Low Cost Zero Till *in situ* Green Manuring for Kharif Rice-a Success Story

ABSTRACT

Low cost zero till *in situ* green manuring using plant species like dhaincha (*Sesbania aculeata*) and sunnhemp (*Crotalaria juncea*) will eliminate the age old problems of large scale adoption of green manuring across the farming community. These two species germinated and grown well when sown before (as paira crop during last irrigation) or after rice harvest under zero till condition, with assured nor western rain/monsoon rain or with one post sowing irrigation (7.5 cm). The zero till paira dhaincha green manuring process opened up the scope of producing green manuring at lower cost and saves up to Rs.15000/ha over conventional rain fed green manuring system. Green manuring by dhaincha produced 50-60 tonnes of biomass at 35-40 DAS in alluvial (North 24 PGS), lateritic (Purulia) and clay soils (Paschim Medinipur), produced 30-50 q raw rice /ha and saved 20-27 kg (30 per cent) chemical nitrogen/ha. This green manure will help in quicker decomposition of rice straw left after combined harvest (3.5- 6,0 t/ha), minimise its field burning, sequester enough carbon to the soil. Fifty tonnes green biomass of dhaincha/sunnhemp, has the potential to absorb 10 tonnes CO_2 from the atmosphere, minimise environmental pollution, improve soil health, its structure and water holding capacity. This technique can be adopted in rice growing countries across the globe without difficulty. Seed production dhaincha and sunnhemp is possible by growing it as paira crop (40 kg/ha) within *kharif* rice which grows up to 45 cm height, produces healthy pods and matures by 70 days which otherwise takes 5-8 months in normal season. If the seed crop is not harvested in rice fallows, from shattered seeds, self seeded zero till and rain fed dhaincha manure can be obtained in rice fallows.

Key word: Zero tillage, green manure biomss, rice yield, nitrogen addition

1. INTRODUCTION

Green manuring concept is scanty across the world except a few places due to the abundant availability of cheap chemical fertilizer, high cropping intensity (leaves no time between crops), high cost of ploughing and irrigations [1] which requires at least one ploughing for sowing and two irrigations costing, Rs.15000/ha at present. The soil is already hungry of plant nutrients and poor in organic matter in high intensity cropping system across the globe, particularly in tropics. Nowadays, the concerns about sustainability of soil productivity and ecological stability, which has come into view with the excessive use of synthetic fertilizers and have become a priority. In this respect, use of legume crops as green manure to improve soil fertility and soil physical conditions has received increasing attention [2,3&4].Globally rice is grown on a total area of approximately 158 million ha, producing more than 700 million tons annually (470.6 million tons of milled rice) in 2015 [5]. Apart from Kharif rice (46 million hectares), majority of the summer rice grown in India (2.971 million hectares) is also under mechanised harvest now [6]. This process leaves a colossal amount of rice stubbles (around 3.5- 6 t/ha) which are primarily brunt by farmers causing huge loss of plant nutrients, adds GHG gases to the environment, destroy soil biota and adds particulate matter to air, causing environmental pollution, a much debated issue today. Dhaincha green manuring was at par with 40 kg N ha^{-1} as urea in increasing the yield of direct-seeded and transplanted crops [7]. Green manure amendment is a profitable manipulation for enhancing carbon sequestration without increasing paddy CH_4 emissions [8]. Compared with the fallow-rice practice, the GM-rice practice increased the soil C stock at a rate of 1.62 Mg CO_2-eq ha^{-1} yr^{-1} and reduced chemical N application by 40% with no loss in the rice yield [9]. The average N loss in flooded soils from applied green manures was considerably lower (14 per cent) than that of split applied urea (35 per cent), thus, resulting in less pollution to the environment [10].

Apart from this, summer rice is also grown in large area in different tropical countries of the world where mechanised rice harvest is also prevalent. Burning of left over wheat stubbles is also posing environmental threats in many places around the globe. Addition of low cost nitrogen rich biomass from zero till green manure with these rice/wheat stubbles will help its quicker decomposition, add nutrition to the soil, improve soil health and minimise rice straw burning [11]. The improvement in soil physical conditions as a result of build up of organic matter by incorporation of green manure or crop residue is associated with a decrease in bulk density, increase in total pore space, water stable aggregates and hydraulic conductivity of the soil [12,13]. Herein attempts were made to find out the zero till green manuring potential of dhaincha after summer or kharif rice in farmers' fields at Swarupnagar (North 24parganas), Baghmundi (Purulia) and in Kalapunja (Paschim Medinipur), West Bengal in 2022 and 2023.

***Keywords*:** Zero tillage, green manure biomss, rice yield, nitrogen addition, economics

2. MATERIALS AND METHODS

Consecutive field experiments were made in farmers fields in North 24 PGS (Swarup Nagar, Goaldah), Paschim Medinipur and Purulia (Baghmundi farm) districts of WB from 2022- 2023 to test the validity of *Sesbania aculeate* and *Crotalaria juncea* as zero till green manure crops for rice. Zero till broadcast sown dhaincha (*Sesbania aculeate*) seeds @ 40 kg/ha germinated and established well (Plate 1, 1^{st} and 2^{nd} from left) on grass bed or after summer rice.

Plate 1. Zero till rain fed dhaincha on grass bed in Purulia (1^{st} from left) & North 24 PGS (2^{nd} from left, after summer rice, irrigated), sunnhemp ($3^{rd\ f}$rom left after summer rice, irrigated) and sowing zero till paira dhaincha (4^{th} from left within summer rice) for green manuring, in Paschim Medinipur, WB

Plate 2. Growth and development of uncovered Dhaincha seeds sown over ploughed lateritic soil, under rain fed condition (pre monsoon shower 51.4 mm), Baghmundi, Purulia, West Bengal

At Swarupnagar (North 24 PGS, Plate 1, 2^{nd} from left), zero till dhaincha seeds (soaked for overnight) were broadcast sown after summer rice harvest on clay soil with one post sowing irrigation (7.5 cm). The dhaincha seeds germinated well without difficulty and established perfectly. In Paschim Medinipur, zero till dhaincha seeds sown after summer rice (clay soil) germinated and grown well receiving pre monsoon shower. At 30 days the dhaincha green biomass was 15 tonnes/ha. At 35 & 40 days after sowing (DAS), the average dhainch plant heights were 90-100 cm & 135 cm, green biomass were 30 t/ha & 50 t/ha and root nodules were 30-36/plant, respectively. *Sesbania aculeate* germinated well as paira crop before summer rice harvest both at North 24 PGS and Paschim Medinipur (Plate 1, 4^{th} from left). *Sesbania aculeata* is water logged tolerant species and requires puddling/mixing in soil by rotavator or case wheeled cultivator/disc plough, before kharif rice transplantation. For mixing by power tiller, dhaincha plants should not exceed 45-60 cm height. Above it, manual chopping is necessary. For manually chopping the standing dhaincha plants are cut by sickle (1.5 to 2 feet above base) and 2 man days are required for 0.134 ha.

At Swaupnagar Goaldah, 24 PGS (N), rice cv. Dharani was transplanted @ 4-5 seedlings/heel after decomposition of dhainch on 16^{th} August. After fifteen only days 5 kg N: $P_2O_{5:}$ K_2O:: 10:26:26 and 4 kg urea was applied in 17 katta land (0.113 ha). It amounts to total 16 Kg N, 11.4 kg P_2O_5 and 11.4 kg K_2O/ha. Hence, after green manuring only 73 %, 62% and 62% of Nitrogen, phosphorus and potassium were applied to soil/ha, over the recommended dose of fertiliser (RDF); N: $P_2O_{5:}$ K_2O::60:30:30/ha. Further 20.5 kg N/ha was top dressed before panicle initiation stage. Thus a total of 36.5 kg nitrogen was applied to the rice only and it saved 23.5 kg nitrogen/ha over RDF. Due to deficit rainfall in *Kharif* season ,three irrigations were applied after rice transplantation.

3. RESULTS AND DISCUSSIONS

At Swaupnagar Goaldah, 24 PGS (N) only 36.5 kg nitrogen was applied to the rice and dhaincha green manuring saved 23.5 kg nitrogen/ha (Table 1) over RDF and the rice yield was 37 q/ha (Plate 3). Rice yield of Purulia was 30 q/ha at RDF (N: $P_2O_{5:}$ K_2O::60:30:30/ha). In Paschim Medinipur, at 35 DAS, 40 tonnes dhaincha biomass was harvested and produced 5 tonnes summer rice/ha and saved 27 kg Chemical nitrogen/ha. Uncovered dhaincha seeds geminated and grown well both on unploughed sod or over ploughed soil under rain fed condition using a pre monsoon rain (51.4 mm rain), at Baghmundi, Purulia in acid lateritic soil [Plate 1 (1^{st} one) & Plate 2]. Average dhaincha plant height was 60 cm, green biomass was 10 t/ha, nodules count were 20/plant at 30 days after sowing (DAS) on lateritic soil at Purulia, Baghmundi farm. In Purulia, at 35 DAS, the average plant height was 80 cm with an average biomass of 25 tonnes/ha. In dense canopy the biomass accumulation was 60 t/ha in 35 DAS. However, nitrogen requirement of rice was reduced due to dhaincha green manuring by 20 kg/ha at Purulia and it produced 3 tonnes rice/ha .

In *kharif* season, *insitu* green manuring of dhaincha (*Sesbania aculeata*, seed rate @ 30 kg/ha) by dual cropping/intercropping (1:1) with rice (seed rate 100 kg/ha) at 20 cm row spacing, eliminated its nitrogen requirement from chemical fertiliser and produced 37 q raw rice (cv. CR-1009)/ha at Bhubaneswar, Odisha [1]. The dhaincha plants at 35-40 DAS can be cut and laid on soil surface/shallow water for its decomposition over time by brush cutter or manually by sickle (15 man-days/ha), [14] .

Plate 3. Matured khraif rice using zero till green manure at Goaldah, North 24 PGS (N)

Attempts were also made t0 grow zero till sunnhemp (*Crotalaria juncea* cv. JRG 610 @ 30 kg/ha, Plate 1, 3rd from left) after summer rice harvest (clay soil) using reliable rain (40-50 mm) or one post sowing irrigation or nor-western rain in Paschim Medinipur, District, village Dakshin Kalapunja. This requires no ploughing and will help in faster decomposition of left over rice stubbles after mechanised harvest. Sunnhemp germinated and grown well after summer rice (plant height 100 cm at 40 DAS) and Kharif rice under zero till system in Paschim Medinipur, WB and North 24 PGS (ICAR-CRIJAF) in 2021& 2022. In summer, the biomass production potential was 35 t/ha at 40 days after sowing. Its biomass production potential is 5-7 t/ha in winter months.

Attempts were also made to grow sunnhemp *(Crotalaria juncea*) in ploughed field after summer rice with one post sowing irrigation (Mid-April) in Paschim Medinipur, WB in 2015 and we got around 30 tonnes of nitrogen rich biomass per hectare in clay soil. It can add 50-60 kg nitrogen/ha when grown for 60-90 days [15]. This has the advantage that it can be terminated by natural water logging from pre-monsoon or monsoon rain and eliminates the cost of turning down by plough. Being rich in nitrogen (0.3% on fresh weight basis) these species decomposes faster and its mixture with silicon rich rice or wheat straw helps in quicker decomposition [16,17] with a biomass of 50 t/ha, it has the potential to absorb 10 tonnes CO_2 from the atmosphere, approximately. This will help in carbon farming that results in increased storage of atmospheric carbon in the soil. Carbon farming is the practice that can help remove carbon dioxide from the atmosphere, and store it for long periods of time in soil, microorganisms, and plant matter [18].

In case of timely adequate monsoon rain (75 mm), an irrigation is saved during ploughing down the green manure in rice soil. As zero till paira green manuring crop of dhaincha needs no additional ploughing for sowing and no irrigation, the net saving in this green manuring process amounts up to Rs. 15,000/ha (Table 2). In zero till irrigated green manure, the savings is Rs.5000/ha over conventional green manuring. Cost of each plough and irrigation is Rs. 5000/ha. As rice puddling is usual for rice transplanting, the 2nd ploughing cost to plough down green manure is also eliminated in many cases.

3.1. Conditions for successful zero till green manuring: For successful zero till green manure, it should be sown as i) paira crop in rice field (*Rabi and Kharif*) in standing water (3- 4 mm) or during last irrigation, ii) on assured nor western rainfall (40-50 mm), iii) on initiation of pre-monsoon shower (last week of May to 1st week of June), iv) sowing of overnight soaked seed under zero till condition with a 7.5 cm irrigation or v) it can also be sown by zero till seed drill, however the cost of mechanised sowing is involved but it assures better germination under low rain. A light grass bed or crop residues (after rice or wheat harvest) [19] assures better germination of green manure seeds by conserving moisture and providing shade for easy establishment of radicles through soil in summer months.

3.2. Seed production techniques of dhaincha and sunnhemp in winter: Seed production dhaincha and sunnhemp is possible by sowing it as paira crop (40 kg/ha) on muddy soil or on 3-4 mm standing water, ten days before kharif rice harvest which grows up to 45 cm, produces healthy pods and matures by 70 days (which otherwise takes 5-8 months in normal season). If the seed crop is not harvested , then from shattered seeds, self seeded zero till and rain fed dhaincha/sunnhemp can be obtained in rice fallows. Seed production potential of winter sunnhemp at ICAR-CRIJAF, Barrackpore, Kolkata over years was 2-3 q/ha. A model of seed crop for winter dhaincha and sunnhemp are shown in Plate 4, which have reached flowering stage at 45 days after sowing at 45-50 cm height in winter month.


Plate 4. Dhaincha and sunnhemp seed production in winter ICAR-CRIJAF (2021-22)

Table 1: Zero till green manuring by *Sesbania aculeate* for *kharif* rice (2022-23)

Sl.No.	**Dhaincha sowing type**	**Dhaincha plant height (cm)**	**Biomass (t/ha)**	**Nodules/plant (Nos.)**	**Rice yield (Q/ha)**	**Chemical nitrogen savings (Kg/ha)**
1.Swarup Nagar North 24 PGS (N)	Zero till Dhaincha after summer rice	135 cm (40 DAS)	50 (40 DAS)	30-36 (40 DAS)	37.0	23.5
2.Baghmundi, Purulia,	Dhaincha sown over ploughed soil	80 cm (35 DAS)	60 t/ha (35 DAS)	20 (35 DAS)	30	20
3.Kalapunja, Paschim Medinipur	Dhaincha sown before ploughing	100 cm (40 DAS)	35 t/ha (40 DAS)	30-36 (40 DAS)	50	27
SD ±		27.83	2.89	7.50	10.14	3.5

Table 2. Comparative economy of conventional and zero till green manuring

Sl.No	**Plough requirements /ha (Nos.)**	**Irrigation requirement /ha (Nos.)**	**Cost of each plough (Rs./ha)**	**Cost of each irrigation (Rs./ha)**	**Total cost (Rs./ha)**	**Savings (Rs./ha)**
1.Conventional green manuring (rain fed)	2	2 (7.5 cm each)	5000	5000	20000	Nil
2. Zero till paira green manure with timely onset of monsoon	0	0	1	0	5000	15000

2. Zero till green manure (irrigated)	0	2	1	0	15000	5000

4. CONCLUSIONS : This zero till green manuring process will eliminate the age old bottle neck of adoption of green manuring at large to produce green manure at lower cost, help in quick decomposition of rice straw and its field burning, sequester enough carbon to the soil, minimise environmental pollution and improve soil health including soil biota, improve soil structure and water holding capacity of soil. Zero till green manure produced 3-5 t rice /ha in different locations, added 35- 60 tonnes bio mass/ha and saved 20- 27 kg (30 per cent) chemical nitrogen/ha. As zero till paira green manuring crop of dhaincha needs no ploughing and irrigation, the net saving in green manuring amounts to Rs. 15,000/ha. Ddhaincha can also be grown as green manures/easily decomposable biomass resources after wheat harvest which can be mixed with its stubble under i*n situ condition* for its quicker decomposition rather burning the later in open field creating environmental pollution. This technique can be adopted in ice growing countries across the globe without difficulty.

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