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Growth and yield losses of direct seeded rice (*Oryza sativa* L.) as affected by major dominant weeds in Chhattisgarh plains: A review paper

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Abstract
Although weeds causes serious yield losses in agriculture, many studies have been conducted on the relationship between weeds and yield loss in direct seeded rice. Major weeds found in Chhattisgarh plains are *Echinochloa colona, Echinochloa crus-galli, Ischaemum rugosum, Oryza sativa* (weedy rice), *Leptochloa chinensis, Paspalum distichum* among the grasses. *Cyperus iria, Cyperus difformis, Cyperus rotundus, Fimbristylis miliacea* among the sedges and *Monochoria veginalis, Eclipta prostrate, Commelina benghalensis, Cynotis axillaris, Ceasulia axillaris, Alternanthera triandra* among the broad leaved weeds. Weeds are most serious biological constraints in direct seeded rice, because weed emergence coincide with the seedlings due to which the productivity is often lower. Weeds being hardy and having profuse root and shoot growth habit, grow faster than rice and thereby check the growth of rice by severe competition in critical crop weed competition period Direct yield loss has been estimated to the range from 16-86% depending on type of rice culture, cultivars, weed species and density, cropping season, plant spacing, fertilizer rate, duration and time of weed infestation and climatic and environmental conditions.

Keywords: Dominant weeds, Yield losses, Biology of weeds

Introduction
Rice (*Oryza sativa* L.) is the most important and extensively grown crop in tropical and subtropical regions of the world as it is staple food for more than 60% of the world population. Rice occupies a prime position among food crops under diversified situation. About 90% of all rice grown in the world is produced and consumed in the Asian region. India is the second largest producer and consumer of rice in the Weeds are considered as a serious problem in DSR (Johnson *et al.*, 1998) because they emerge before or at the same time as the rice (Oerke *et al*., 1994; Johnson *et al*., 1998; Mallik, 2001). *Echinochloa* is one of the most serious grass weeds of rice in the tropics. Greenhouse studies were conducted to evaluate growth and reproduction of jungle rice in response to water stress. Plant height, biomass, and seed production of jungle rice grown alone were reduced with increasing water stress. However, most stressed plants (irrigated at 12.5% of field capacity) still produced considerable biomass (8.5 g plant^{-1}) and seeds (>1,600 seeds plant^{-1}). When jungle rice and rice were grown together under water-stressed condition, jungle rice was taller than rice.

Ischaemum rugosum is a serious weed in many crops, particularly in rice. It is one of the most serious weeds of rice in Sri Lanka, India, Madagascar, Thailand, Fiji and Suriname (Holm *et al.*, 1977) [31-32] and is a serious weed of rice in Brazil, Ghana, Peru, the Philippines, Cambodia, Guinea, Liberia, Malaysia (Sarawak), Senegal and Trinidad. It is an aggressive weed, whose most-favoured habitat is in wetland rice (Moody *et al.*, 1984) [53]. In one trial, *I. rugosum* was shown to be more competitive to rice than *Echinochloa crus-galli* or *E. colonum* (Antigua, 1993) [6]. *I. rugosum* was the third most troublesome weed in field trials on clay loam at Raipur, India (Chandrakar *et al.*1993) [16].

Cyperus iria is most often found as a weed in Japan, the Pacific Islands and Australia to the south, and through India to the west. Outside Asia, it has been reported in southern and western Africa and in the USA. *Cyperus iria* is rated by Holm *et al.* (1977) [31, 32] as one of the three most important weeds of rice in Sri Lanka, India and the Philippines. It is a principal weed in Indonesia and Japan and a common weed in Fiji, Thailand and the USA.

Cyperus difformis is a sedge which is listed in Holm's list of the world's worst weeds, being a problem especially in rice, sugarcane, tea and maize. It is a dominant weed in direct-seeded rice when it occurs in high plant densities; forms dense mats of vegetation in the young crop and can cause rice yield losses of 12-50%.

According to NGRP (2002) *Cyanotis axillaris* is native to South and East Asia and Australia, but Kostermans *et al*. (1987) [43, 82] describe it as "pantropical." Presumably the wider distribution results from relatively recent introduction and naturalization. Based on these and other sources, the distribution of this species is classified as follows: Native in Asia (Bangladesh, Burma, Cambodia, China, India, Indonesia, Laos, Malaysia, Malesia, Philippines, Sri Lanka, Thailand, Vietnam).

Weeds are recognized as major biological constraints that hinder the attainment of optimal rice productivity (Kumar and Ladha 2011, Rao and Nagamani 2013) [45] and quality. It is estimated that every year, weeds cause yield losses from 15 to 76% in rice crop (Mondal *et al*. 2005) [52]. Direct yield loss has been estimated to the range from 16-86% depending on type of rice culture, cultivars, weed species and density, cropping season, plant spacing, fertilizer rate, duration and time of weed infestation and climatic and environmental conditions (Duary *et al*. 2004) [25].

An attempt has been made to present the research work done on quantification of yield losses due to dominant weeds in direct seeded rice in country and abroad on the following aspects:

Effect of various weed species on yield of Direct seeded rice

Effect of mixed flora on yield of Direct seeded rice

Biology of different weed species under observation.

Effect of various weed species on yield of Direct seeded rice

Kapoor and Ramkrishna (1974) [38] reported that Competition between Echinochloa colona and crops has been studied by a number of authors and they have demonstrated that Echinochloa colona is a strong competitor for nutrients and water. Echinochloa colona has been listed as a common weed in rice, maize cotton, mung-bean.

Kapoor and Ramkrishna (1975) [39] reported that Echinochloa colona causes substantial yield reductions because of its severe infestations, rapid growth and great competitive ability.

Holm *et al.* (1977a) [31-32] reported that *Ischaemum rugosum* is a serious weed in many crops, particularly in rice. It is one of the most serious weeds of rice in Sri Lanka, India, Madagascar, Thailand, Fiji and Suriname and is a serious weed of rice in Brazil, Ghana, Peru, the Philippines, Cambodia, Guinea, Liberia, Malaysia (Sarawak), Senegal and Trinidad.

Holm *et al.* (1977b) [31-32] reported that *Cyperus iria* is rated as one of the three most important weeds of rice in Sri Lanka, India and the Philippines, It is a principal weed in Indonesia and Japan and a common weed in Fiji, Thailand and the USA.

Mercado and Talatala (1977) [49, 50] reported that In Bulacan, Philippines, Mercado a natural population (280 plants/m²) of *Echinochloa colona* reduced dry seeded rice yield by 76%.

Suriapermana (1977) [84] reported that season-long competition of *Echinochloa colona* with transplanted rice cv. IR34 caused 43% yield reduction compared with 31% loss with competition from *Monochoria vaginalis* and 55% loss in the unweeded check plot where all the test weed species and the natural weed population competed simultaneously against rice.

Moody *et al.* (1984) [53] reported that *Alternanthera sessilis* an aggressive weed, whose most-favoured habitat is in wetland rice.

Chandrasena (1989) [17] surveyed 147 weeds in rice fields in Sri Lanka and noted that 44 species occurred in at least 20% of the fields, these weeds included *E. crus-galli*, *E. colonum* and *I. rugosum*.

Ampong-Nyarko and DeDatta (1991a) [4] reported that it is difficult to separate the competitive effects of *Cyperus iria* from those of other components of the weed flora but the weed caused 40% yield reductions in rice, in Asian rice production, where herbicides are not used, this weed may account for 60-70% of the total biomass of the rice field.

Ampong-Nyarko and DeDatta (1991b) [5] reported that it is difficult to separate the competitive effects of *Cyperus difformis* from those of other components of the weed flora, but 12-50% reductions in rice grain yields have been caused by this weed.

Itoh (1991) [36] reported that intensive infestation by the *Ischaemum rugosum* caused a 48% loss in rice yield in Malaysia.

Singh *et al.* (1991) [79] recorded over 25% of the total loss in rice yield when *Ischaemum rugosum* was allowed to compete for 40 days and opined that the most critical period of competition was 40-70 DAT.

Azmi (1992) [8] reported that in Malaysia, the estimated average rice yield loss is between 10 to 35%, and yield losses by grasses, broad-leaved weeds and sedges are 41, 28 and 10%, respectively.

Rao and Moody (1992) [63] reported that grass weed seedlings of rice seedling nursery are unintentionally transplanted with rice seedlings and average rice yield reductions from transplanted *E. glabrescens* ranged from 6% at the 5% infestation level to 73% at the 40% infestation level.

Urkurkar and Chandrakar (1992) [87] reported that eight weed species were dominant in the experimental field, which were *Echinochloa colona* (30%), *Echinochloa crusgalli* (1%), *Ischaemum rugosum* (15%), *Eleusine indica* (10%), *Cyperus iria* (15%), *Eclipta alba* (6%) and *Caesulina axillaris* (4%).

Antigua (1993) [6] reported that in one trial, *Ischaemum* rugosum was shown to be more competitive to rice than *Echinochloa crus-galli* or *Echinochloa colonum*.

Chandrakar *et al.* (1993) [16] *Ischaemum rugosum* was the third most troublesome weed in field trials on clay loam at Raipur, India.

Azmi and Baki (1995) [9] estimated that the yield loss caused by grasses (mainly *E. crus-galli*), broadleaved weeds and sedges was 41, 28 and 10%, respectively.

Huh *et al.* (1995) [35] reported that the number of panicle plant^{-1}, spikelets panicle^{-1}, grain weight and grain yield of rice in dry sown showed highly negative correlation with the growth of *Echinochloa crusgalli*, *Ludiwigia prostrate*, *Cyperus difformis* and *Cyperus serotinus.*

Roldan (1995) [68] conducted an experiment to determine the effect of different populations of *Echinochloa colona* the commonest grass weed on the yield of dry seeded rice cv. PSBR C16. Yield from the hand-weeded control (weeded at 20, 33 and 45 days after crop emergence) was 3.3 t ha^{-1} in 1994 and 2.3 t ha^{-1} in 1995. In 1994, yield losses ranged from 15% when there was season-long competition from five *Echinochloa colona* plants m^{-2} to 36% with competition from 40 *Echinochloa colona* plants m^{-2}. Losses in 1995 were 3 and 30%, respectively, for the same densities. The natural

population of *Echinochloa colona* (50 plants m^{-2} in 1994, 101 plants m^{-2} in 1995) caused 30% yield loss in 1994 and 48% yield loss in 1995 compared to 49 and 83%, respectively, for the unwedded control.
Fischer *et al*. (1997) [27] reported that rice cultivars differed in their competitiveness against *Echinochloa colona*. Average yield losses ranged from 27 to 62% under saturating *Echinochloa colona* infestations of up to 5.9 t DM ha^{-1}. Leaf area index, tiller number, and canopy light interception recorded in competition, and not much before 40 days after emergence, correlated positively with rice competitiveness.
Paradkar *et al.* (1998) [58] revealed that all densities of *Echinochloa crusgalli* adversely affecting yield attributes of rice and the value decreased linearly as the population increased. Infestation of 15 plants m^{-2} of *Echinochloa* significantly decreased productive tillers and grain yield as compared to weed free plots. The competition of 30 and 45 plant m^{-2} decreased grain by 40 and 45.8% respectively, while the reduction to the extent of 26 and 61.5% was noted due to 75 and 120 plants m^{-2}, respectively.
Dhammu and Sandhu (2002) [24] reported that in transplanted rice, *C. iria* competition for the first 30 days caused less than one fourth (12.9%) of the total losses in yield while competition for 40 days resulted in more than half (43.5%) of the total losses due to the weed.
Singh and Angiras (2003) [73] reported that threshold levels for a few weed species were also worked out. For example: *Cyperus iria* at density of 30 m^{-2} and *Echinochloa crus-galli* density of 20 m^{-2}, is considered the threshold level for transplanted rice, as it causes the minimum loss of 6.57% and 8.74%, respectively, in grain yield, above which control measures are to be undertaken.

2.5 Effect of mixed flora on yield of Direct seeded rice

De Datta and Haque (1982) [23] studied that the occurrence of weeds has become a serious problem and they limit the yield and quality of crops. It is often stated that some weeds because total crop failure and weeding practices are absolutely essential.
Mamun (1990) [46] suggested that weed growth reduced the grain yield by 68-100% for direct seeded aus rice, 16-48% for transplanted aman rice and 22.36% for modern boro rice.
Ramamoorthy (1991) [61] revealed that excessive weed growth and severe crop-weed competition drastically reduce the crop yield in the unweeded check and it was 88% of the treatments where herbicides were at higher doses in the *kharif* rice.
Sinha *et al.* (1992) [81] and Behera and Jha (1992) [13] conducted an experiment separately and stated that unchecked weed compete with rice plants for light, nutrients and moisture resulting reduction of grain yield upto 80%.
Ravichandran (1993) [67] found that excessive weed growth and severe crop-weed competition in the dry-seeded rice drastically reduced the grain yield by 78% compared with the unweeded control. He also found that the application of thiobencarb in combination with 2, 4-D and hand -weeding twice produced lesser number of grains $panicle^{-1}$.
Amarjit *et al.* (1994) [3] reported that weeds under adverse condition affects plant height, leaf architecture, tillering habit, shading ability, growth pattern and life duration of rice cultivars. Poor weed control is one of the major factor for yield reduction of rice depending on the type of weed flora and their intensity.
Gogoi *et al.* (1996) [30] at Jorhat reported that 20 to 95% yield losses by weeds and hand weeding was the most common and predominant method of control which was most cost effective, but labour intensive.
Behera and Jena (1997) [12] reported that effective panicle m^{-2} was markedly increased by all the tested weed management practices as compared to unweeded check.
Sharma (1997) [71] from Cuttuck noted that the loss in grain yield caused by unchecked weed growth ranged from 18.2 to 59.2% in different years under direct sown rice.
Azmi and Abdullah (1998) [10] reported that weedy rice at 35% infestation can cause total yield loss of about 60%, and under serious infestation, yield loss of 74% has been recorded in direct seeded rice.
Kolhe and Tripathi (1998) [42] from Indira Gandhi Krishi Vishwavidyalaya, Raipur reported that weed flora of direct seeded rice were *Echinochloa colona*, *Digitaria sanguinalis*, *Ischaemum rugosum*, *Cyperus iria* and *C. difformis*.
Patel *et al.* (1998) [59] at Raigarh (C.G.) observed that when the weeds were allowed to grow with the crop, grain yield was reduced by about 48.6%.
Choubey *et al.* (2001) [20] reported that extent of yield loss due to weeds in direct seeded rice varied from 40 to 100%.
Karim *et al.* (2004) [40] reported that yield reduction due to weeds is more critical in direct seeded rice than in transplanted rice.
Oerke and Dehne (2004) [55] reported that Weeds are estimated to cause rice yield losses of 35% in the tropics.
Saha *et al.* (2005) [69] observed that the maximum yield reduction due to weeds were 41% found in farmer practice of one hand weeding at 45-50 DAS.
Singh *et al.* (2005) [74] reported that reduction in grain yield (51.9%) due to weed was registered in weedy check treatment.
BRRI (2006) [15] reported that in Bangladesh, rice yield losses due to weeds were estimated at 70-80% in *Aus* rice (early summer), 30-40% in transplanted *Aman* rice (late summer) and 22-36% in *Boro* rice (winter rice).
Mishra and Singh (2007) [51] reported that on average, rice yield loss due to weed ranges from 15 to 20%, but in severe cases the yield loss may exceed 50%.
Rao *et al*. (2007) [62] reported that in dry seeded aerobic rice, relative yield loss caused by weeds is as high as 50-91%.
Singh *et al.* (2007) [77] observed that total weed dry weight and weed density were lower with conventionally puddled transplanted rice and highest with aerobic direct-seeded rice on furrow-irrigated raised-bed systems, followed by aerobic direct-seeded rice. In terms of weight grassy weed constituted 78–96% of total weed weight in all systems of rice establishment. Loss of grain yield of rice due to weed competition ranged from 38% to 92%, being the highest in aerobic direct-seeded rice. Both weed density and dry weight were negatively correlated with rice grain yield. Aerobic direct-seeded rice treatment produced yield and net economic returns similar to conventionally puddled transplanted rice treatment when weeds were controlled.
Kumar *et al.* (2008) [44] reported that in the absence of weed control, rice yield get reduced by 35-100% in direct-seeded.
Sunil *et al.* (2010) [86] reported that season-long weed competition in direct seeded aerobic rice may cause yield reduction up to 80%.
Mamun *et al.* (2013) [47] conducted two experiments in 2009 and 2010 at central part of Bangladesh to examine the effects of multispecies weeds on grain yield and to determine the economic threshold (ET) of weeds in direct seeded rice (DSR). Grain yield losses due to weed interference increased with weed population density increase. Panicle per meter sq.,

grains per panicle, 1000-grain weight and grain yield varied significantly due to different weed density in both years of the study, and recorded that 47% grain yield losses due to weeds.

2.6 Biology of different weed species under observation

Gilliland *et al.* (1971) [29] reported that *Ischaemum rugosum* is a vigorous annual (in strongly desiccating soil) or short-lived perennial, tufted, sometimes with stilt roots, rooting at the nodes, with erect, slanting or ascending, often much-branched culms, up to 1.5 m tall, The species can be identified by the distinctive, prominent transverse ribs or ridges on the lower glume of the spikelet. The spinal awns are prominent and the nodes of the culm are tufted and hairy. The leaf sheaths are usually loose, up to 16 cm long, glabrous or hairy like the blades, with some long, slender, bulbous-based hairs on the margin and at the base at the node, The leaf blades are acuminate, the lower ones narrowed gradually to the base; 30 cm long x 1.5 cm wide, the margin is cartilaginous and scabrid, the base densely hairy. The ligule is variable, a brownish membrane, 6 mm deep. The inflorescence is terminal, apparently simple when young, but separating with age into its two constituent racemes, usually 7-10 cm long, each raceme with the spikelets arranged in pairs, one sessile, one pedicelled, on one side of the triangular, hairy rachis present.

Arora *et al.* (1976) [7] reported that *Echinochloa colona* propagates primarily by seed. However, the lower creeping part of the plant has the capacity to regenerate and multiply through cut portions.

Holm *et al.* (1977) [31-32] reported that *Cyperus iria* is an annual sedge, sometimes behaving as a perennial it propagates from seed (achenes or nutlets); a large plant can produce up to 5000 progeny.

Mercado and Talatala (1977) [49, 50] reported that *Echinochloa colona* commences flowering 34 weeks after emergence. The seeds are shed successively, beginning at week 7, and remain dormant for some time

Datta and Biswas (1979) [22] reported that *Alternanthera sessilis* has been recorded flowering and fruiting all year in some areas. In India, the plants flower and fruit throughout the year with most vigorous vegetative growth at the onset of the monsoon season, and most vigorous reproductive growth at the end of the season. Flowers are self-pollinated and the fruits are dispersed by both wind and water.

Holm *et al.* (1979) [31-32] reported that *Cyanotis axillaris* is a "principal" weed in India, Sudan, and Thailand, in northeastern India, it flowers and fruits from September to December.

Sen (1981) [70] reported that when nodes of *Echinochloa colona* come in contact with the soil, rooting occurs and new shoots develop. These, when separated from the mother plant, can give rise to independent plants.

Moody *et al.* (1984) [53] reported that *Alternanthera sessilis* is an annual or perennial herb, 0.2-1 m high, with strong creeping tap roots. The stems are generally prostrate, often rooting at the nodes, sometimes floating, creeping or ascending at the tips, cylindrical and slightly hairy, with numerous erect branches. It is propagated by vegetative fragments, and seeds, and fruits which are dispersed myrmechorously (by ants) the average number of seeds produced per plant is about 2000.

Chun and Moody (1986) [21] reported that germination of *E. colona* occurred 2 to 3 days after sowing and the two-leaf stage is reached by 8 days after sowing. Unlike rice, which produces the first leaf without a leaf blade, the first leaf of *E. colona* had a well-developed leaf blade about 2 cm long. When the sixth leaf of the main culm emerged, the first leaf of the primary tiller arose from the axil of the third leaf of the main culm. The production of primary tillers ceased when the main culm reached the 11-leaf stage but the production of secondary tillers continued together with the elongation of the internode from the base of the main culm.

Pancho (1986) [57] reported that *Alternanthera sessilis* is an annual or perennial herb, 0.21m high, with strong creeping tap roots. The stems are generally prostrate, often rooting at the nodes, sometimes floating, creeping or ascending at the tips, cylindrical and slightly hairy, with numerous erect branches. It is propagated by vegetative fragments, and seeds, and fruits which are dispersed myrmechorously (by ants) and the average number of seeds produced per plant is about 2000.

Kostermans *et al.* (1987) [43, 82] reported that *Cyperus difformis* is usually found on flooded or very wet soils, open soggy grasslands, pools (but not in deep water) and riverbanks, often associated with *C. halpan* and *C. iria*, where it is usually scattered but often becoming dominant. It prefers fertile soils but can also grow on poor sandy or clay soils

Kim and Moody (1989) [41] reported that *E. colona* produced seeds more efficiently than rice. The first flower was produced when its relative dry weight was 26% of its maximum dry weight compared to more than 60% for rice. Seeds were produced over a period of 4 months for *E. colona* compared to 2 months for rice. Efficient seed production was related to high photosynthetic efficiency, high growth rate and high rationing ability

Raju and Reddy (1989) [60] reported that seeds are produced in great quantities and are highly viable. *E. colona* plants can produce as many as 42,000 viable seeds in a life cycle. The seeds remain viable for about 3 years even under waterlogged conditions.

Mannetje and Jones (1992) [48] reported that *Ischaemum rugosum* is a highly variable species. Two varieties have been distinguished: var. *rugosum*, which has developed pedicelled spikelets, and var. *segatum*, in which the pedicelled spikelets are much reduced; these varieties are not separated geographically.

Flora of China Editorial Committee (2014) [28] reported that in China *Alternanthera sessilis* flowers from May to July and fruits from July to September.

References

1. Abdullah M, Shultana AMR, Rana MM, Mridha AJ. Economic Threshold Density of Multi Species Weed for Direct Seeded Rice. Asian Journal of Agriculture and Rural Development. 2013; 3(8):523-531.
2. Ali MA, Ladha JK, Rickman J, Lales JS. Comparison of different methods of rice establishment and nitrogen management strategies for lowland rice. Journal of Crop Improvement. 2006; 16(1/2):173-189.
3. Amarjit B, Ganai BA, Singh KN, Kotru R. Weed control in transplanted rice (*Oryza sativa*). Indian Journal of Agronomy. 1994; 39(1):16-18.
4. Ampong Nyarko K, DeDatta SK. A Handbook for Weed Control in Rice International Rice Research Institute, Manila, 1991a, pp. 145.
5. Ampong Nyarko K, DeDatta SK. A Handbook for Weed Control in Rice, 1991b.
6. International Rice Research Institute, Manila, p. 145. Antigua G. Integrated weed management of rice in Cuba. Proceedings of a monitoring tour and workshop on integrated pest, 1993.

7. Arora RK, Khanna PP, Singh R. Weeds of north India. Bulletin No. 13, Farm Information Unit, Directorate of Extension, Ministry of Agriculture and Irrigation, New Delhi, India, 1976, 93.
8. Azmi M. Competitive ability of barnyard grass in direct seeded rice. Teknologi Padi. 1992; 8:19-25.
9. Azmi M, Baki BB. The succession of noxious weeds in tropical Asian rice fields with emphasis on Malaysian rice ecosystem. Proc. 15th Asian Pacific Weed Science society Conference, Tsukuba, Japan, 1995, 51-67.
10. Azmi M, Fujji Y, Abdullah MZ. Study on allelopthic effect of selected Malaysian rice variteis and rice field weed spices. J Tropic Agric Food Sci. 1998; 28:39-54.
11. Bastiaans L, Kropff MJ. Weeds, Weed Competition. Encyclopedia of Applied Plant Sciences. Elsevier, Oxford, 2003, pp. 1494-1500.
12. Behera AK, Jena SN. Weed management in direct seeded rice under puddle condition, *Oryza*. 1997; 34(4):337-340.
13. Behera UK, Jha KP. Technology for improving and stabilizing rice yields in drought prone region of Klahnadi. Indian Farming. 1992; 42(4):9-13.
14. Begum M, Juraimi AS, Rajan A, Omar SRS, Azmi M. Competition of *Fimbristylis miliacea* weed with rice. Int. J. Agric. Biol. 2009; 11(2):183-187.
15. BRRI (Bangladesh Rice Research Institute). Bangladesh Rice Knowledge Bank. Bangladesh Rice Research Institute, 2006.
16. Chandrakar BL, Tripathi RS, Tuteja SS, Taunk. Effect of application timings and formulations of anilofos in broadcast seeded semi dry rice (*Oryza sativa*). Integrated weed management for sustainable agriculture. Proceedings of an Indian Society of Weed Science International Symposium, Hisar, India, 1993, 18-20.
17. Chandrasena JPNR. A survey of rice field weeds in Ratnapura and Kurunegala districts of Sri Lanka. Journal of the National Science Council of Sri Lanka. 1989; 17(2):187-211.
18. Chauhan BS, Johnson DE. Growth and Reproduction of Junglerice (*Echinochloa colona*) in Response to Water Stress, Weed Science. 2010; 58(2):132-135.
19. Chauhan BS, Johnson DE. Row spacing and weed control timing affect yield of aerobic rice. Field Crop Res. 2011; 121:226-231.
20. Choubey NK, Kolhe SS, Tripathi RS. Relative performance of cyhalofop-butyl for weed control in direct seeded rice. Idan J. Weed Sci. 2001; 33:132-135.
21. Chun JC, Moody K. Growth, development, and morphological characteristics of *Echinochloa colona*. Korean Journal of Weed Science. 1986a; 6:1-6.
22. Datta SC, Biswas KK. Autecological studies on weeds of West Bengal *Alternanthera sessilis*. Bulletin of the Botanical Society of Bengal. 1979; 33(1/2):526.
23. De Datta SK, Haque MZ. Weeds, weed problems and weed control in deepwater rice areas. Proceedings of the International Deep-water Rice Workshop, International Rice Research Institute held in Manila, Philippines, 1982, 427-442.
24. Dhammu HS, Sandhu KS. Critical period of Cyperus iria L. competition in transplanted rice. Proc. of 13th Australian Weeds Conference, Sheraton Perth Hotel, Perth, Western Australia, 2002, 79-82.
25. Duary B, Mondal DC, Hossain A. Integrated weed management in direct seeded dry sown rice in the lateritic belt of West Bengal. Indian Journal of Weed Science. 2004; 37(1&2):101-102.
26. Fazlul I, Karim SMR, Haque SMA, Islam MS. Effect of population density of *Echinochloa colonum* on rice. Pakistan J. of Agron. 2003; 2(3):120-125.
27. Fischer A, Ramfrez HV, Lozano J. Suppression of junglerice (*Echinochloa colona* L.) by irrigated rice cultivars in Latin America. Agronomy Journal. 1997; 89(3):516-521.
28. Flora of China Editorial Committee, Flora of China. St. Louis, Missouri and Cambridge, Massachusetts, USA: Missouri Botanical Garden, 2014.
29. Gilliland HB, Holttum RE, Bor NL, Burkill NM. A revised Flora of Malaya, Grasses. Singapore Botanical Gardens, Vol III, 1971.
30. Gogoi AK, Brown H, Cussans GW, Devine MD, Duke SO, Fernandes QC *et al.* Integrated weed management Of rice in high rainfall region of India. Proceeding of the second international weed control congress, Copenhagen, Denmark, 1996, 715-719.
31. Holm LG, Plucknett DL, Pancho JV, Herberger JP. The World's Worst Weeds, Distribution and Biology. University Press of Hawaii, USA, 1977a.
32. Holm LG, Plucknett DL, Pancho JV, Herberger JP. The World's Worst Weeds, Distribution and Biology. University Press of Hawaii, USA, 1977b.
33. Holm LG, Pancho JV, Herberger JP, Plucknett DL. A Geographical Atlas of World Weeds. Wiley, New York, 1979, pp. 391.
34. Huang SW, Ying JF, Ye PG, Cai HF, Fei HL. Arrangement of simplified and labour saving cultivation methods for double rice cropping. China Rice. 1996; 6:10-13.
35. Huh SM, Cho LG, Kwon SL. Emergence of weed species and their competition characteristics in direct seeded rice. Korean Journal of Weed Science. 1995; 16:282-291.
36. Itoh K. Life cycles of rice field weeds and their management in Malaysia. Tropical Agriculture Research Centre, Tsukuba, Japan. Penang, West Malaysia: Cheong Seng Chan Sendirian Berhad, 1991.
37. Islam MA, Khan MNH, Rahman MM. Effect of cultural weed control practice on Aus (summer) rice. Bangladesh J. Agric. Sci. 1980; 7:43-46.
38. Kapoor P, Ramakrishnan PS. Soil factors influencing the distribution of ecotype populations in *Echinochloa colonum* (L.). Botanical Journal of the Linnean Society. 1974; 69(1):65-78.
39. Kapoor P, Ramakrishnan PS. Weed crop behaviour in pure and mixed stands of maize and *Echinochloa colona*. Proceedings of the Indian Academy of Science. 1975; 82(5):175-194.
40. Karim SMR, Man AB, Sahid IB. Weed problems and their management in rice fields of Malaysia. Weed Biol. Manag. 2004; 4:177-186.
41. Kim SC, Moody K. Growth dynamics of rice and several weed species under density and fertilizer stress. Proceedings of 12th Asian Pacific Weed Science Society Conference Taipei, Taiwan, 1989, 47-56.
42. Kolhe SS, Tripathi RS. Integrated weed management in direct seeded rice. Indian Journal of Weed Science. 1998; 30(1-2):51-53.
43. Kostermans AJGH, Wirjahardja S, Dekker RJ. The weeds: description, ecology and control, 1987, pp. 24-565.
44. Kumar V, Bellinder RR, Gupta RK, Malik RK, Brainard DC. Irrigated rice cultivars in Latin America. Agron J. 2008; 89:516-521.

45. Kumar V, Ladha JK. Direct-seeded rice: recent developments and future research needs. Advances in Agronomy. 2011; 111:297-413.
46. Mamun AA. Agro-ecological studies of weeds and weed control in a flood prone village of Bangladesh. Proceedings of Japan International Co-operation Agency, Dhaka, Bangladesh, 1990, 28-165.
47. Mamun MAA, Shultanal R, Mridha AJ, Rana MM. Economic Threshold management of rice in the Caribbean, held in Guyana and Trinidad & Tobago, 2013, 7-11.
48. Mannetje LT, Jones RM. Plant Resources of South East Asia. Wageningen, Netherlands: Pudoc Scientific Publishers, 1992.
49. Mercado BL, Talatala RL. Competitive ability of *Echinochloa colonum* L. against direct seeded lowland rice. Proceedings of the 6th Asian Pacific Weed Science Society Conference, Indonesia, 1977a, 161-165.
50. Mercado BL, Talatala RL. Competitive ability of *Echinochloa colonum* L. against direct-seeded lowland rice. Proceedings of the Sixth Asian-Pacific Weed Science Society Conference, Jakarta, Indonesia, 1977b, 161-165.
51. Mishra JS, Singh VP. Integrated weed management in zero till direct seeded rice-wheat cropping system. Ind J Agron. 2007; 52:198-203.
52. Mondal DC, Hossain A, Duary B. Effect of pyrazosulfuron–ethyl on weeds and yield of transplanted rice under Lateritic Belt of West Bengal. Indian Journal of Weed Science. 2005; 37(3&4):263-64.
53. Moody K, Munroe CE, Lubigan RT, Paller EC. Major Weeds of the Philippines. University of the Philippines at Los Banos College, Laguna, Philippines, 1984.
54. NGRP. World Economic Plants in GRIN (Germplasm Resources Information Network). United States Department of Agriculture, Agricultural Resources Service, National Germplasm Resources Program (NGRP), Beltsville, 2002.
55. Oerke EC, Dehne HW. Safeguarding production- Losses in major crops and the role of crop protection. Crop Prod. 2004; 23(4):275-285.
56. Ooi GHC. Saturn D the almost perfect herbicide for weed control in rice fields. Proceedings of the National Seminar and Workshop on paddy. Indian Journal of Weed Science. 1988; 23(12):15.
57. Pancho JV. Weed control in tropical crops. Volume II, Los Banos, Philippines. Weed Science Society of the Philippines, 1986, 18.
58. Paradkar NR, Kurchania SP, Tiwari JP, Bhalla CS. Cometitive impact of *Echinochloa crusgalli* (L.) on yield attributes and yields of drilled rice. World Weeds. 1998; 5:57-60.
59. Patel SR, Lal N, Thakur DS. Integrated weed management in direct seeded rice (*Oryza sativa*). Environment and Ecology. 1998; 16(4):852-854.
60. Raju RA, Reddy MN. Control of jungle rice in the Godavari delta. Indian Farming. 1989; 39(2):30-31.
61. Ramamoorthy K. Effect of herbicides on weeds and yield of upland rice (*Oryza sativa* L.) and residual effect on cowpea (V*igna unguiculata*) and green gram (*Phaseolus vigna*). Indian Journal of Agronomy. 1991; 36(3):304-307.
62. Rao AN, Johnson DE, Sivaprasad B, Ladha JK, Mortimer AM. Weed management in direct seeded rice. Adv Agron. 2007; 93:153-255.
63. Rao AN, Moody K. Competition between *Echinochloa glabrescens* and rice (*Oryza sativa*). Tropical Pest Management. 1992; 38:25-29.
64. Rao AN, Nagamani A. Eco-efficient weed management approaches for rice in tropical Asia, 2013, 78-87.
65. Rathore AL. Crop, land and rain water management strategies for increasing productivity and cropping intensity of rainfed rice area of Chhattisgarh. Strategies for Drought Copping and Double Cropping in Rainfed Rice Areas. Project Report. Department of Land and Water Management. IGAU, Raipur (C.G.), 2001.
66. Rathore AL, Sahu KK, Jha SK. Effect of dry seeded rice on mitigation of drought and improving water use efficiency and productivity of rainfed rice. Proceedings of International symposium on rainfed rice ecosystems: Prospective and Potential. Indira Gandhi Agricultural University, Raipur, 2004.
67. Ravichandran VK. Weed control in dry - seeded rice (*Oryza sativa*). Indian Journal of Agronomy. 1993; 38(3):477-480.
68. Roldan GV. The effect of different densities of *Echinochloa colona* (L.) Link on the growth and yield of rice cv. PSBR C16 under dry seeded rainfed lowland conditions. MSc thesis, Rizal State College, Tanay, Rizal, Philippines, 1995, 96.
69. Saha S, Dani RC, Patra BC, Moorthy BTS. Performance of different weed management techniques under rainfed upland rice (*Oryza sativa* L.) production system. Oryza. 2005; 42(4):287-289.
70. Sen DN. Ecological approaches to Indian weeds. Geobios International, Jodhpur, India, 1981, 301.
71. Sharma AR. Effect of integrated weed management and nitrogen fertilization on the performance of rice under flood-prone lowland conditions. Journal of Agricultural Science. 1997; 129:409-418.
72. Sharma RS, Thakur CL, Agrawal KK. Comparison of transplanted and direct seeded rice for productivity, profitability and physical properties of soil. *Oryza*. 1995; 32:183-187.
73. Sidhu S, Kooner R, Verma A. On-farm assessment of direct-seeded rice production system under central Punjab conditions. Journal of Crop and Weed. 2014; 10(1):56-60.
74. Singh G, Singh RG, Singh OP, Mehta RK, Kumar V, Singh PP. Effect of weed- management practices on direct seeded rice (*Oryza sativa* L.) under puddle lowlands. Indian Journal of Agronomy. 2005; 50(1):35-37.
75. Singh KP, Angiras NN. Ecophysiological studies of *Cyperus iria* L. in transplanted rice under mid hill conditions of Himachal Pradesh, India. Physiology and Molecular Biology of Plants. 2003; 9:283-285.
76. Singh KP, Angiras NN. Studies on the threshold level of *Echinochloa crus-galli* L. in transplanted rice under mid hill conditions of Himachal Pradesh. Advances in Plant Sciences. 2008; 21:505-508.
77. Singh S, Ladha JK, Gupta RK, Bhushan L, Rao AN. Weed management in aerobic rice systems under varying establishment methods. Crop protection. 2007; 27(3-5):660-671.
78. Singh T, Kolar JS, Sandhu KS. Critical period of competition Between Wrinkle Grass (*Ischaemum rugosum* Salisb.) and transplanted paddy. Indian J Weed Sci. 1991; 23:1-5.

79. Singh T, Kolar JS, Sandhu KS. Critical period of competition between wrinkle grass (*Ischaemum rugosum* Salisb.) and transplanted paddy. Indian Journal of Weed Science. 1991; 23(1-2):1-5.
80. Singh UP, Singh RP. Effect of weed management, fertility and cultivars on weed growth and yield of rainfed lowland, submergence prone rice. Indian Journal of Weed Science. 2003; 33(3-4):124-126.
81. Sinha BDP, Moorthy BTS, Rajamani S, Manna GB. Integrated weed management benefits from directed seeded upland rice. Indian Journal of Agronomy. 1992; 42(9):7-8.
82. Soerjani M, Kostermans AJGH, Tjitrosoepomo G. Weeds of Indonesia. Jakarta, Indonesia, Balai Pustaka, 1987, pp. 716.
83. Subbaiah SV. Proceedings of 2nd CREMNET workshop cum group meeting, 1999, 15-16.
84. Suriapermana S. Weed competition in transplanted rice. International Rice Research Newsletter. 1977; 2(3):9-10.
85. Sultana R. Competitive ability of wet-seeded boro rice against *Echinochloa crusgalli* and *Echinochloa colonum*. MSc Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh, 2000, pp. 36-50.
86. Sunil CM, Shekara BG, Kalyanmurthy KN, Shankaralingapa BC. Growth and yield of aerobic rice as influenced by integrated weed management practices. Ind J Weed Sci. 2010; 42(3&4):180-183.
87. Urkurkar JS, Chandrakar BL. Herbicidal manipulation to improve efficiency of fertilizer nitrogen in direct sown rice. Proceedings of Annual Weed Science Conference, Hissar, 1992, pp. 33.
88. WARDA (West Africa Rice Development Association). Annual Report for West Africa Rice Development Association, Bouake, Cote d'Ivoire, 1996.