Indian Journal of Weed Science **47**(1): 16–20, 2015

Weed density and diversity in jute under long-term experiment in jute-rice-wheat cropping system

Mukesh Kumar*, D.K. Kundu, A.K. Ghorai, Sonali P. Mazumdar and M. Ramesh Naik
ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, West Bengal 700 120

Received: 3 January 2015; Revised: 8 March 2015

ABSTRACT

Studies on the impact of long-term fertilizer application on changes in weed community composition are important and likely to provide insight into the effects of prolonged fertilizers on weed community structure and infestation. Nine treatments of long term fertilizers experiment, *viz*. (i) control (plots which did not receive NPK fertilizers or farm yard manures (FYM) (ii) 50% of recommended doses of NPK (iii) 100% NPK (recommended dose of fertilizers) (iv) 150% NPK, (v) 100% NPK + hand weeding (No herbicides application in jute, rice and wheat (vi) 100% NPK + Zn (vii) 100% NP, (viii) 100%N (ix) 100% NPK+FYM 10 t/ha/year before sowing of jute with four replication were included in the present investigation. A total of 12 weed species were recorded under different fertilizer treatments. Significantly higher total weed density (733/m^2) was recorded in 100% NPK + FYM treatments compared to other treatments. Significant variation in weed species was also recorded in different fertilizers treatment. *Cyperus rotundus* density was comparatively higher in control, 50% NPK and 100% NPK + Hand weeding plot. *Echinochloa* colona density was higher in 150% NPK, 100% NPK + Zn and 100% NP. Comparatively higher broad-leaved weed density were recorded in 100% NPK + FYM. The highest Shannon-weiner index (H'=2.02), Simpson diversity index (D'=0.81) and weed species evenness (E'=0.81) were recorded in 100% NPK + FYM and the lowest (H'=1.0, D'=0.62 and E'=0.5) in control plot. Thus, weed management strategies in FYM applied jute field should be given highest priority for getting higher fibre yield.

Key words: Fertilizers, FYM, Jute, LTFE, Weed diversity, Weed management, Yield

Weeds are important components of agricultural ecosystems. Weed communities and their diversity play a significant role in determination of the nature of weed management strategies to be adopted in crops and cropping system (Storkey and Cussans 2007). Development of integrated weed management strategy needs knowledge of weed ecology and biology in agro-ecosystems (Wilson *et al.* 2009) and inclusion of multiple tactics, such as the prevention, avoidance, monitoring, and suppression of weeds (Buhler 2002). Fertilizer application is one of the most wide spread agronomic practices that are used to improve soil fertility and enhance crop productivity. Simultaneously, it significantly affects weed growth and its community composition directly through affecting soil nutrient availability and indirectly through intensifying resource competition between crops and weeds and results in new selective pressures to weed species and thus change the occurrence frequencies (Das and Yaduraju 1999, Andreasen and Skovgaard 2009, Smith *et al.* 2010).

While improving the crop's yield and quality, fertilizers profoundly influence the diversity of the whole weed community and its individual component (Wan *et al.* 2012). To fulfill the increasing demand of jute fibre. It is inevitable to increase the productivity in a sustainable manner as the area under jute is constant since last 30 years. The weeds in jute fields are considered as a major problem as they reduce fibre yield up to 80% and hence, it is inevitable to develop weed management strategies to control weeds (Ghorai 2008, Ghorai *et al.* 2013). Studies on the impact of long-term fertilizes application on changes in weed community composition are important and are likely to provide insight into the effects of prolonged fertilizer use on weed community structure and infestation. Therefore, this study was undertaken to examine the effect of long term uses of manure and fertilizer application on density and diversity of weeds in jute to provide a scientific basis for developing an integrated weed management strategy for jute under jute-rice-wheat cropping system.

***Corresponding author:** mukesh.agro@gmail.com

MATERIALS AND METHODS

A long-term field experiment was established at the Central Research Institute for Jute and Allied Fibres (CRIJAF) Barrackpore (22°452 N, 88°262 E, 9.0 m msl) in 1971 on the new alluvial soil in the hot humid sub tropic of eastern India for jute (*Corchorus olitorius* L)-rice (*Oryza sativa* L.)- wheat (*Triticum aestivum* L.)- cropping system. The soil was a sandy loam (hyperthermic, typic eutrochrept, US soil taxonomy). The experiment was laid out in randomized block design (RBD) and all the plots were separated by concrete ridges and irrigation furrows to provide irrigation plot by plot. Seven treatments, *viz*. (i) control (plots which did not receive NPK fertilizers or farm yard manures (FYM) (ii) 50% of recommended doses of NPK (iii) 100%NPK (recommended dose of fertilizers) (iv) 150% NPK, (v) 100% NPK + hand weeding (No herbicides application in jute, rice and wheat (vi) 100% NPK + Zn (vii) 100% NP, (viii) 100%N (ix)100% NPK+FYM at 10 t/ha/year before sowing of jute with four replication were included in the present investigation. Recommended doses of N–P–K for jute were 60–13–25 kg/ha,

The N, P and K fertilizers was applied in the form of urea, single super phosphate and muriate of potash, respectively. After harvesting of wheat in the month of last week of March, the land was prepared for sowing of jute. The weed control in jute was done manually by hand weeding and/or wheel hoe or by scrapper and butachlor at 1.0 kg/ha at 20-25 DAS. For weed control in rice, butachlor at 1.0 kg/ha was applied 10 days after translating (DAT) followed by one manual weeding at 30- 35 DAT. For controlling the weed in wheat, 2,4-D at 500 g/ha was applied followed by one manual weeding at 45 DAS.

The sample of weeds was collected by using four randomly selected 0.5 × 0.5 m quadrat (0.25 m^2) in each plot of size 20 × 10 m before weeding at 25 DAS in both 2012 and 2013. Weeds falling in quadrats were counted species wise, calculated and presented in number of weeds/m^2 and were transformed prior to analysis, using square root transformation $\sqrt{(x + 0.5)}$. Importance Value Index (IVI) of a plant species was calculated to have overall picture of ecological importance of a species in relation to community structure by adding relative frequency, relative density and relative dominance. The biodiversity of the weeds was measured including: the species richness R (*i.e.* the total number of species occurred in field); the species diversity, which was measured by the Shannon-Wiener index *i.e.* *H*‹§=”*Pi*log *Pi,* in which *Pi* is the proportion of individual numbers of the *i* species to the total individual number of each species in the quadrats. It was calculated from the formula as *Pi = Ni/N*, of which *N* is the total individual number of each weed species and *Ni* is the individual number of the *I* species; the degree of community dominance, as measured by the Simpson index, *D* = 1-”*Pi*^{2}; the community evenness, as measured by the evenness index (Pielou index), *J = H1/logS*. The Duncan Multiple Range Test (DMRT) was worked out where variance ratio (‘F’ test) was significant at P d”0.05 by using SPSS v. 16.0.

RESULTS AND DISCUSSION

A total of 12 weed species observed in the experimental plots were *Cyperus rotundus*, *Brachiaria ramose*, *Digitaria sanguinalis*, *Echinochloa colona, Eleusine indica*, *Amaranthus viridis, Physalis minima Cleome viscosa*, *Digera arvensis, Phyllanthus niruri, Portulaca oleracea* and *Trianthema portulacastrum.* Application of different doses of fertilizers affected the weed community and composition in jute. The significant difference (P= 0.05) in total weeds density was observed among different manure and fertilizers treatments (Table 1). Significantly higher weed density was recorded in 100% NPK+ FYM treatments compared to all other treatments. The weed density in 150% NPK, 100% NPK and 50% NPK was almost similar but higher than control and 100% NP treatment.

The influence of fertilizers on weed density has been reported by many researchers (Moss *et al.* 2004, Wan *et al.* 2012). Das and Yaduraju (1999) in wheat, Nie *et al.* (2009) in rice and Mohammaddoust *et al.* (2009) in barley reported that balanced nutrient and higher NPK favoured crop growth but in case of jute, because of its very small and delicate seedling and non-tillering behaviour, it cannot compete with weed during initial 20-25 days. Weed density in 100% NPK + HW was also significantly higher than other treatments except 100% NPK + FYM. Species wise variation in weed density was also observed in different fertilizers and manure treatments. *Cyperus rotundus* density was higher in control and 50% NPK and 100% NPK + HW treatments. Among the grass, weeds *Echinochloa colona* density was the highest in 100% NPK + Zn, 150% NPK and 100% NPK + FYM treatments. Density of broad-leaved like *Physalis mimina* and *Phyllanthus niruri* was higher under 100% NPK + FYM. Weeds like *Brachiaria ramose* and *Digera arvensis* were only recorded in 100% NPK + FYM plot. Different fertilizer treatments had different levels of available N, P and K in soil which influenced weed density and its growth. Banks *et al.* (1976) observed that total weed density was lowest in plots receiving no fertilizer and highest in these plots receiving N, P, K, while some weed species populations decreased as fertility became more balanced.

Table 1. Weed density (no./m^2) in jute under different fertilizers treatment (pooled data of 2012 and 2013)

Weed species	Control	50% NPK	100% NPK	150% NPK	100% NPK + HW	100 % NPK + Zn	100% NP	100% N	100% NPK+ FYM
Cyperus rotundus	13.21 (174)	12.75 (162)	7.91 (62)	4.95 (24)	19.30 (372)	8.86 (78)	6.96 (48)	7.65 (58)	3.81 (14)
Echnichloa colona	6.36 (40)	8.97 (80)	9.62 (92)	13.36 (178)	6.96 (48)	13.58 (184)	10.12 (102)	6.04 (36)	13.51 (182)
Eleusine indica	4.42 (19)	4.95 (24)	7.52 (56)	5.70 (32)	4.95 (24)	9.19 (84)	3.54 (12)	2.92 (8)	8.28 (68)
Digitaria sanguinalis	3.67 (13)	3.94 (15)	3.81 (14)	3.54 (12)	3.54 (12)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	4.95 (24)
Trianthema portulacastrum	2.92 (8)	2.92 (8)	1.58 (2)	3.81 (14)	3.24 (10)	3.24 (10)	0.71 (0.0)	2.92 (8)	4.53 (20)
Physalis minima	0.71 (0.0)	3.24 (10)	9.72 (94)	4.95 (24)	6.96 (48)	2.55 (6)	4.06 (16)	9.41 (88)	15.31 (234)
Phyllanthus niruri	0.71 (0.0)	3.24 (10)	2.55 (6)	4.06 (16)	2.74 (7)	0.71 (0.0)	2.92 (8)	4.95 (24)	6.96 (48)
Digera arvensis	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	6.12 (37)
Amaranthus viridis	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	2.55 (6)	2.55 (6)	1.58 (2)	2.55 (6)	2.55 (6)	5.34 (28)
Cleome viscosa	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	2.55 (6)	2.55 (6)	1.22 (1)	2.55 (6)	2.55 (6)	5.34 (28)
Portulaca oleracea	0.71 (0.0)	0.71 (0.0)	0.71(0.0)	3.67 (13)	3.67 (13)	2.55 (6)	3.67 (13)	3.67 (13)	5.87 (34)
Brachiraia ramose	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	4.06 (16)
Total	16.0^{ab}	17.6^{bc}	18.1^{c}	18.0^{c}	23.4^{d}	19.3^{c}	14.5^{a}	15.7^{ab}	27.1^{e}

Original value in parentheses transformed by square root transformation x+0.5. Sigificant differences by different letters DMRT

Table 2. Importance value index (IVI) of weed species in jute under different fertilizers treatments

Weed species	Control	50% NPK	100% NPK	150% NPK	100% NPK + HW	100 % NPK + Zn	100% NP	100% N	100% NPK + FYM
Cyperus rotundus	157	118	37	31.2	144	57.5	59.4	58.9	11.2
Echnichloa colona	52.4	67	77.8	82.3	30.6	110	106	42.6	56
Eleusine indica	35.9	30.4	36.4	38	20.1	60.4	25	16.6	27
Digitaria sanguinalis	31.2	26.7	18.4	21	14.4	0	0	0	15.5
Trianthema portulacastrum	33.9	18.8	18	22	0	16.8	0	0	72
Physalis minima	0	17.9	97	31	30.6	13.8	29.1	81.3	145
Phyllanthus niruri	0	20.3	15	24.5	10.5	0	21.1	32.4	22
Digera arvensis	0	0	0	0	0	0	0	0	19
Amaranthus viridis	0	0	0	13.7	10	13.9	16.3	14.4	16.6
Cleome viscosa	0	0	0	13.8	8.6	12	16.7	14.4	14.93
Portulaca oleracea	0	0	0	22	15.6	16	26	23	17.4
Brachiraia ramose	0	0	0	0	0	0	0	0	11.8

Although, fertilizers clearly promoted crop growth, many studies have shown that nutrients benefit weeds more than crops (Liebman and Davis 2000, Sindel and Michael 1992). Thus, the effects of fertilization on weed density may vary with weed species and their composition. Dominance of *Cyperus rotundus* was observed in lower doses of fertilizer application and had an Importance Value Index (IVI) of 157,144 and 118 in control, 50 % NPK and 100 % NPK + hand weeding, respectively (Table 2.) *Cyperus rotundus* is a perennial sedge, which can survive with low available nutrients, as it propagates mainly through vegetative parts (tubers and rhizomes) and once it is established in the field, it is very difficult to control. It has been reported as one of the worst weeds in the world (Holm 1977). Furthermore, *Cyperus* dominated in fields because of slow growth of the crop in control (no fertilizer) and 50% NPK treatment. Once *Cyperus* established with a higher density, it did not allow the growthand establishment of other weed species (Kumar *et al.* 2012).

Dominance of *Echinochloa colona* was recorded in 100% NPK+ Zn (IVI=110), 100% NP (IVI=106) and 150% NPK (IVI=82) *i.e.* in balanced and higher fertilizers doses. The highest weed density of broad-leaved weeds was recorded in 100% NPK + FYM. The type of manure that was applied in this long-term experiment was cow dung with waste of feeds that was derived from dairy farms; weeds like *Echinochloa colona*, *Digera arvensis, Phyllanthus niruri*, *Physalis minima* are used as animal feed in this area and these may have returned to field with FYM. FYM affects weed species diversity by increasing seed density or by introducing species as FYM is a source of many weed seeds (Cook *et al.* 2007, Walia *et al.* 2014).

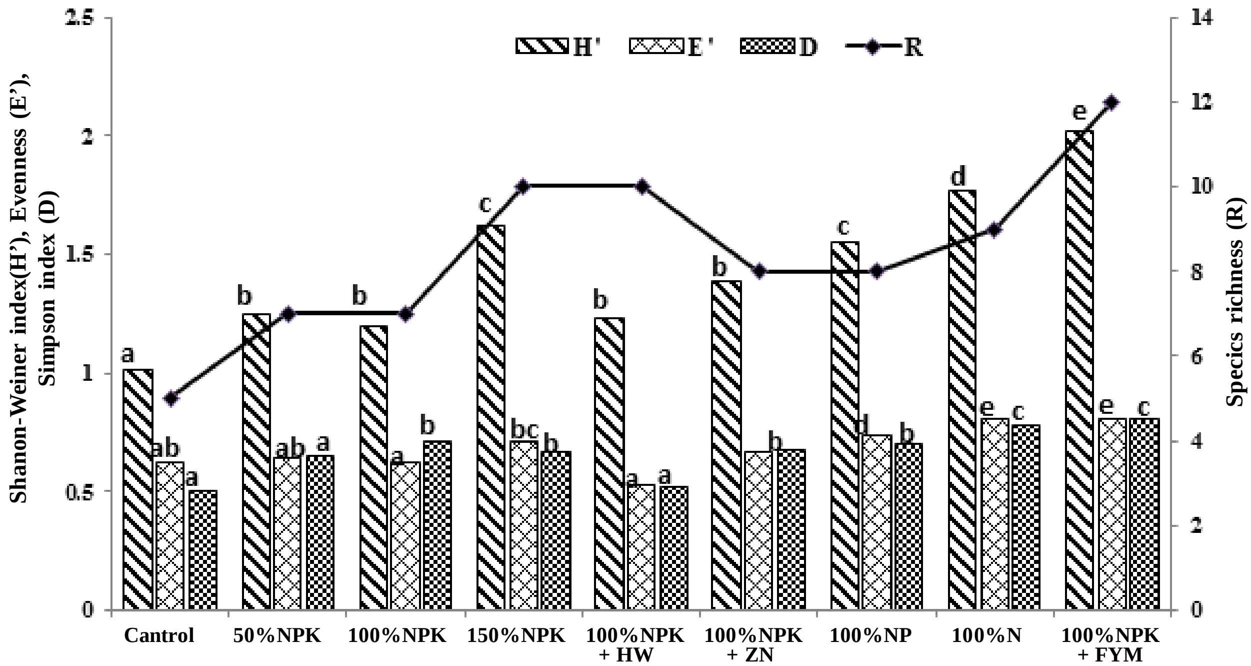

Fig. 1. Effect of different fertilizers and manure treatments on Shanon-Weiner index(H'), Evenness (E'), Simpson index (D) and Specie richness (R)of weeds. Different letters indicate significant differences among the treatments in the same season ($P < 0.05$).

Weed diversity

The weed species richness (R) was the highest (12) in 100% NPK + FYM and the lowest (5) in control plot (Fig. 1). The species richness under all other treatments was in order of 150% NPK (9) > 100% N (8) =100% NP =100% NPK + Zn (8)> 100% NPK (7)= 50% NPK and was higher in 150% NPK and 100% NPK + FYM treated plots because of higher density of broad-leaved weeds and higher available nutrient in this treatment which enhances germination and weed growth of many weed species (Charles *et al.*, 2006).

The weed diversity (Shannon's H1) was significantly higher (Pd" 0.05) in 100% NPK + FYM and lower in control plot compared to other treatments (Fig. 1). If weed species are equally distributed, the diversity and evenness will be more but dominance of some weed species will lead to decrease in diversity and evenness of weed species in an ecosystem (Wilson *et al.* 2003). *Cyperus* was dominant in control and 50% NPK treatments led to decrease in the weed diversity. The Simpson diversity index (D') was significantly higher in 100% NPK + FYM and 100% N compared to other treatments. The higher weed diversity in 100% NPK + FYM due to high available nutrients and weed species diversity was also affected by FYM as it is source of many weed seeds (Liemann and Davis 2000).

The weed species evenness (E') in 100% NPK + FYM and 100% N was almost same but significantly higher compared to other treatments. The lowest Simpson Index in 100% NPK + hand weeding and control plot was mainly due to the highest density of *Cyperus rotundus* in this treatment as *Cyperus* was dominat in control plot. Hand weeding is not effective in managing *Cyperus* as it grows from vegetative underground parts and hence long term use of single method of weed control increases the density of *Cyperus* in hand weeding plot.

Thus, it may be concluded that recommended doses of fertilizer recorded medium levels of weed density, and higher level of NPK and NPK integration with FYM recorded higher weed density and diversity. Higher infestation of *Cyperus rotundus* was recorded under lower doses of fertilizer while, higher infestation of *Echnichloa colona* was recorded under higher doses of fertilizers. The highest weed species richness and diversity was observed under 100% NPK + FYM (10 t/ha) treatment. Hence, weed management practices in FYM applied field should be given the highest priority.

REFERENCES

Andreasen C and Skovgaard IM. 2009. Crop and soil factors of importance for the distribution of plant species on arable fields in Denmark. *Agriculture Ecosystem and Environment* **133**: 61-67.

Banks PA, Santleman PW, Tucker BB. 1976. Influence of soil fertility treatments on weed species in winter wheat. *Agronomy Journal* **68**: 825-827.

Buhler DD. 2002. Challenges and opportunities for integrated weed management. *Weed Science* **50:** 273-280.

Charles KS, Ngouajio M, Warncke DD, Poff KL, Hausbeck MK. 2006. Integration of cover crops and fertilizer rates for weed management in celery. *Weed Science* **54:** 326-334.

Cook AR, Posner JL, Baldock JO. 2007. Effects of dairy manure and weed management on weed communities in corn on Wisconsin cash-grain farms. *Weed Technology* **21**: 389-395.

Das TK and Yaduraju NT. 1999. Effect of weed interference on the growth, nutrient uptake and yield of wheat as affected by irrigation and fertilizers. *Journal of Agricultural Science* **133**: 45-51.

Ghorai AK. 2008. Integrated weed management of jute (*Corchorus olitorius*). *Indian Journal Agronomy* **53**(2): 149-151.

Ghorai AK, Rajib De, Chowdhury H, Majumdar B, Chakraborty A, Kumar, M. 2013. Integrated management of weeds in raw jute. *Indian Journal of Weed Science* **45**(1): 47-50.

Holm LG, Plucknett DL, Pancho JV and Herberger JP. 1977. *The World's Worst Weeds: Distribution and Biology*. University Press of Hawaii, Honolulu.

Kumar M, Das TK and Yaduraju NT. 2012. An integrated approach for management of *Cyperus rotundus* (purple nutsedge) in soybean–wheat cropping system. *Crop Protection* **33**:74-81.

Liebman M and Davis AS. 2000. Integration of soil, crop and weed management in low-external-input farming system. *Weed Research* **40**: 27-47.

Mohammaddoust Chamanabad HR, Ghorabani AAA, Tulikov AM and Zargarzadeh F. 2009. Long-term effects of crop rotation and fertilizers on weed community in spring barley**.** *Turkish Journal of Agriculture and Forestry* **33:** 315-323.

Moss SR, Storkey J, Cussans JW, Perryman SAM and Hewitt MV. 2004. The Broadbalk long-term experiment at Rothamsted: what has it told us about weeds? *Weed Science* **52**: 864-873.

Nie J, Yin LC, Liao YL, Zheng SX and Xie J. 2009.Weed community composition after 26 years of fertilization of late rice. *Weed Science* **57**: 256-260.

Sindel BM, and Michael PW. 1992. Growth and competitiveness of *Senecio madagascariensis* Poir. (Fireweed) in relation to fertilizer use and increases in soil fertility. *Weed Research* **32:** 399-406.

Smith RG, Mortensen DA and Ryan MR. 2010. A new hypothesis for the functional role of diversity in mediating resource pools and weed crop competition in agroecosystems. *Weed Research* **50:** 37-48.

Storkey J and Cussans JW. 2007. Reconciling the conservation of in-field biodiversity with crop production using a simulation model of weed growth and competition. *Agriculture Ecosystem and Environment* **122**: 173-182.

Walia MK, Walia SS and Dhaliwal SS. 2014. Long term impact of chemical fertilizers and organic manures on weed dynamics of rice in rice-wheat system. *International Journal of Science, Environment and Technology* **3**(3): 1260-1267.

Wan K, Tao Y, Li R, Pan J, Tang L and Chen F. 2012. Influences of long-term different types of fertilization on weed community biodiversity in rice paddy fields. *Weed Biology and Management* **12:** 12-21.

Wilson WL, Abernethy VJ and Murphy KJ. 2009. Prediction of plant diversity response to land use change on Scottish agricultural land. *Agriculture Ecosystem and Environment* **94**: 249-263.