Indian Journal of Traditional Knowledge
Vol. 11(2), April 2012, pp. 354-357

Weed management through salt application: An indigenous method from shifting cultivation areas, Eastern Himalaya, India

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Received 19.11.2009, revised 30.12.11

An experiment has been undertaken to evaluate the efficacy of traditional practices to use common salt for weed management in *jhum* paddy in mid hills conditions in Eastern Himalayas with the objective to study the effect of salt application on morphological characters, yield attributes, yield and economics of paddy under shifting cultivation areas. Salt @ 120 kg ha^{-1} with two spay resulted significantly ($P<0.05$) higher grain yield over control, and also higher weed control efficiency than three hand weeding. The salt and hand weeding have resulted same effect by reducing the chaffy grain. Salt application is found to be the best weed management strategy with Benefit: Cost ratio of 1.79.

Keywords: Indigenous weed management, Weed control efficiency, Salt, *Jhum* paddy, Broad leaved weeds

IPC Int. Cl.[8]**:** A01M 21/00, A01D, A01B 1/16, A01B 39/18, C01D 3/04, E21C 41/20, A01G 9/00, A01G 16/00, A01G

The weeds are major menace in successful cultivation of upland paddy. In North Eastern Hill (NEH) Region of India, paddy is the major crop even in the shifting areas. However, it is characterized by low productivity due to invasion of weeds. Sometimes the severe weed menace forced to go for re sowing of paddy. The main practice of weed control is hand weeding for 3-4 times during crop growth period which involves more labour input cost and reduced net return. Besides paddy, as many as 60 crop species have been reported to be cultivated in *jhum* fields[1,2]. Statistically, NEH region accounts for 7.8% of the total paddy area in India with 5.9% share in paddy production with productivity level of 1.4 tons ha^{-1}.

The use of modern herbicides is also negligible in *jhum* land. Some farmers are using common salt for control of weeds especially the broad leaf weeds. The extremely acidic soil conditions in shifting cultivation areas helps in controlling the weeds though use of common salt. The modern commercial weedicides like 2, 4-D and the conventional common salt are all sodium (Na) based. Like common salt, application of Na salt of 2, 4-D can kill even sedges up to 90% besides increasing yield significantly[3].

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Keeping in view the importance of use of salt for weed control, an experiment has been conducted at *jhum* field during two consecutive cropping seasons, i.e. 2006-2007 and 2007-2008 on local *jhum* cultivar (*Rachu*) in Lampong Sheanghah village of Mon district of Nagaland.

Methodology

The experimental site was located at 943-993 masl altitude, 26° 46' 454"N latitude and 95° 04' 612"E longitude, respectively. The South facing area of the experimental site was slashed during last part of November and burnt during last week of January. Twelve nos. of plots each of 100m^2 area were demarcated across the slope along the contour so as to provide homogenous environment to each plot and paddy seeds were sown in first week of March and harvested during first week of August every year. The quantity of salt standardized through multi location experiment in *Jhum* field and found the optimum rate as 120 kg/ha. The salt was applied in two sprays, one after sowing and another at active tillering stage in four nos. of plots. Hand weeding, i.e. traditional method of weed control was followed in another four plots. Likewise, four plots were left as such to serve as control. The experiment was conducted in simplified randomized block design with four replications in Inceptisol soils. The average rainfall during crop season was recorded to be 1875 and 1985 mm, respectively, during 2006-07 and 2007-08 with temperature range of 25-32°C and relative humidity of 85.0-94.0%. Total sunshine hour were recorded to be 152.4, 195.19, 165.7, 85.1, 87.1 and 91.4, respectively, during March, April, May, June, July and August. The data were recorded on growth and yield parameters. The weed control efficiency (WCE) was calculated using the following formula[4]: WCE (Dry matter or density of weeds in unweeded plot – Dry matter or density of weeds in treatment)/Dry matter or density of weeds in un-weeded plot) x 100.

Result and discussion

A significant difference in plant height was observed among the salt treated plot, hand weeding and control (Table 1). In all cases, hand weeding had the tallest plants compared to salt treatment or control plot. Salt and hand weeding plots, however, resulted in significantly ($P< 0.05$) higher number of tillers /hill and test weight over control. Similar was the case for number of panicle/plant. However, significant variation was observed on number of grain/panicle including grain yield and biomass cover (Table 2). On an average, straw yield was significantly higher in salt and hand weeded treatments compared to control. The salt and hand weeding also resulted in lesser amount of chaffy grain (Table 2). Salt treated plots have resulted in significantly ($P< 0.05$) higher weed control efficiency over hand weeding.

Salt application was best weed management strategy in terms of comparatively higher profits. Though gross and net returns were higher in hand weeding but incurring of high expenditure in terms of labour cost reduced the net monetary returns in hand weeded plots (Table 3).

The data indicated that salt treated plots had significantly low weed biomass. The specific physiological adaptations in paddy make it relatively resistant to salt than broad leaved weed species. However, in subsequent cropping, the growth of narrow leaves increased more than normal in salt treated plots[5,6]. The optimum dose for effective weed control is 1 kg of salt dissolved in 12 L of water. The higher the dose, more effective is the weed control. But large quantities of salt were found to affect even paddy plant.

Different responses to salinity have been reported between germinating and growing seedlings of a number of plants[6]. Salt tolerance in paddy may be due to mobilisation of food reserves in the growing regions, i.e., embryonic axes, some can occur before germination. Once the polysaccharides are mobilized, those are converted into monomers, i.e. sucrose, glucose and fructose that are readily transportable to sites where they are required for

Table 3—Economics analysis for weed management in *jhum* fields (pooled data)

Sl. No.	Components	Salt treated plot	Hand weeding	Control
1	Cost of cultivation (Rs/ha)	5,600.0	7,100.0	5,000.0
2	Gross return (Rs/ha)	15,600.0	17,760.0	8,160.0
3	Net return (Rs/ha)	10,000.0	10,660.0	3,160.0
4	B:C ratio	1.79	1.50	0.63

Table 1—Morphological characters of paddy (pooled data)

Sl. No.	Morphological characters	Salt treated plot	Hand weeded plots	Control plots
1.	Plant height (cm)	87.78 ± 3.03	94.08 ± 2.59	75.80 ± 1.51
2.	No. of tillers/hill	8.5 ± 0.95^{a}	9.8 ± 1.42^{a}	4.1 ± 0.70
3.	No. of panicle/plant	8.0 ± 1.42^{a}	10.10 ± 1.94^{ab}	5.20 ± 0.61^{b}
4.	Panicle length	18.80 ± 0.63^{a}	20.03 ± 1.53^{a}	18.0 ± 2.21^{a}
5.	No. of grain/panicle	125.50 ± 1.06	135.0 ± 5.25	110.20 ± 2.74
6.	Test weight	24.20 ± 0.85^{ab}	26.80 ± 2.12^{a}	23.60 ± 0.66^{b}

For each character in a row, means followed by same letter are not significantly ($P < 0.05$) different.

Table 2—Biomass production in paddy (pooled data)

Sl. No.	Components	Salt treated plot	Hand weeding	Control
1	Grain yield (q/ha)	19.50 ± 1.13	22.20 ± 0.7	10.20 ± 1.07
2	Straw yield (q/ha)	45.60 ± 3.62^{a}	41.20 ± 1.39^{a}	35.60 ± 0.40
3	Root biomass of paddy (q/ha)	5.60 ± 0.27	8.50 ± 0.52	3.50 ± 0.56
4	Weed biomass (q/ha)	8.20 ± 0.44	10.10 ± 0.56	26.50 ± 0.53
5	Chaffy grain (q/ha)	0.68 ± 0.2^{a}	0.58 ± 0.08^{a}	3.1 ± 0.36^{ab}
6	Weed control efficiency	69.03 ± 2.07	61.88 ± 2.73	-

For each character in a row, means followed by same letter are not significantly ($P < 0.05$) different.

growth. The soluble carbohydrates also seem to play an important role in osmotic regulation of cells during germination [7-10].

The osmotic adjustment in paddy is an important physiological adaptation, which might be the reason for selectivity of paddy plant to NaCl. For osmotic adjustment, plants use inorganic ions such as Na and K and/or synthesize organic compatible solutes such as proline, betaine, polyols, and soluble sugars. Vacuolar sequestration of Na is an important and cost effective strategy for osmotic adjustment that also reduces the Na concentration in the cytosol in paddy plant[11]. The herbicidal effect of NaCl on *A. conyzoides* (a major weed species in *jhum* fields) is primarily an osmotic effect rather than a specific ion effect. This is because of the fact of type and rapidity of appearance of observed stress symptoms, the absence of differences when using different application rates, the improved efficiency under dry conditions, and the rapid reemergence of weed seedlings after the treatment. Besides the target weed *A. conyzoides,* several other common Asteraceae weeds including *Crassocephalum crepidioides* Benth are also controlled by application of NaCl in shifting cultivation areas[12].

The process of compartmentation requires that halophytes have a mechanism to maintain differences in ion concentration across the membrane that surrounds their vacuoles; this mechanism depends on membrane structure[13] and on the proteins that transport ions across membranes. Common salt affect the plant by lowering of the water potential, direct toxicity of any Na and Cl absorbed and interference with the uptake of essential nutrients. The paddy develops tolerance to salt by way of compartmentation and compatible solutes, regulation of transpiration, control of ion movement; membrane characteristics and tolerating high Na/K ratios in the cytoplasm. High levels of Na^+ or high Na^+ : K^+ ratios can disrupt various enzymatic processes in the cytoplasm owing to the ability of Na^+ to compete with K^+ for binding sites[14,15]. The sensitivity of cytosolic enzymes to Na+ is similar in both weeds and tolerant plant, indicating that the maintenance of a low cytosolic Na^+: K^+ ratio is a key requirement of plant growth in salt solution [16,17]. The sodium concentration within the leaves of paddy exposed to salinity shows a wide distribution between individuals and transgressive segregation, features of a multigenic character[18]. However, in paddy, sodium influx into the xylem through the apoplastic pathway appears to be more significant [19,20]. However, silica deposition[21] and polymerization of silicate in the endodermis and rhizodermis blocks Na influx through the apoplastic pathway in roots of paddy.

The results suggest that salt application is very effective to control weed population in *jhum* fields. Since, *jhum* cultivation is labour intensive; application of salt could reduce the labour expenditure to a great extent. Further, net monetary benefits were also higher in salt treated plots.

Conclusion

The study reveals that the age old practice of use of common salt for weed control under acidic conditions of *jhum* paddy in north east India is not only effective in minimization of weed competition with cultivated crop (paddy) but also results in comparatively high paddy productivity without having any negative effect on growth, yield attributes of paddy. The practice of use of salt for weed management is also cost effective compare to other popular practice of weed management like hand weeding. The acidic soils of shifting cultivation have not shown any deterioration in its quality but there is need to study the long term effect of use of salt on physico-chemical properties of the soils.

Acknowledgement

Financial assistance received from National Agricultural Innovation Project of ICAR is gratefully acknowledged.

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