at an interplant spacing of 10 cm. The crop was harvested during the last week of August during both the years. The performances of different treatments were studied in terms of types of weed flora, weed population, weed dry weight, WCE (Weed Control efficiency) and their subsequent effect on crop growth and yield attributes and grain yield of rice. The economics including cost of cultivation, gross return/ha, net return/ha and BCR (Benefit cost ratio) were worked out for both years.

Results and Discussion

Weed flora

Weed flora recorded from the experimental field comprised of 29 weed species out of which broadleaved weed, grasses and sedges comprised 20, 7 and 2 species respectively. The dominant weed species observed were *Digitaria setigera* Roth ex Roem. & Schult, *Cynadon dactylon* (L.) Pers., *Eleusine indica* (L.) Gaertn., *Echinochloa colona* (L.), *Cyperus rotundus* L., *Cyperus irria* L., *Borreria articularis* (L. f.) F. N. Will., *Ageratum conizoides* L., *Ipomoea triloba* L., *Mimosa pudica* L. and *Melochia corchorifolia* L.

Sowing method effects on weed growth

Weed population, dry weight, and WCE were significantly influenced by the different sowing methods [Table-1]. Line sowing was superior over broadcasting in reducing weed population and weed dry weight and also registered the highest WCE. Line sowing of the crop may have resulted in early and uniform crop emergence and establishment, which allowed the crop to be more competitive with the weed. Under drilling or line sowing due to uniform depth of sowing crop stand is uniform while under broadcasting method crop stand is uneven and due to haphazard spacing there is excess or no competition in some areas of the field [13]. Early establishment of a good crop stand under line sowing may have resulted in subsequent advantage for weed control by way of increasing selectivity between crop and weed and ease in weeding operations. This finding is supported by the earlier reports of Sharma and Choubey [16]. Whereas, slow emergence and poor crop stand under broadcasting method might have resulted in the weed having a competitive edge over the crop. In broadcasting method the seeds fall at different depths leading to uneven crop stand. At any given time, the plants are at different height, size and age also the spacing available for the individual plants also varies considerably which results in excess or no competition in some areas of the field [13].

Cultivar effects on weed growth

The cultivar '*Kezie*' registered significantly lower weed population and weed dry weight throughout the crop season ultimately recording higher WCE over the cultivar '*Leikhumo*' [Table-1]. The superior weed suppression ability exhibited by '*Kezie*' may be due to better crop growth and accumulation of higher crop biomass early in the cropping season. The cultivar *Kezie* was observed to exhibit higher biomass and crop growth rate early during the vegetative stage this attributes may have resulted in early ground cover and canopy establishment thereby exhibiting better weed suppression and lower weed biomass. These findings are in line with the findings of Fukai [7] who also reported that the plant type, which has rapid shoot growth and covers the ground during vegetative stage, can compete strongly against weed. Zhao [18] also reported similarly. Cousens *et al.* [4] also reported that higher biomass accumulation early in the cropping period gives better competitive edge to a species throughout the growth period.

Weed management effects on weed growth

Weed management practices had significant effect on all weed attributes *viz*, weed population, weed dry weight and WCE [Table-1]. Weed population and weed dry weight were recorded to be significantly highest for unweeded control throughout the crop season. Mirza Hasanuzzaman *et al.* [9] also reported that weed density was significantly greater in unweeded plots than other treatments. At 30 DAS, the weed management treatment hand weeding at 20 & 40 DAS registered significantly lower weed population and weed dry weight over pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS. This may be due to the fact that manual removal of weed at 20 DAS might have effectively controlled the growth of weed in the former case whereas, decreasing efficiency of butachlor with the lapse of time [15] may have attributed for higher weed growth in the later case. Similar results were also reported by Bikash Kumar Mandal *et al.* [12] who reported that hand weeding was most effective in controlling all three types of weed *viz.* Grasses, sedges and broad leaved when compared with different herbicides in rice fields. At subsequent stages of observations both the weed management treatments were at par with each other and recorded significantly lower weed population and weed dry weight over unweeded control. This was in agreement with the findings of Singh and Patel [17]. Ultimately, significantly higher WCE was recorded by hand weeding at 20 & 40 DAS over the treatment pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS.

Table-1 *Sowing methods, cultivars and weed management effects on weed and crop growth attributes*

Treatment	Weed population (No./m²)		Weed dry weight (g/m²)		Weed control efficiency (%)		Plant height (cm)		Tillers (No./m²)		Plant dry weight (g/m²)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Sowing Methods												
Broadcasting	21.70 (470.39)	20.77 (430.89)	155.74	148.51	59.86	60.79	102.87	114.80	246.42	238.92	1056.71	1041.94
Line Sowing	17.92* (320.63)	16.76* (280.40)	132.04*	123.71*	61.06*	62.71*	139.17*	135.56*	309.93*	315.75*	1507.38*	1557.60*
LSD (P=0.05)	3.76	3.89	16.54	15.06	0.93	0.94	35.93	20.36	63.27	58.47	345.81	396.13
Cultivars												
'*Leikhumo*'	22.22 (493.23)	21.29 (452.76)	153.21	146.52	60.07	61.33	133.98*	137.10*	253.47	247.17	1192.69	1206.64
'*Kezie*'	18.57* (344.34)	17.45* (304.00)	139.51*	131.45*	60.61*	61.94*	98.71	101.54	326.53*	328.72*	1259.92	1277.11
LSD (P=0.05)	2.42	2.59	10.98	10.62	0.49	0.54	16.46	11.95	44.47	31.46	NS	NS
Weed Management												
Unweeded control	37.94 (1438.94)	36.34 (1320.10)	343.32	327.94	0.00	0.00	95.41	99.43	172.98	202.46	757.94	714.19
W_1	10.38* (107.24)	9.58* (91.28)	41.13*	36.88*	92.57*	94.64*	139.19*	142.73*	354.73*	359.21*	1602.10*	1654.66*
W_2	11.11 (122.93)	10.37 (107.04)	47.21	43.52	88.81	90.61	128.46	133.39	306.81	270.33	1486.08	1530.46
LSD (P=0.05)	1.20	1.26	8.61	8.56	0.36	0.41	10.63	9.05	30.82	23.60	110.62	122.71

Figures in parenthesis represent original values

W_1- Hand weeding at 20 & 40 DAS

W_2- Pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS

LSD (P=0.05)- Least significant difference at probability level 5%

NS- Non-significant

Sowing method effects on crop growth

The reduced weed growth observed under line sowing resulted in better availability of growth resources for luxuriant growth of the crop thereby recording significantly higher plant height and number of tillers and also higher plant dry weight compared to broadcasting [Table-1]. Roy *et al.* [14] also reported that the highest and lowest number of effective tillers/hill was registered under direct seeding and broadcasting respectively. Gogoi [8] also observed an increase in plant height with the increase in planting density. Higher plant height and no. of tillers observed under line sowing may be attributed for higher dry matter accumulation recorded under line sowing.

Cultivar effects on crop growth

The cultivar '*Leikhumo*' recorded significantly higher plant height over '*Kezie*', which was due to the fact that the former was a tall cultivar whereas the later was semi-dwarf in nature. However, '*Kezie*' was found to record higher number of tillers compared to '*Leikhumo*', which may be due to superior weed suppression. Both the cultivars were at par with each other with respect to plant dry weight, which may be credited to higher number of tillers and increased plant height as recorded by '*Kezie*' and '*Leikhumo*' respectively [Table-1]. Estorninos *et al.* [6] also pointed out that rice cultivars with higher tiller production also recorded higher biomass accumulation.

Weed management effects on crop growth

Between the two weed management treatments tested, hand weeding at 20 & 40 DAS was found superior in recording the highest plant height, number of tillers and plant dry weight [Table-1]. Pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS was also found to record significantly higher crop growth attributes *viz*., plant height, number of tillers and plant dry weight as compared to unweeded control. Higher weed control efficiency associated with both the treatments resulted in lower crop-weed competition effecting better crop growth and development. Higher weed control efficiency favorably induces greater tiller production [1], better crop growth and biomass yield [10].

Sowing method effects on crop yield and yield attributes

Comparatively superior weed suppression and reduced crop weed competition observed under line sowing, as compared to broadcasting, resulted in better expression of yield attributes *viz*., number of panicles/m^2, panicle weight, number of filled grains/panicle and 1000 grain weight and ultimately resulted in higher grain yield [Table-2]. Higher nutrient uptake by the rice crop helped to achieve higher source-sink capacity through increase in the number of panicles/m^2 number of filled grains/panicle which positively reflected in higher grain yield of rice [3]. Whereas, inferior yield attributes and grain yield recorded under broadcasting can be attributed to the increased removal of nutrients by the weed due to high crop weed competition associated with the treatment. Roy *et al.* [14] also reported that broadcasting produced the lowest number of effective tillers/hill, total filled grains/panicle, 1000-grain weight and grain yield.

Cultivar effects on crop yield and yield attributes

Significantly higher grain yield was recorded by the cultivar '*Kezie*' over '*Leikhumo*' which was due to better expression of yield attributes *viz*., number of panicles/m^2 and number of filled grains/panicle [Table-2]. Superior expression of the yield attributes in turn may be attributed to increase in availability of growth resources due to effective weed suppression. A cultivar's characteristics *viz*., morphology and growth rate can have a considerable impact on the growth and development of both the crop and weed. The morphological and physiological attributes of a strongly competitive crop will facilitate better resource capture from weed and thereby effect efficient utilization of those resources [11].

Weed management effects on crop yield and yield attributes

Hand weeding at 20 & 40 DAS registered the highest rice grain yield [Table-2] compared to both pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS and unweeded control. Dwivedi *et al.* [5] also reported that hand weeding twice was the best weed control treatment producing the highest grain yield. Whereas, pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS was also found to record significantly higher grain yield as compared to that recorded under unweeded control. Significantly higher grain yields, as compared to unweeded control, observed under both hand weeding at 20 & 40 DAS and pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS may be attributed to superior expression of yield attributing characters *viz*., panicle numbers/m^2, panicle weight, filled grains/panicle and 1000 grain weight exhibited by both the treatments [Table-2]. While superior expression of yield attributes recorded by both hand weeding at 20 & 40 DAS and pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS may be attributed to the increase in availability of growth resources to the crop as a result of superior weed control efficiency associated with both the treatments. Baharat Bhushan Rao *et al.* [2] also reported that grain yield could be associated with production of higher dry matter, greater number of productive tillers, heavier panicle, number of total grains/panicle and 1000-grains weight.

Table-2 *Sowing methods, cultivars and weed management effects on yield attributes and yield of rice*

Treatments	Panicles (No./m^2)		Panicle weight (g)		Filled grains (No./panicle)		1000 grain weight (g)		Grain yield (t/ha)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Sowing Methods										
Broadcasting	144.81	158.28	3.23	4.37	108.32	134.38	21.95	22.63	2.05	2.17
Line Sowing	236.31*	218.11*	6.12*	6.54*	208.82*	181.16*	27.45*	28.12*	2.85*	3.00*
LSD (P=0.05)	83.39	55.84	2.16	1.85	78.06	46.63	4.84	4.75	0.59	0.42
Cultivars										
'*Leikhumo*'	159.17	161.06	4.07	4.82	127.32	126.27	23.83	24.48	2.20	2.37
'*Kezie*'	246.67*	233.61*	4.55	5.32	173.72*	166.06*	24.73	25.42	2.50*	2.61*
LSD (P=0.05)	54.10	37.14	NS	NS	42.28	32.14	NS	NS	0.28	0.23
Weed Management										
Unweeded control	51.25	94.96	2.67	4.13	104.06	93.68	17.74	19.09	0.91	1.01
W_1	288.46*	257.17*	6.26*	6.90*	204.61*	215.55*	29.13*	29.64*	3.42*	3.57*
W_2	231.96	212.46	5.10	5.34	167.04	164.08	27.23	27.39	3.03	3.18
LSD (P=0.05)	36.31	16.76	0.65	0.35	28.90	18.51	1.61	1.95	0.18	0.16

W_1- Hand weeding at 20 & 40 DAS

W_2- Pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS

LSD (P=0.05)- Least significant difference at probability level 5%

NS- Non-significant

Economics

The economics of the various treatment combinations including cultivation cost/ha, gross return/ha, net return/ha and BCR [Table-3] was worked out taking into consideration the grain and straw yield and the cost of inputs required for production of the rice crop. Current market prices for grain and straw were used to calculate the net profit or loss in terms of rupees/hectare. The highest cost of

cultivation was recorded by both the cultivars '*Kezie*' and '*Leikhumo*' in combination with broadcasting and hand weeding at 20 & 40 DAS which can be attributed to higher seed cost associated with broadcasting and higher labor cost associated with hand weeding. The lowest cost of cultivation was incurred by both the cultivars in combination with line sowing and unweeded control, which can be attributed to lower seed cost associated with line sowing and exclusion of weed control under unweeded control. The cultivation practice involving the cultivar '*Kezie*' with line sowing and hand weeding at 20 & 40 DAS did not record the lowest cost of cultivation however it was found to be the most economically viable cultivation practice providing the highest gross and net returns/ha and also recording the highest BCR which could be attributed to higher gross returns, in excess of the cost of cultivation incurred, due to higher grain yields of rice under the treatments. The lowest gross return/ha, net return/ha and BCR were recorded by cultivar '*Leikhumo*' in combination with broadcasting and unweeded control which was due to rice grain yield reduction as a result of ineffective weed control under the treatments resulting in a negative balance in the net returns.

Table-3 *Comparative economics of different treatments*

Treatments	Cost of cultivation (Rs./ha)	Gross return/ha (Rs.)		Net return/ha (Rs.)		Benefit cost ratio	
		2009	2010	2009	2010	2009	2010
'Leikhumo' + broadcasting + unweeded control	14281	5040	5607	-9241	-8674	0.35	0.39
'Leikhumo' + broadcasting + W_1	20581*	25390	28813	4809	8232	1.23	1.40
'Leikhumo' + broadcasting + W_2	18211	22137	25620	3926	7409	1.22	1.41
'Kezie' + broadcasting + unweeded control	14281	6333	7605	-7948	-6676	0.44	0.53
'Kezie' + broadcasting + W_1	20581*	29333	31107	8752	10526	1.43	1.51
'Kezie' + broadcasting + W_2	18211	27333	26953	9122	8742	1.50	1.48
'Leikhumo' + line sowing + unweeded control	14034	11333	12330	-2701	-1704	0.81	0.88
'Leikhumo' + line sowing + W_1	17634	36333	36543	18699	18909	2.06	2.07
'Leikhumo' + line sowing + W_2	16614	31917	33260	15303	16646	1.92	2.00
'Kezie' + line sowing + unweeded control	14034	12333	13084	-1701	-950	0.88	0.93
'Kezie' + line sowing + W_1	17634	38333*	40410*	20699*	22776*	2.17*	2.29*
'Kezie' + line sowing + W_2	16614	35940	37380	19326	20766	2.16	2.25

Cost of cultivation was uniform for both years

W_1- Hand weeding at 20 & 40 DAS

W_2- Pre-emergence butachlor application @ 1.5 kg/ha 3 DAS + hand weeding at 40 DAS

Conclusion

Early and uniform crop emergence and establishment under line sowing compared to broadcasting resulted in reduced weed growth and significantly superior expression of yield attributes, which ultimately resulted in higher grain yield of rice. The cultivar *'Kezie'* was found to show better WSA (Weed suppression ability) early from the crop season. The growth rate of the cultivar *viz.* higher plant dry weight and more no. of tillers resulted in early ground cover and better competition with weed resulting in superior crop growth and yield. Hand weeding at 20 & 40 DAS resulted in effective control of all three categories of weed as compared to application of butachlor with hand weeding at 40 DAS, which recorded higher weed growth as a result of decreasing efficiency of the herbicide with the lapse of time. Ultimately, hand weeding at 20 & 40 DAS resulted in better crop growth and grain yield of rice. Line sowing of the cultivar '*Kezie*' with hand weeding at 20 & 40 DAS was the most effective cultivation practice in minimizing weed competition and enhancing crop growth and yield of direct-seeded rice recording the highest gross and net return/ha and also BCR.

Conflict of Interest: None declared

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