Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(2): 878-882
Received: 07-01-2021
Accepted: 09-02-2021

Sourabh Munnoli
Department of Agronomy,
TNAU, Coimbatore,
Tamil Nadu, India

D Rajakumar
Department of Agronomy,
TNAU, Coimbatore,
Tamil Nadu, India

Corresponding Author:
Sourabh Munnoli
Department of Agronomy,
TNAU, Coimbatore,
Tamil Nadu, India

Evaluation of chemical and non-chemical weed management practices on growth attributes of aerobic rice

Sourabh Munnoli and D Rajakumar

Abstract
A field experiment was conducted at the Wetlands Farm of Department of Farm Management, Tamil Nadu Agricultural University to evaluate the effect of different chemical and non-chemical weed management practices on the growth of aerobic rice. Pre emergence (PE) application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + Early post emergence (EPOE) application of bispyribac sodium (25 g ha-1) on 20 DAS significantly higher leaf area index, drymatter production, crop growth rate and SPAD values. This sequential application of pendimethalin and bispyribac sodium recorded 61.11 per cent increased dry matter over weedy check at maturity. Meanwhile growing intercrops as living mulch showed promising results for using it as a component of integrated weed management practice.

Keywords: aerobic rice, mulching, sequential application of herbicides, integrated weed management

Introduction
Aerobic rice concept capitalizes on the advantages of the characteristics of rice varieties adopted in upland with less water requirement and irrigated varieties with high response to inputs. One of the major constraints, which limit the yield of aerobic rice, is that this crop suffers severely from weed infestations. Among all the rice growing eco systems, the greatest weed pressure and competition occurs in aerobic rice system and the least in the transplanted situation. Because dry tillage and alternate wetting and drying conditions are favorable for germination and growth of weeds. Almost double the weed density and weed biomass was observed in aerobic rice field when compared to conventional transplanted condition (Mahajan *et al*., 2011) [3].

Though direct sown aerobic rice systems have several advantages over lowland puddled transplanted rice systems, weeds pose the greater threat that is the prime biological constraint to the production of such systems because of the absence of standing water to suppress weed emergence. Several methods are used for the management of weeds in aerobic rice. Herbicides have been increasingly and broadly applied in aerobic rice cultivation. Both pre-emergence herbicides, applied before crop emergence and post-emergence herbicides, applied after crop emergence, can be used in aerobic rice fields, and are effective if they are properly used. The current trend in weed management focuses on integrated weed management for reducing the usage of herbicides due to their adverse effects on the environment. To provide more sustainable weed control measures and protect the environment, reducing reliance on herbicides and applying cultural measures in integrated weed management approaches have been advocated nowadays (Chauhan and Johnson, 2010) [1].

Materials and Methods
The field experiment was conducted in the 'B1' filed of Wetland Farms of Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during *Kharif* season of 2017. The farm is geographically located at 11°N latitude and 77°E longitude at an altitude of 426.7 m above mean sea level. Coimbatore is located in the Western agro climatic zone of Tamil Nadu. The soil of the experimental field was neutral in reaction (pH: 7.1), low in available N (215.1 kg ha^{-1}) and high in available P (13.5 kg ha^{-1}) and K (487.0 kg ha^{-1}).

T_1 - PE application of pendimethalin (1.0 kg ha-1) on 3 DAS + HW on 40 DAS
T_2 - EPOE of bispyribac sodium (25 g ha-1) on 20 DAS + HW on 40 DAS
T_3 - EPOE of chlorimuron ethyl + metsulfuron methyl (4 g ha-1)
T_4 - PE application of pendimethalin (1.0 kg ha-1) on 3 DAS + EPOE of bispyribac sodium (25 g ha-1) on 20 DAS
T_5 - Daincha intercropping (1:1) + spreading on 30DAS (T5)

T_6 - Cowpea intercropping (1:1) + spreading on 30DAS (T6)
T_7 - Coir pith mulching (5 tons ha-1) on 3 DAS (T7)
T_8 - Shredded coconut waste mulching (5 tons ha-1) on 3 DAS (T8)
T_9 - Mechanical weeding on 20 and 40 DAS (T9)
T_{10} - Hand weeding on 20 and 40 DAS (T10)
T_{11} - Mechanical weeding on 20 DAS + hand weeding on 40 DAS (T11)
T_{12} - Weedy check

The experiment was laid out in randomized block design with seven treatments in three replications. Treatment details are as follows
(HW - Hand weeding: MW - Mechanical weeding: DAS - Days after sowing: PE – Pre emergent: EPOE – Early post emergent)

Leaf area index (LAI)
The Leaf area index (LAI) of rice was worked out at active tillering, panicle initiation and flowering stage as per the method proposed by Palanisamy and Gomez (1974) [6] using the formula given below.

$$LAI = \frac{L \times B \times K \times \text{No. of green leaves hill}^{-1}}{\text{Ground area occupied by the plant}} \times 100$$

Where,
L = Maximum length of 3rd leaf blade from the top (cm),
B = Maximum breadth of the same leaf (cm), and K = Constant (0.75).

Dry matter production
Five plants were randomly selected from the sampling area and they were uprooted along with the roots and washed properly at active tillering, panicle initiation, flowering and harvest stages. These samples were chopped, air-dried in the shade and then oven dried at 70 ºC ± 5 ºC for 72 hours till constant weight is reached. The dry weight was recorded using an electronic top pan balance and the dry matter was expressed in kg ha^{-1}.

Crop growth rate
It indicates the rate of crop growth per unit area per unit time. Crop growth rate (CGR) was calculated by using the formula of Watson (1958) [9] and expressed in g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

where, W_1 and W_2 are whole plant dry weight at time t_1 and t_2 respectively and P is the ground area on which $W_1$and W_2 are recorded.

Chlorophyll meter readings (SPAD values)
Chlorophyll meter from Minolta (model 502 of Minolta, Japan) was used to measure SPAD values. The chlorophyll index was measured in the fully expanded leaves that will nitrogen status of rice plant. Five readings were taken from each treatment and the values were computed by following the procedures suggested by Minolta (1989) [4].

Results and Discussion
Effect of weed management practices on leaf area index (LAI) (Table 1)
At all the crop growth stages *viz.*, Active tillering (AT), Panicle initiation (PI) and flowering, all the chemical weed management treatments (except EPOE application of chlorimuron ethyl + metsulfuron methyl on 2-3 leaf stage of weeds -T_3) and HW on 20 and 40 DAS (T_{10}) showed higher LAI. Since the chemical weed management practices ensured the better control of weeds and ensured the good growth of the crop. HW on 20 and 40 DAS (T_{10}) (3.87, 4.92 and 5.67), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE of bispyribac sodium (25 g ha^{-1}) on 20 DAS (T_4) (3.81, 4.89 and 5.42), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (T_1) (3.77, 4.78 and 5.21) and EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (T_2) (3.73, 4.62 and 5.14 on AT, PI and flowering stages, respectively) recorded significantly higher LAI.
Mechanical weeding (MW) on 20 DAS + hand weeding on 40 DAS (T_{11}) (3.34, 4.11 and 4.52) was comparable with EPOE application of chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) (T_3) (3.29, 3.98 and 4.38 on AT, PI and flowering stages, respectively).
Coir pith mulching @ 5 tons ha^{-1} on 3 DAS (T_7) (2.44, 2.59 and 2.69) and weedy check (T_{12}) (2.21, 2.42 and 2.58 on AT, PI and flowering stages, respectively) recorded lower LAI values which were on par with each other. Coir pith mulching was ineffective in giving proper ground coverage for suppressing weed growth. Munnoli *et al.*, 2018 [5], reported similar results.

Effect of weed management practices on no. of tillers (Table 1)
HW on 20 and 40 DAS (T_{10}) recorded higher number of tillers (341.1 m^{-2}) which was comparable with PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (T_4) (336.2 m^{-2}), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (T_1) (327.1 m^{-2}) and EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (T_2) (319.1m^{-2}).
Mechanical weeding on 20 DAS + Hand weeding on 40 DAS (T_{11}) (285.1 m^{-2}) and EPOE application of chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) (T_3) (269.2 m^{-2}) were next better performing treatments. Coir pith mulching @ 5 tons ha^{-1} on 3 DAS (T_7) registered lower number of total tillers (166.3 m^{-2}) and was comparable with weedy check (T_{12}) (160.2 m^{-2}).

Table 1: Effect of chemical and non-chemical weed management practices on leaf area index (LAI) of aerobic rice and No. of tillers m^{-2} at maturity.

Treatments	leaf area index			No. of tillers m^{-2}
	Active tillering	Panicle initiation	Flowering	Maturity
T_1: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + hand weeding on 40 DAS	3.77	4.78	5.21	327.1
T_2: EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS + hand weeding on 40 DAS	3.73	4.62	5.14	319.1
T_3: EPOE chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) on 2-3 leaf stage of weeds	3.29	3.98	4.38	269.2
T_4: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS	3.81	4.89	5.42	336.2

T_5: *Daincha* intercropping (1:1) + spreading on 30 DAS	2.93	3.51	3.79	236.3
T_6: Cowpea intercropping (1:1) + spreading on 30 DAS	2.90	3.43	3.62	221.3
T_7: Coir pith mulching (5 tons ha^{-1}) on 3 DAS	2.44	2.59	2.69	166.3
T_8: Shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS	2.81	3.08	3.28	198.3
T_9: Mechanical weeding on 20 and 40 DAS	2.85	3.21	3.41	209.3
T_{10}: Hand weeding on 20 and 40 DAS	3.87	4.92	5.67	341.1
T_{11}: Mechanical weeding on 20 DAS + hand weeding on 40 DAS	3.34	4.11	4.52	285.1
T_{12}: Weedy check	2.21	2.42	2.58	160.2
SEd	0.16	0.21	0.28	15.0
CD (P=0.05)	0.33	0.45	0.59	31.2

(PE – Pre emergent, EPOE – Early Post Emergence application, DAS – Days after sowing)

Effect of weed management practices on drymatter production (DMP) (Table 2)

HW on 20 and 40 DAS (T_{10}) (2997, 4268, 7555 and 10494 kg ha^{-1} on AT, PI, flowering and maturity stages, respectively) recorded higher drymatter production which was comparable with PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (T_4) (2898, 4145, 7152 and 10203 kg ha^{-1}), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (T_1) (2808, 3985, 7018 and 10026 kg ha^{-1}) and EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (T_2) (2713, 3875, 6790 and 9789 kg ha^{-1} on AT, PI, flowering and maturity stages, respectively). Similar reports are reported by Tiwari *et al.* (2006) [18], Ramachandiran and Balasubramanian (2012) [7] and Ghosh *et al.* (2016) [2]. This is attributed to lower weed abundance and nutrient depletion due to the weeds in respective plots. Higher number of tillers ensured the higher leaf production that directly reflected on drymatter production that is essential for the total assimilating area available to the plant and quantum of source that would be available for translocation to the sink.

MW on 20 DAS + HW on 40 DAS (T_{11}) recorded drymatter production of 2412, 3482, 6036 and 8748 kg ha^{-1} on AT, PI, flowering and maturity stages, respectively which was on par with EPOE application of chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) (T_3) (2324, 3374, 5787 and 8411 kg ha^{-1} on AT, PI, flowering and maturity stages, respectively). Supremacy of mechanical weeding followed by hand weeding (T_{11}) over two mechanical weeding (T_9) was because hand weeding on 40th day contributed for effective control of the weeds that in turn showed a positive effect on the better growth of the crop. In EPOE of chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) (T_3), the dominance of grassy weeds and lack of hand weeding on 40th day failed to arrest the weed profusion. Under that, poor growth characters were observed. Munnoli *et al.*, 2018 [5], reported similar results.

Coir pith mulching @ 5 tons ha^{-1} on 3 DAS (T_7) (1415, 2311, 3835 and 5128 kg ha^{-1}) and weedy check (T_{12}) (1368, 2238, 3695 and 4970 kg ha^{-1} at AT, PI, flowering and maturity stages, respectively) recorded lower drymatter than other treatments. Reduced availability of resources to the crop resulting in poor growth characters of aerobic rice in above mentioned treatments.

Table 2: Effect of chemical and non-chemical weed management practices on drymatter production (DMP) (kg ha^{-1}) of aerobic rice

Treatments	Active tillering	Panicle initiation	Flowering	Maturity
T_1: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + hand weeding on 40 DAS	2808	3985	7018	10026
T_2: EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS + hand weeding on 40 DAS	2713	3875	6790	9789
T_3: EPOE chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) on 2-3 leaf stage of weeds	2324	3374	5787	8411
T_4: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS	2898	4145	7152	10203
T_5: *Daincha* intercropping (1:1) + spreading on 30 DAS	2040	2981	4695	6884
T_6: Cowpea intercropping (1:1) + spreading on 30 DAS	1945	2903	4547	6657
T_7: Coir pith mulching (5 tons ha^{-1}) on 3 DAS	1415	2311	3835	5128
T_8: Shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS	1685	2703	4336	6376
T_9: Mechanical weeding on 20 and 40 DAS	1825	2813	4542	6679
T_{10}: Hand weeding on 20 and 40 DAS	2997	4268	7555	10494
T_{11}: Mechanical weeding on 20 DAS + hand weeding on 40 DAS	2412	3482	6036	8748
T_{12}: Weedy check	1368	2238	3695	4970
SEd	141	188	336	351
CD (P=0.05)	284	391	697	729

(PE – Pre emergent, EPOE – Early Post Emergence application, DAS – Days after sowing)

Effect of weed management practices on crop growth rate (CGR) (Table 3)

Between active tillering to panicle initiation, higher CGR was witnessed in HW on 20 and 40 DAS (T_{10}) (6.36 g m^{-2} day^{-1}) which was comparable with PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (T_4) (6.24 g m^{-2} day^{-1}), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (T_1) (5.89 g m^{-2} day^{-1}) and EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (T_2) (5.81 g m^{-2} day^{-1}).

From panicle initiation to flowering stage, HW on 20 and 40 DAS (T_{10}) registered higher CGR of 27.39 g m^{-2} day^{-1}, which was comparable with PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (T_1) (25.28 g m^{-2} day^{-1}) and PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25.00 g ha^{-1}) on 20 DAS (T_4) (25.06 g m^{-2} day^{-1}).

Between flowering and maturity stages, HW on 20 and 40 DAS (T_{10}) recorded 6.53 g m^{-2} day^{-1} of CGR which was at par with PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (T_4) (6.78 g m^{-2} day^{-1}), PE application of pendimethalin

(1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (T_1) (6.68 g m^{-2} day^{-1}) and EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (T_2) (6.66 g m^{-2} day^{-1}). Favorable environment created by weed free situation enhanced the crop growth rate in these treatments. It was found that the dry matter accumulation increased with the advancement of growth and with assured weed free condition created by hand weeding and/or chemical weed management practices. Increased growth attributes increased the photosynthate production, resulting in enhanced dry matter accumulation. Tiwari *et al.* (2006) [18] reported similar result of higher crop growth rate in weed free situation.

At all growth stage intervals *viz*., AT to PI, PI to flowering and flowering to maturity, the weed management practice, coir pith mulching @ 5 tons ha^{-1} on 3 DAS (T_7) recorded the lowest CGR of 4.48, 12.70 and 2.87 g m^{-2} day^{-1} at AT to PI, PI to flowering and flowering to maturity, respectively which was comparable with weedy check (T_{12}) (4.35, 12.14 and 2.83 g m^{-2} day^{-1} at AT to PI, PI to flowering and flowering to maturity, respectively).

Table 3: Effect of chemical and non-chemical weed management practices on crop growth rate (CGR) (g m^{-2} day^{-1}) of aerobic rice

Treatments	T - PI	PI - FLW	FLW - M
T_1: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + hand weeding on 40 DAS	5.89	25.28	6.68
T_2: EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS + hand weeding on 40 DAS	5.81	24.29	6.66
T_3: EPOE chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) on 2-3 leaf stage of weeds	5.25	20.11	5.83
T_4: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS	6.24	25.06	6.78
T_5: *Daincha* intercropping (1:1) + spreading on 30 DAS	4.71	14.28	4.86
T_6: Cowpea intercropping (1:1) + spreading on 30 DAS	4.79	13.70	4.69
T_7: Coir pith mulching (5 tons ha^{-1}) on 3 DAS	4.48	12.70	2.87
T_8: Shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS	5.09	13.61	4.53
T_9: Mechanical weeding on 20 and 40 DAS	4.94	14.41	4.75
T_{10}: Hand weeding on 20 and 40 DAS	6.36	27.39	6.53
T_{11}: Mechanical weeding on 20 DAS + hand weeding on 40 DAS	5.35	21.28	6.03
T_{12}: Weedy check	4.35	12.14	2.83
SEd	0.28	1.29	0.31
CD (P=0.05)	0.59	2.68	0.66

(PE – Pre emergent, EPOE – Early Post Emergence application, DAS – Days after sowing)
(T- Active tillering; PI- Panicle initiation; FLW- Flowering; M- Maturity)

Effect of weed management practices on SPAD (Table 4)

At AT stage, the SPAD values ranged from 33.92 to 38.30 and all the treatments were comparable to each other except coir pith mulching @ 5 tons ha^{-1} on 3 DAS (T_7) (28.20) and weedy check (T_{12}) (23.90), which recorded significantly lesser SPAD values compared to rest of other treatments.

At PI and flowering stages, HW on 20 and 40 DAS (T_{10}) recorded higher SPAD values (40.30 and 42.07) which was on par with, PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (T_4) (40.00 and 41.89), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (T_1) (39.1 and 41.73), EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (T_2) (39.81 and 41.62 on PI and flowering stages, respectively). Coir pith mulching @ 5 tons ha^{-1} on 3 DAS (T_7) (30.21 and 30.71) and weedy check (T_{12}) (29.77 and 30.76 at panicle initiation and flowering stages, respectively) recorded lesser values compared to all other treatments.

Table 4: Effect of chemical and non-chemical weed management practices on SPAD values on aerobic rice

Treatments	Active tillering	Panicle initiation	Flowering
T_1: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + hand weeding on 40 DAS	38.12	39.91	41.72
T_2: EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS + hand weeding on 40 DAS	37.92	39.81	41.62
T_3: EPOE chlorimuron ethyl + metsulfuron methyl (4 g ha^{-1}) on 2-3 leaf stage of weeds	35.70	36.21	36.42
T_4: PE pendimethalin (1 kg ha^{-1}) on 3 DAS + EPOE bispyribac sodium (25 g ha^{-1}) on 20 DAS	38.21	40.00	41.89
T_5: *Daincha* intercropping (1:1) + spreading on 30 DAS	35.00	35.92	36.12
T_6: Cowpea intercropping (1:1) + spreading on 30 DAS	34.20	35.21	35.92
T_7: Coir pith mulching (5 tons ha^{-1}) on 3 DAS	28.20	30.21	30.71
T_8: Shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS	35.73	35.42	35.21
T_9: Mechanical weeding on 20 and 40 DAS	33.92	35.71	35.39
T_{10}: Hand weeding on 20 and 40 DAS	38.30	40.30	42.07
T_{11}: Mechanical weeding on 20 DAS + hand weeding on 40 DAS	35.93	35.81	35.41
T_{12}: Weedy check	23.90	29.77	30.76
SEd	2.22	1.51	2.07
CD (P=0.05)	4.60	3.14	4.29

(PE – Pre emergent, EPOE – Early Post Emergence application, DAS – Days after sowing)

Conclusion

A single weed management practice was not able to manage weeds effectively with higher crop growth. Herbicides offered the most effective way of weed management and ensured good crop growth. PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS was found to be effective in aerobic rice with higher LAI, no. of tillers m^{-2} at maturity, drymatter production and crop growth rate. If the sequential application is not warranted, PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS) or EPOE application of bispyribac sodium (25 g

ha^{-1}) on 20 DAS) could be combined with one hand weeding on 40 DAS.

References

1. Chauhan BS, Johnson DE. Implications of narrow crop row spacing and delayed Echinochloa colona and Echinochloa crus-galli emergence for weed growth and crop yield loss in aerobic rice. Field Crops Res 2010;117(2-3):177-182.
2. Ghosh D, Singh UP, Ray K, Das A. Weed management through herbicide application in direct-seeded rice and yield modeling by artificial neural network. Spanish J. Agrl. Res 2016;14(2):1003
3. Mahajan G, Timsina J. Effect of nitrogen rates and weed control methods on weeds abundance and yield of direct-seeded rice. Archives of Agron. and Soil Science 2011;57(3):239-250.
4. Minolta C. Manual for chlorophyll meter SPAD-502. Osaka: Minolta Radiometric Instruments Divisions 1989.
5. Munnoli S, Rajakumar D, Chinnusamy C, Thavaprakaash N. Integrated Weed Management in Aerobic Rice. Madras Agric. J 2018;105(4-6):161-164.
6. Palaniswamy K, Gomez K. Length-Width Method for Estimating Leaf Area of Rice Agronomy J 1974;66(3):430-433.
7. Ramachandiran K, Balasubramanian R. Effect of weed management on growth, yield attributes and yield of aerobic rice. Madras Agric. J 2012;99(1-3):96-98.
8. Tiwari N, Kohle S, Savu R, Mahobia R, Sahu T. Effect of herbicides on dry matter accumulation, crop growth rate and grain yield of direct seeded rice (*Oryza sativa* L.) under inceptisols of Chhattigarh plains. J. Interacademicia 2006;10(1):40-43.
9. Watson D. The dependence of net assimilation rate on leaf-area index. Annals of Botany 1958;22(1):37-54.