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A study on effective non-chemical weed management techniques for direct seeded rice

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Abstract
A field experiment was conducted during the *kharif* season of 2018 at the experimental farm of Agronomy, NU:SASRD, Medziphema campus, Nagaland, to study the effect of non-chemical weed management techniques for direct seeded rice. The experiment was laid out in randomized block design with 8 treatment combinations consisting of non chemical weed management practices comprised of five treatments *viz*. Weedy check (W_1), Hand weeding at 30 and 60 DAS (W_2), Soil solarisation (W_3), Brown manuring (W_4), Organic mulching (W_5). Sowing methods comprised of three treatments *viz*. Broadcasting (S_1), Line sowing at 20 cm (S_2) and Hand dibbling (S_3). Non-chemical weed management treatment hand weeding at 30 and 60 DAS significantly reduced weed density, weed biomass and increased weed control efficiency, grain yield (35.05 q ha^{-1}), straw yield (80.93 q ha^{-1}) whereas weedy check (W_1) recorded the highest weed density, weed biomas and lowest weed control efficiency, grain yield (17.30 q ha^{-1}), straw yield (69.77 q ha^{-1}). Among the sowing methods S_2-Line sowing recorded lower weed density, weed biomass and higher weed control efficiency, highest grain yield (29.24 q ha^{-1}).

Keywords: Weedy check, soil solarisation, brown manuring, organic mulching

Introduction
Nagaland is basically a land of agriculture. About 70% of the population depends on agriculture. The contribution of agricultural sector in the state is very significant. Rice is the widely consumed staple food. Majority of the farmers are engaged in the cultivation of rice. Nagaland accounts an area of 1, 89,480 ha with a production of 4, 29,640 tonnes out of which upland rainfed occupies an area of 94,700 ha with a production of 1,81,820 tonnes (Anonymous, 2014) [1]. The major land use pattern is slash and burn locally known as Jhum. The farmers in Nagaland practices the traditional way of cultivating crops. Upland rice productivity of Nagaland is very low owing to heavy weed infestation. Manual weeding is not only expensive but insufficiency of labour is another drawback at the time of need. The occurrence of weeds in agricultural crops leads to substantial yield reductions causing economic losses all over the world. Crop damage from weeds generally is larger than from other pests (Oerke, 2006) [12]. Weeds in direct seeded rice compete with crop for moisture, nutrient, light, temperature, space and can cause yield reduction up to 50-91% (Rao *et al*., 2007) [14]. Weed control using chemical has become popular among farmers being the most practical, effective and economical tool of weed management in rice. However, excessive use of herbicides causes environmental pollution and induces the proliferation of resistant weed biotypes (Kikon *et al*., 2018). Weed control methods must be sought that are friendlier to the environment and substantially reduce the weed management for farmers (Juraimi *et al*., 2013) [8]. 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 yield (Kikon and Gohain, 2016) [9]. Taking into account of all these consequences, the need to develop effective and economical non-chemical weed control has become priority for rice production and therefore, a field experiment was undertaken to evaluate the effective non-chemical weed management techniques for direct seeded rice.

Materials and Methods
The experiment was conducted during the *kharif* season of 2018 at the experimental farm of Agronomy, NU:SASRD, Medziphema campus, Nagaland. Climate is sub-humid tropical zone with an average rainfall ranging from 2000- 2500 mm.

The mean temperature experienced in the area varies between 21℃ – 30℃. The soil of the experimental site was as sandy loam and well drained and acidic in reaction (pH 4.6), characterized as low in available nitrogen, medium in P_2O_5 and medium in K_2O ha^{-1}. The experiment was laid out in randomized block design with the 8 treatment combinations consisting of non chemical weed management practices comprised of five treatments *viz*. Weedy check (W_1), Hand weeding at 30 and 60 DAS (W_2), Soil solarisation (W_3), Brown manuring (W_4), Organic mulching (straw) (W_5). Sowing methods comprised of three treatments *viz*. Broadcasting (S_1), Line sowing at 20 cm (S_2) and Hand dibbling (S_3). The size of each plot was 3 m × 3 m with gross area of 9 m^2. The date of sowing was 15th of June 2018. The three sowing methods were followed i.e. Broadcasting method (80 kg ha^{-1}), Line sowing by keeping 20 cm row to row spacing (80 kg ha^{-1}) and Hand Dibbling (75kg ha^{-1}) which was carried out randomly without any spacing. Nitrogen, phosphorus and potassium were uniformly applied basal at the rate of 60, 30 and 30 kg ha^{-1}, respectively, to all plots. Other agronomic practices were followed as per the standard packages of practices to grow the rice crop. Five random plants were selected in each plot at maturity according treatments for measurement of yield attributes. At harvesting grain and straw yields were recorded separately. The data obtained from the experiment were statistically analyzed using the F-test as per the standard procedure to determine the significance of difference between treatment means.

Result and Discussion

Results showed that at 30 DAS the variation on weed density due to various non-chemical weed management practices was found to be significant. The treatment W_5 i.e. organic mulching recorded lowest weed density (2.48) and was found to be superior to the other treatments whereas the treatment W_1 i.e. weedy check (control) recorded the highest weed density (9.50). At 60 DAS and 90 DAS non-chemical weed control treatment W_2 i.e. Hand weeding at 30 and 60 DAS recorded the lowest weed density 3.40 and 1.13 respectively, which was found to be at par with Organic mulching treatment (W_5), while the highest weed density was recorded for treatment W_1 i.e. weedy check (control) 10.53 and 8.25 respectively. The variations on weed density due to treatments were found to be significant [Table 1(a)]. This finding is in close similarity with the findings of Ravichandran and Prabhakaran (2017) [15]. Baloch *et al*. (2006) [2] reported that hand weeding showed significantly lower weed density at 90 DAS. Among different sowing methods the lowest weed density 6.06, 5.37 and 3.96 was recorded for S_2-line sowing treatment in 30 DAS, 60 DAS and 90 DAS respectively, while the highest weed density (7.18) was recorded for hand dibbling method of sowing (S_3) at 30 DAS [Table 1(a)]. The variations in weed density due to the interactions effect of various treatments at 30 DAS were found to be non-significant. However, the lowest weed density (1.85) was found in treatment combination S_2W_5 and the highest weed density (9.80) was recorded for treatment combination S_3W_1. At 60 DAS the variations in weed density due to the interactions effect of various treatments were found to be non-significant. However, the lowest weed density (2.84) was found in treatment combination S_2W_2 and the highest weed density (10.70) was recorded for treatment combination S_3W_1. The differences in weed density due to the interaction effect of various treatments at 90 DAS were found to be non-significant. However, the lowest weed density (0.99) was found in treatment combination S_2W_2 and the highest weed density (9.13) was recorded for treatment combination S_1W_1 [Table 1(b)].

The effect of various non-chemical treatments on weed biomass at 30 DAS was observed to be significant. The treatment W_5 i.e. organic mulching with straw recorded lowest weed biomass (1.45) and was found to be statistically superior to the other treatments whereas the treatment W_1 i.e. weedy check (control) recorded the highest weed biomass (4.88) at 30 DAS. The treatment W_2 i.e. hand weeding at 60 and 90 DAS recorded the lowest weed biomass 1.14 and 0.78 respectively and was found to be at par with W_5 whereas the treatment W_1 i.e. weedy check (control) recorded the highest weed biomass 5.11 and 4.89 respectively [Table 2(a)]. Behera and Jena (1998) [4] reported that significantly highest weed population and biomass were found where weeds were not disturbed during whole season of the crop growth and lowest when plots were seasonally weed free. Hand weeding twice recorded significantly less weed dry matter than unweeded control. Dutta and Gogoi (1994) [7] also reported similar result where hand weeding at 15, 25 and 35 DAS recorded lower weed population and dry weight. The lowest weed biomass 3.07, 2.40 and 2.14 was recorded for S_2- line sowing at 30, 60, 90 DAS respectively, while the highest weed biomass 3.51, 3.03 and 2.15 was recorded for broadcasting method of sowing at 30, 60, 90 DAS respectively. The lowest weed biomass in case of line sowing (S_2) may be due to easy weeding operations with tools and implements [Table 2(a)]. The variations in weed biomass due to the interaction effect of various treatments at 30 DAS were found to be non-significant. The lowest weed biomass (1.38) was found in treatment combination S_1W_5 and the highest weed biomass (4.89) was recorded for treatment combination S_3W_1. At 60 DAS the disparity in weed biomass due to the interaction effect of different treatments was found to be non-significant. The lowest weed biomass (0.96) was found in treatment combination S_1W_2 and the highest weed biomass (5.54) was recorded for treatment combination S_1W_1. The variations in weed biomass due to the interaction effect of different treatments at 90 DAS were found to be non-significant. However, the lowest weed biomass (0.72) was found in treatment combination S_2W_2 and the highest weed biomass (4.65) was recorded for treatment combination S_2W_1 [Table 2(b)].

Among the the highest weed control efficiency (87.82) was observed for treatment W_5 *i.e*. organic mulching with straw while the lowest weed control efficiency (0.00) was observed for treatment W_1 i.e. weedy check at 30 DAS. At 60 and 90 DAS the treatment W_2 i.e. hand weeding at 30 and 60 DAS recorded the highest weed control efficiency 96.62 and 99.45 respectively, while the treatment W_1 i.e. weedy check recorded the lowest weed control efficiency (0.00) at 60 and 90 DAS. The higher weed biomass ultimately resulted in low weed control efficiency and this was found true in weedy check plot where the weeds were left unweeded in the field. The highest weed control efficiency was observed under organic mulching at 30 DAS (W_5) which was found to be superior to the other treatments [Table 3(a)]. This finding is in close similarity with the results of Ravichandran and Prabhakaran (2017) [15]. Comparable higher weed control efficiency was also observed under treatment W_5 and W_4. This result is in conformity with the findings of Singh and Deo

(2004) [16] where hand weeding at 20 and 40 DAS showed 72 per cent weed control efficiency over unweeded control in direct seeded rice plants. Singh and Singh (2001) [17] reported similar findings that the highest weed control efficiency was obtained by weed free condition followed by two hand weeding done at 25 and 45 days after sowing (DAS). The data revealed that the highest weed control efficiency (49.36) was recorded for treatment S_1 *i.e.* Broadcasting and the lowest weed control efficiency (38.54) was observed for treatment S_3 *i.e.* Hand dibbling at 30 DAS. At 60 and 90 DAS the highest weed control efficiency 69.25, 67.70 respectively was recorded for treatment S_2 i.e. line sowing at 20 cm while the lowest weed control efficiency 54.67, 59.43 was observed for treatment S_3 i.e. Hand dibbling at 60 and 90 DAS [Table 3(a)]. Lower weed density and biomass resulted in higher weed control efficiency under line sowing at 60 and 90 DAS. At 30 DAS the treatment combination S_1W_5 recorded the highest weed control efficiency (94.70) whereas the treatment combinations S_1W_1, S_2W_1 and S_3W_1 recorded the lowest weed control efficiency (0.00). At 60 DAS the treatment combination S_1W_2 recorded the highest weed control efficiency (98.36) whereas the treatment combinations S_1W_1, S_2W_1 and S_3W_1 recorded the lowest weed control efficiency (0.00). The treatment combination W_2S_2 recorded the highest weed control efficiency (99.83) whereas the treatment combinations S_1W_1, S_2W_1 and S_3W_1 recorded the lowest weed control efficiency (0.00) at 90 DAS [Table 3(b)].

Among the method of non-chemical weed management, grain yield (35.05 q ha^{-1}), straw yield (80.93 q ha^{-1}), harvest index (HI) were the highest in hand weeding at 30 and 60 DAS (W_2) and the lowest in weedy check (Table 4). Similar results were recorded by Kikon and Gohain (2016) [10] reported that hand weeding at 20 and 40 days after sowing produced higher number of panicles m^{-2} and panicle weight which significantly increased the yield. Parameswari and Srinivas (2014) [13] reported that hand weeding at 20 and 40 DAS in direct sown rice resulted in significantly lower weed density, weed dry weight and lower removal of nutrients by weeds resulting in superior grain yield. Dixit and Singh (1981) [6] also revealed that hand weeding twice was the best weed control method producing the highest grain yield. Subhas and Jitendra (2001) [18] concluded that higher grain yield and better weed control was associated with hand weeding. Among the sowing methods the highest grain yield (29.24 q ha^{-1}) and straw yield (81.48 q ha^{-1}) was recorded for the treatment S_2 i.e. line sowing at 20 cm and was found to be at par with S_1 and the lowest grain yield (24.74 q ha^{-1}) was noted for the treatment S_3 i.e. hand dibbling. The disparity in grain yield due to different sowing methods was found to be significant (Table 4). The differences in grain yield due to the interaction effects were observed to be non-significant. However, the highest grain yield (38.83 q ha^{-1}) was listed for the treatment combinations S_2W_2 while the lowest grain yield (15.20 q ha^{-1}) was listed for the treatment combinations S_1W_1 [Table 4(a)]. The variations in straw yield resulted due to the interaction effects of different treatments were observed to be significant. The highest straw yield (88.33 q ha^{-1}) was listed for treatment combination S_1W_5 which was at par with S_2W_4, S_2W_2, S_1W_2, S_1W_3 and S_2W_5 while the lowest straw yield (61.86 q ha^{-1}) was recorded for treatment combination S_3W_1 [Table 4(b)]. Das *et al*. (2015) [5] also reported that the highest grain yield was obtained in line sowing method. This result is in close similarity with the findings of Bari (2004) [3] who also concluded that significantly higher grain yield was obtained from direct seeded line sowing method than other methods. Kour *et al*. (2018) [11] also revealed that higher paddy yield was obtained in line sowing as compared to other sowing methods. In line sowing method superior weed suppression and reduced crop weed competition were observed compared to other methods producing higher grain yield. The uniform plant stand established in line sowing gave opportunity to compete effectively with weeds resulting in better uptake of nutrients and better early growth which enhanced the grain yield significantly.

Table 1(a): Effects of non-chemical weed management practices and sowing methods on weed density (No. m^{-2}) at different growth stages of rice

Treatments	Weed density (No. m^{-2}) Days after sowing (DAS)		
A. Non-chemical weed management	**30**	**60**	**90**
W_1 - Weedy check (control)	9.50 (91.44)	10.53 (111.77)	8.25 (68.77)
W_2 - Hand weeding	8.93 (80.00)	3.40 (11.33)	1.13 (0.88)
W_3 - Soil solarisation	6.57 (44.66)	7.38 (54.77)	5.91 (35.88)
W_4 - Brown manuring	6.03 (36.66)	4.20 (17.66)	3.89 (14.88)
W_5 - Organic mulching	2.48 (6.11)	3.78 (14.11)	1.96 (3.66)
S.Em±	0.35	0.25	0.24
CD (P=0.05)	1.02	0.74	0.72
B. Sowing methods			
S_1 – Broadcasting	6.87 (52.6)	6.17 (45.00)	4.65 (29.8)
S_2 - Line sowing	6.06 (44.2)	5.37 (36.73)	3.96 (22.53)
S_3 - Hand dibbling	7.18 (58.53)	6.03 (44.06)	4.07 (22.13)
S.Em±	0.27	0.19	0.19
CD (P=0.05)	0.79	0.57	0.55

Data were subjected to square root transformation; figures in parenthesis are original values

Table 1(b): Interaction effects of non-chemical weed management practices and sowing methods on weed density (No. m^{-2}) at different growth stages of rice

Treatment combinations	Weed density (No. m^{-2}) Days after sowing (DAS)		
	30	**60**	**90**
S_1W_1 – Broadcasting + Weedy check (control)	9.46 (90.0)	10.52 (111.00)	9.13 (83.33)
S_1W_2- Broadcasting + Hand weeding	8.89 (79.0)	3.48 (11.66)	1.22 (1.00)
S_1W_3 – Broadcasting + Soil solarisation	6.71 (45.0)	7.90 (62.66)	6.56 (44.00)

S_1W_4 – Broadcasting + Brown manuring	6.40 (40.0)	4.80 (22.66)	3.90 (15.00)
S_1 W_5 – Broadcasting + Organic mulching	2.88 (8.33)	4.16 (17.00)	2.46 (5.66)
S_2W_1 – Line sowing + Weedy check (control)	9.24 (86.6)	10.38 (107.66)	8.43 (71.66)
S_2W_2- Line sowing + Hand weeding	8.55 (73.3)	2.84 (7.66)	0.99 (0.66)
S_2W_3 – Line sowing + Soil solarisation	5.09 (26.0)	6.64 (44.33)	4.85 (23.33)
S_2W_4 – Line sowing + Brown manuring	5.57 (32.0)	3.48 (12.00)	3.82 (14.33)
S_2W_5 – Line sowing + Organic mulching	1.85 (3.00)	3.50 (12.00)	1.71 (2.66)
S_3W_1 – Hand dibbling + Weedy check (control)	9.80 (97.6)	10.70 (116.66)	7.19 (51.33)
S_3W_2- Hand dibbling + Hand weeding	9.37 (87.6)	3.88 (14.66)	1.71 (1.00)
S_3W_3 – Hand dibbling + Soil solarisation	7.91 (63.0)	7.58 (57.33)	6.33 (40.33)
S_3W_4 – Hand dibbling + Brown manuring	6.12 (37.3)	4.33 (18.33)	3.94 (15.33)
S_3W_5 – Hand dibbling + Organic mulching	2.71 (70.0)	3.66 (13.33)	1.71 (2.66)
S.Em±	0.61	0.44	0.43
CD (P=0.05)	NS	NS	NS

Data were subjected to square root transformation; figures in parenthesis are original values

Table 2(a): Effects of non chemical weed management practices and sowing methods on weed biomass (g m^{-2}) at different growth stages of rice

Treatments	**Weed biomass(g m^{-2})**		
	Days after sowing (DAS)		
A. Non chemical weed management	**30**	**60**	**90**
W_1 - Weedy check (control)	4.88 (26.77)	5.11 (27.04)	4.89 (24.73)
W_2 - Hand weeding	4.48 (22.21)	1.14 (0.90)	0.78 (0.14)
W_3 - Soil solarisation	3.18 (10.00)	3.95 (9.78)	3.03 (9.75)
W_4 - Brown manuring	2.77 (7.45)	2.42 (3.83)	2.26 (5.36)
W_5 - Organic mulching	1.45 (1.67)	1.48 (1.89)	1.23 (1.22)
S.Em±	0.44	0.20	0.24
CD (P=0.05)	1.28	0.57	0.69
B. Sowing methods			
S_1 – Broadcasting	3.51 (14.69)	3.03 (9.30)	2.15 (6.31)
S_2 - Line sowing at 20 cm	3.07 (10.78)	2.40 (7.60)	2.14 (6.44)
S_3 - Hand dibbling	3.47 (15.38)	3.03 (9.16)	3.04 (11.13)
S.Em±	0.34	0.20	0.18
CD (P=0.05)	NS	0.57	0.53

Data were subjected to square root transformation; figures in parenthesis are original values

Table 2(b): Interaction effects of non chemical weed management practices and sowing methods on Weed biomass (g m^{-2}) at different growth stages of rice

Treatment combinations	**Weed biomass(g m^{-2})**		
	Days after sowing (DAS)		
	30	**60**	**90**
S_1W_1 – Broadcasting + Weedy check (control)	5.46 (30.76)	5.54 (31.83)	4.55 (21.59)
S_1W_2- Broadcasting + Hand weeding	5.10 (26.60)	0.96 (0.42)	0.73 (0.04)
S_1W_3 – Broadcasting + Soil solarisation	3.13 (9.47)	4.85 (23.79)	2.41 (5.94)
S_1W_4 – Broadcasting + Brown manuring	2.50 (5.83)	2.65 (6.58)	1.81 (2.80)
S_1 W_5 – Broadcasting + Organic mulching	1.38 (1.46)	1.16 (0.89)	1.23 (1.21)
S_2W_1 – Line sowing + Weedy check (control)	4.29 (20.11)	5.01 (26.46)	4.65 (22.96)
S_2W_2- Line sowing + Hand weeding	3.77 (15.75)	1.20 (1.03)	0.72 (0.02)
S_2W_3 – Line sowing at 20 cm + Soil solarisation	3.00 (8.74)	2.51 (5.82)	2.50 (5.89)
S_2W_4 – Line sowing at 20 cm + Brown manuring	2.85 (7.75)	1.70 (2.51)	1.59 (2.21)
S_2W_5 – Line sowing at 20 cm + Organic mulching	1.42 (1.56)	1.57 (2.19)	1.21 (1.13)
S_3W_1 – Hand dibbling + Weedy check (control)	4.89 (29.42)	4.78 (22.83)	5.48 (29.65)
S_3W_2- Hand dibbling + Hand weeding	4.56 (24.92)	1.27 (1.26)	0.90 (0.37)
S_3W_3 – Hand dibbling + Soil solarisation	3.41 (11.79)	4.49 (19.96)	4.10 (16.60)
S_3W_4 – Hand dibbling + Brown manuring	2.95 (8.79)	2.91 (9.05)	3.37 (11.07)
S_3W_5 – Hand dibbling + Organic mulching	1.56 (1.99)	1.71 (2.60)	1.26 (1.32)
S.Em±	0.76	0.44	0.40
CD (P=0.05)	NS	NS	NS

Data were subjected to square root transformation; figures in parenthesis are original values

Table 3(a): Effect of non-chemical weed management and sowing methods on weed control efficiency (%) at different growth stages of rice

Treatments	**Weed control efficiency (%)**		
	Days after sowing (DAS)		
A. Non chemical weed management	**30**	**60**	**90**
W_1 - Weedy check (control)	0.00	0.00	0.00
W_2 - Hand weeding	17.33	96.62	99.45
W_3 - Soil solarisation	48.31	36.49	56.98

W_4 - Brown manuring	60.51	77.72	71.93
W_5 - Organic mulching	87.82	92.06	93.02
B. Sowing methods			
S_1 - Broadcasting	49.36	57.82	65.70
S_2 - Line sowing	40.47	69.25	67.70
S_3 - Hand dibbling	38.54	54.67	59.43

Table 3(b): Interaction effects of non chemical weed management practices and sowing methods on weed control efficiency (%) at different growth stages of rice

Treatment combinations	Weed control efficiency (%) Days after sowing (DAS)		
	30	60	90
S_1W_1 – Broadcasting + Weedy check (control)	0.00	0.00	0.00
S_1W_2- Broadcasting + Hand weeding	12.26	98.36	99.66
S_1W_3 – Broadcasting + Soil solarisation	61.60	19.71	67.40
S_1W_4 – Broadcasting + Brown manuring	78.26	73.45	69.60
S_1 W_5 – Broadcasting + Organic mulching	94.70	97.60	91.86
S_2W_1 – Line sowing at 20 cm + Weedy check (control)	0.00	0.00	0.00
S_2W_2- Line sowing at 20 cm + Hand weeding	23.03	96.30	99.83
S_2W_3 – Line sowing at 20 cm + Soil solarisation	44.13	70.68	61.50
S_2W_4 – Line sowing at 20 cm + Brown manuring	48.13	88.16	85.03
S_2W_5 – Line sowing at 20 cm + Organic mulching	86.90	91.10	92.13
S_3W_1 – Hand dibbling + Weedy check (control)	0.00	0.00	0.00
S_3W_2- Hand dibbling + Hand weeding	16.71	95.20	98.86
S_3W_3 – Hand dibbling + Soil solarisation	39.20	19.09	42.06
S_3W_4 – Hand dibbling + Brown manuring	54.96	71.56	61.17
S_3W_5 – Hand dibbling + Organic mulching	81.86	87.50	95.06

Table 4: Effect of non-chemical weed management practices and methods of sowing on yield attributes of rice

Treatments	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
A. Non chemical weed management				
W_1-Weedy check control	23.30	17.30	69.77	21.60
W_2 - Hand weeding	24.82	35.05	80.93	30.18
W_3 - Soil solarisation	23.39	28.18	79.58	26.10
W_4 - Brown manuring	24.07	26.56	74.81	25.45
W_5 - Organic mulching	24.22	28.64	81.67	25.72
S.Em±	0.50	1.26	1.59	0.86
CD (P=0.05)	NS	3.67	4.62	2.49
B. Sowing methods				
S_1 - Broadcasting	24.05	27.47	80.05	25.15
S_2 - Line sowing	24.11	29.24	81.48	26.17
S_3 - Hand dibbling	23.72	24.74	70.53	26.10
S.Em±	0.39	0.98	1.23	0.66
CD (P=0.05)	NS	2.84	3.58	NS

Table 4(a): Interaction effect of non chemical weed management practices and sowing methods on grain yield (q ha^{-1}) of rice

Treatment combinations	Grain yield (q ha^{-1})
S_1W_1 – Broadcasting + Weedy check (control)	15.20
S_1W_2- Broadcasting + Hand weeding	35.26
S_1W_3 – Broadcasting + Soil solarisation	30.00
S_1W_4 – Broadcasting + Brown manuring	31.60
S_1 W_5 – Broadcasting + Organic mulching	25.30
S_2W_1 – Line sowing + Weedy check (control)	18.53
S_2W_2- Line sowing + Hand weeding	38.83
S_2W_3 – Line sowing + Soil solarisation	29.06
S_2W_4 – Line sowing + Brown manuring	25.66
S_2W_5 – Line sowing + Organic mulching	34.10
S_3W_1 – Hand dibbling + Weedy check (control)	18.16
S_3W_2- Hand dibbling + Hand weeding	31.06
S_3W_3 – Hand dibbling + Soil solarisation	25.50
S_3W_4 – Hand dibbling + Brown manuring	22.43
S_3W_5 – Hand dibbling + Organic mulching	26.53
S.Em±	2.19
CD (P=0.05)	NS

Table 4(b): Effect of non chemical weed management practices and sowing methods on straw yield (q ha^{-1}) of rice

Treatments	Straw yield (q ha^{-1})
A. Non chemical weed management	
W_1 - Weedy check (control)	69.77
W_2 - Hand weeding	80.93
W_3 - Soil solarisation	79.58
W_4 - Brown manuring	74.81
W_5 - Organic mulching	81.67
S.Em±	1.59
CD (P=0.05)	4.62
B. Sowing methods	
S_1 - Broadcasting	81.48
S_2 - Line sowing	80.05
S_3 - Hand dibbling	70.53
S.Em±	1.23
CD (P=0.05)	3.58

Conclusion

The results of the study indicated that the treatment combination Line sowing method with Organic mulching (S_2W_2) was observed to be produced higher yield by reducing weed density, biomass and higher weed control efficiency over the other treatment combinations and the method could be applied for higher productivity of direct seeded rice under Nagaland.

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