"Agricultural Weeder With Nail Assembly" for Weed Control, Soil Moisture Conservation, Soil Aeration and Increased Crop Productivity

ABSTRACT

This "Agricultural weeder with nail assembly" **(Design registration no. 289754 in class 15-03, dt. 13-09-2019, Patent Office Kolkata, GOI)** has been developed to weed out young composite weed flora including germinating ones mechanically, from line sown and broadcast field (cereals, pulses, oilseeds, jute, mesta, flax, sunnhemp,) and horticultural crops (vegetables and flowers etc.) since 5-7 days of crop sowing at field capacity (FC). Due to its low draft (8-12 kg only at FC) women, youngsters and aged persons can also operate the tool easily.It increases soil aeration (Oxygen diffusion rate, ODR: 303 µg O_2 m^{-2} sec^{-1}), keeps the soil cooler (1-5^{0}C) and improves soil moisture (4-15%) by soil mulching in drier months and improves jute yield (10-12%) and its water productivity. This tool contains i) a nail assembly with 5-6 nos. of nails (6-8 mm dia.) fixed with nuts at 3 cm apart in series ii) scrapper (of different types) and iii) tine, to suit different types of operations . Addition of a boat replacing its front wheels and two conical rotors in the main frame, make it suitable to control weeeds in transplated rice field also. In two operations, at 5 days interval since 5 DAE, it requires only 12-18 man days/ha and saves Rs.15000 to Rs.20000/ha. With the help of this tool, 85 to 90 per cent of composite ~~weeds~~ weeds can be controlled. It produced 33 to 40 quintal jute fibre/ ha, 4.5 to 5 tonnes of upland and transplanted land rice, 3.0 to 4.5 tonnes of wheat and 15 q mustard/ha under farmers field and at ICAR-CRIJAF in different years. Till now around 55000 numbers of "Agricultural Weeder with Nail assembly" have been distributed to the jute farmers of West Bengal by Dep't. of Agril. Govt. of WB.

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Comment [2]: Take to methodology

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Key words: Manual weeder, weed control, soil moisture, soil air, economics, adoption

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INTRODUCTION~~:~~

In field and horticultural crops, a huge amount of money, nearing 30% to 40% of~~f~~ the total cost of cultivation, is usually drained in manual weeding process alone which minimises the net from crop husbandry. The environmental concern of use of herbicides in agriculture is also known to all. With the advancement of time, quick spread of rural education, rise of standard of living and availability of other drudgery free remunerative jobs including 100 days jobs in MGNREGA, man power availability is less during peak hours in agricultural sector. Using this mechanical weeder, simultaneous weeding, thinning line arrangement and soil mulching can be created in broadcast crop. The fine nails pulverizes the soil ~~and~~ thus conservinge~~e~~ soil moisture (5-15% more) and saves the crop f~~or~~rom~~m~~ long drought spells and increases water productivity under limited irrigation. It keeps the soil cooler by 1-5^{0}C and increases soil aeration (Ghorai, et al, 2016-17). Additional components, like scrapper helps to weed out established weeds and tines supplied with it can be used for line making after final soil preparation. In prepared soil the tool is helpful to mix seeds and fertilizer in field for proper germination and better nutrient use efficiency. In jute, it saves up to 100-135 man days/ha depending on weed densities. Reducing manpower requirement in manual weeding, the net return from crop husbandry also increased. Clean environment in crop field keeps the insect and pests at low ebb. It minimises dependenceon manpower requirement. This tool is suitable for operation in all field (cereals, pulses and oilseeds) and horticultural crops (flower, fruits and vegetable Photo 3-8).

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Brief description of the tool: The tool contains the main frame (made of M S angle 25mm x 25mm x 5mm x 307mm long) that holds the nail assembly and wheel assembly, a handle and the fixing bracket - nail assembly (Photo 1). The nail assembly consists of nail assembly fixing bar,

nails, shaft nail assembly, holding bracket nail assembly. The nails are attached to the nail assembly fixing bar by nuts. The nails are uniformly spaced at 30 mm intervals. The retainer nail assembly is attached to the shaft nail assembly at one end and pivoted with the main frame through pivot bracket-retainer. Draw bar handle i.e. handle fixed to the main frame at pivot bracket handle and its height is adjusted with the help of angular-bracket-handle to suit height adjustment as per operators' suitability. The retainer helps to absorb a part of the draft generated at the nails in maintaining stability and rigidity of the nails. The angular orientation of the nails helps it to penetrate easily for desired weed control. Thus the draft requirement of the implement is lesser than prior weeders. Provisions have been made here two attach ii) one scrapper and iii) one tine iv) two conical rotors and v) one boat for its use in upland and in transplanted rice fields. Single wheel "Agricultural weeder with nail assembly" has also been developed to operate it in between very close spaced crops like onion etc (Photo 2). Raw materials required are M.S. angle, M.S. rod, M.S. Tubular pipe, M.S. flat of different dimensions, fixing bolts and nuts etc.

Photo 1. Agricultural weeder with nail assembly, Design registration no. 289754 in class 15-03, dt. 13-09-2019, Patent Office Kolkata, Govt. of India

Time of application, precautions and procedure of use: For composite weed control at emerging stage, the tool with its nails has to be operated with to and fro movement at field capacity stage of soil (5-7 days after emergence of crops). Opening the central nail, the tool can be operated over crop rows (10 cm tall) and the weeds within the rows can be controlled. For

controlling established weeds in between rows the scrapper has to be fitted behind the tool and can be operated ~~since~~ from15 days after sowing on wards. Single wheel arrangement has also been made for weed control in close growing crops (like onion, jute, rice etc), To operate the tool in transplanted rice, the front wheels and the nail assembly should be removed and conical rotors and the boat has to be fitted. This can be operated in transplanted rice field since 15 days after transplanting. For flexibility in use, scrappers, tines, conical rotors and boats can be fitted with the tool using nut and bolts (Ghorai, 2019). Operating the tool at field capacity, keeping 7-10 cm gaps in between two successive runs, simultaneous weeding, thinning, line arrangement and soil mulching is done in broadcast jute, mesta, mustard and, sesamum etc. The "Nail assembly" is used for early weed control and mud stirring in transplanted rice field, fitting it with 3- 4 feet long bamboo/wooden handle.

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Photo 2. Agricultural Weeder with Nail assembly, having single front wheel and addition of conical rotors and boat for operation in transplanted rice (from left).

Photo 3. Simultaneous weeding, thinning, line arrangement, soil aeration and soil mulching in broadcast jute

Photo 4. *Trianthema spp* control at early stage by Agricultural Weeder with Nail assembly.

Photo 5. Weed control **"within rows"** in sunnhemp by Agricultural Weeder with Nail assembly opening its central nail.

RESULTS AND DISCUSSIONS

Weed control by Agricultural weeder with nail assembly

This tool was operated over years in jute and mesta growing states across the country to weed out young composite weed flora including germinating ones mechanically, from line sown and broadcast field (jute, mesta, flax, sunnhemp, cereals, pulses, oilseeds) and horticultural crops (vegetables and flowers etc.) since 5-7 days of crop sowing at field capacity (Photo 3-8, Ghorai *et al*, 2009-2014; Singh, 2014, Singh *et a*l, 2019). In two operations, at 5 days interval since 5 DAE, it requires only 12-18 man days/ha. With the help of this tool, 85 to 90 per cent of composite weeds weeds can be controlled (Ghorai *et al*, 2016, Mandal *et al*, 2018). However, rest 10 - 15 % of the weed flora has to be removed manually. It is cheaper (Rs.15000 to Rs.20000/ha) than conventional manual weeding. Over years this tool produced jute fibre yield upto 45.8 q/ha, upland rice yield upto 45 q/ha and wheat yield yield upto 45 q/ha have been

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recorded over years. It produced higher fibre yield by 10 -20 % over conventional weed control metods (Table 1). This tool recorded higher weed control efficiency (84 per cent), net return (Rs.65615/ha) and B:C ratio (2.07) over conventional manual weeding twice (63.62 per cent, Rs. 56192 and 1.80 respectively) Table 2, Ghorai *et al*, 2016.It minimizes the soil cracks (Photo 6, Ghorai *et al*, 2016-17) in jute field found 4-5 days after sowing and aerates soil by pulverizing it during its operation. Due to low draft (8-15 12 kg only at FC) women, youngsters and aged persons can also operate the tool easily (Photo 7).

Table 1: Effect of different weed management treatments on yield of jute-rice-vegetables/oilseeds/pulses cropping systems (2017-18)

Treatments	Fibre yield (q/ha)	Green gram /carrot yield (q/ha)	Rice yield (q/ha)	Pulses/oil seeds/veg (q/ha/nos./ha)
T1: NJ 7010+TMB 37 (1:1) Pretilachlor 50EC @ 0.9l/ha+1HW -Rice -Bottle gourd	29.46	9.08	31.5	60000/ha
T2: NJ 7010+TMB 37 (Mixed) Pretilachlor 50EC @ 0.9l/ha +1HW -Rice+Pumpkin (Gunny bag columns) +Spinach (Zero till paira)	29.13	7.20	34	100 q+ 40 q
T3: NJ 7010+Sukumar (1:1) Pretilachlor 50EC @ 0.9l/ha+1HW-Rice-Ash gourd (Gunny bag columns)+Khesari (Zero till paira crop)	29.48	7.41	33.33	25000 nos./ha
T4 : Ipfencarbazome@ 68.43 g/ha+1HW-Rice+Bitter gourd (Gunny bag columns)	32.48	-	35.33	12.70 q
T5: Ipfencarbazome@ 91.24 g/ha+1HW- Fenugreek (Zero till paira crop)	35.93	-	35.33	--
T6:Ipfencarbazome@ 114g/ha+1HW-Coriander (Zero till paira crop)	39.73	-	32.33	--
T7: **Agricultural weeder with nail assembly** +1HW –Rice- Bengal gram (Zero till crop)	**39.42**	-	32.67	-
T8: Two manual weedings-Rice-Field pea (Minimum tillage by tines)	**33.03**	**-**	**33.33**	**17.25 q**
T9:NJ 7010+TMB 37 (Relay)-rice-Rice-Lentil (Zero till paira crop)	25.67	-	33.33	8.82 q

T10 : NJ 7010+ Carrot (1:1) 2HW-Rice-Khesari (Zero till paira crop)	24.67	25.0	32.33	16.66 q
T11: Control (no manual weeding)-rice-Mustard (Zero till paira crop)	19.53	-	35	15.91 q
S..Em (±)	1.95	-	1.60	-
C.D. 5%	5.74	-	NS	-

Table 2: Weed control efficiency of Agricultural weeder with nail assembly (pooled) with other weed control processes

Soil water conservation in jute field under limited water supply/ deficit rainfall using "agricultural weeder with nail assembly".

Soil moisture conservation capacity, soil moisture tension, soil temperature, aeration, water

Treatments imposed:	Fibre equivalent yield (inclusive of jute stick and pulse waste) (q/ha)	Weed control efficiency (%)	Net return (Rs./ha)	Benefit cost ratio
1.Jute (30 cm) + PM-4 + Butachlor 50 EC @1kg /ha +1HW	49.51	71.61	90401	2.25
2. Jute (35 cm) + PM-5 + Butachlor 50 EC @1kg /ha +1HW	48.08	68.04	86814	2.23
3. Jute (30 cm) + Sukumar + Butachlor 50 EC @1kg /ha +1HW	47.07	82.19	840273	2.19
4. Jute (25cm) + RMG-62, Butachlor @50 EC 1kg /ha +1HW	52.64	69.27	102213	2.46
5. **Jute (25 cm)+ Agricultural weeder with nail assembly (5- 21 DAS) on broadcast jute for simultaneous weed control, line arrangement and soil mulching +1HW**	**39.15**	**84.33**	**65615**	**2.07**
6. Open furrow (25cm) sowing of jute+Butachlor 50 EC @1kg +1HW	35.89	57.19	52422	1.83
7. Butachlor 50 EC @1kg /ha + Glyphosate 0.8 kg SL/ha at 21 DAS +1HW (25 cm)	37.66	82.19	62742	2.06
8. Two manual weeding in jute (25 cm), 15 and 21 DAS	**38.97**	**63.62**	**56192**	**1.80**
9. Jute + Okra (cv. Shakti) [(2:1, 25 cm, okra sown 3rd week of Nov). Jute sown on 22nd March +2HW	56.70	81.93	105766	2.31
10. Unweeded control (25 cm)	13.02	0	-19453	0.69
11. Glyphosate 1.23 l SL/ha by CRIJAF herbicide applicator at 20 DAS +1HW (25 cm)	40.79	81.93	75464	2.28
C.D. (5%)	2.10	15.25	11873	0.262

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productivity and jute fibre production under limited irrigation/deficit rainfall over long term

average (40 per cent from 15th March to 15th June) were determined through field experiments at ICAR-CRIJAF and Amadalavalasa, AP (2008-2016). The results were validated in large scale in farmers' field and ICAR-CRIJAF, till 2021. Operation of agricultural weeder with nail assembly in jute at 4-6 days after emergence controlled germinating weeds, created soil mulch pulverizing the top soil (4-5 cm), increased soil aeration [ODR: Oxygen diffusion rate, 303 µg O_2 m^{-2} sec^{-1} under soil mulch over only 140 µg O_2 m^{-2} sec^{-1} in non-mulch soil, Chakraborty *et al*, 2021), minimised soil cracks those developed at early stages (Photo 6), maintained low soil moisture tension (Fig 1, Ghorai*et al*, 2014-15.), 4-15 per cent more soil moisture in different situations over no nail plots and kept the soil cooler (by 1-5 degree Celsius) at 5 to 10 cm soil depth. In 2016-17, the crop did not receive any rain till 30 days following its sowing with a pre-sowing irrigation. Weed free environment, better hydro thermal regime of soil and good aeration helped the young jute seedlings to escape early drought stress. This environment produced active, taller (23 cm) and deep rooted jute plants over stunted and lanky jute seedlings (11 cm) with shallow roots under prolonged drought (Photo 6). It saves one irrigation by maintaining better soil moisture through soil mulching.

Comment [9]: Results indicate that use of Weeders led to ……. possibly due to increased soil pulverization and increased soil aeration (Chakraborty, 2021)

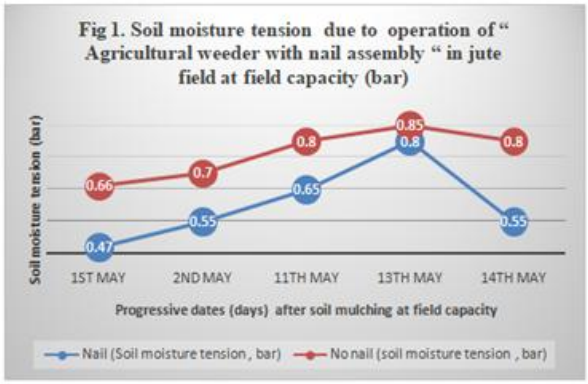

Photo 6. Soil crack reduction and moisture conservation in jute field by Agricultural Weeder with Nail assembly

Showing huge soil cracks in broadcast jute, a usual source of fast water loss from jute field in summer.

Soil mulch in broadcast jute and its line arrangement by Agricultural Weeder with Nail assembly at 5 DAE (no soil crack and thus maintains more moisture)

Soil mulching by Agricultural Weeder with Nail assembly (5 & 8 DAE) maintained 5-6% more moisture, kept the soil cooler (by 1-3 degree Celsius) at 5 to 10 cm soil depth and helped the jute seedling to escape early drought stress (No rain till 30 days after sowing), Ghorai et al, CRIJAF annual report, 2016-17, pp 27-28).

A. Irrigation methods and soil water conservation practices for jute: In the year 2014-15, the rainfall deficit from 15th March to 15th June was 40 per cent over long term average, which primarily helps in initial establishment of jute crop. One irrigation in flat bed method of sowing at recommended fertilizer dose (RDF: N:P:K::60:30:30), could produced 25.6 q jute fibre /ha. At RDF and one flood irrigation followed by soil mulching (at field capacity) by CRIJAF nail weeder produced 28 q jute fibre /ha and is 2.35 over traditional flood irrigation system. Soil mulching by nail weeder maintained 4-5 per cent more soil moisture over no nail plots and maintained lower soil moisture tension before drying the soil. The water productivity and rain water use efficiency of Agricultural weeder with nail assembly operated plots was higher (1942 lit water/kg fibre, 2.598Kg fibre/ha/mm**)** over no nailed plots (2120 lit water/kg fibre, 2.381Kg fibre/ha/mm**),** ~~Table 3 (Ghorai *et al*., 2014-15)~~.In other year, the said system yielded 34.18 q jute fibre/ha (32.50 q/ha in control) with water productivity of 1284.62 litre water/kg fibre over 1351.5 litre water/kg fibre from no mulch traditional system.~~In roselle similar yield improvement was reported from Amadalavalasa, Andhra Pradesh (Table 4).~~ Framers of jute growing districts could harvest 2-3 q more fibre using this technique under limited irrigation.Under limited moisture supply, it produces 10-20 per cent more fibre yield over conventional practice in different years from 2009-2020.

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Table3 : Yield and water productivity of jute under limited water supply using Agricultural Weeder with Nail assembly

Treatment	Fibre yield (Kg/ha)	Total rain (mm) received in growth period	Irrigation water (mm)applied	Total water received (mm)in growth period	Rain water use efficiency (Kg fibre/ha/mm)	Water productivity (lit water/kg fibre)*
1. Flat bed sowing, N:P:K:: 60:30:30 & one irrigation	**25.6**	**1027**	**50**	**1077**	**2.381**	**2120**
2. Flat bed sowing, N:P:K:: 80:40:40 & one irrigation	28.0	1027	50	1077	2.599	1941
3. **Flat bed sowing, N:P:K:: 60:30:30 & one irrigation &Agricultural Weeder with Nail assembly at 5 DAE**	**28.0**	**1027**	**50**	**1077**	**2.598**	**1942**
4. Flat bed sowing, N:P:K:: 80:40:40, one irrigation & nail weeder at 5 DAE	28.5	1027	50	1077	2.649	1905
5. Open furrow sowing, N:P:K:: 60:30:30 &oneirrigation	26.7	1027	30	1057	2.522	**2039**
6. Flat bed sowing, N:P:K:: 60:30:30 &2 irrigations	28.75	1027	100	1127	2.55	1890
7. Flat bed sowing, N:P:K:: 80:40:40 &2 irrigations	27.95	1027	100	1127	2.48	1945
8. . Flat bed sowing, N:P:K:: 60:30:30 & two irrigations & nail weeder twice after each irrigation.	28.87	1027	100	1127	2.56	1883
9. Flat bed sowing, N:P:K:: 60:30:30 &3 irrigations	29.2	1027	150	1172	2.48	1861
10. Flat bed sowing, N:P:K:: 60:30:30 & one irrigation and mung waste 2t/ha	28.4	1027	50	1077	2.64	1921
C.D.	NS	-	-	-	SD±	SD±

Table 4: Effect water conservation methods and nutrients on rainfed roselle at Amadalavalasa, AP

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Treatments	Plant height (cm)	Basal diameter (cm)	Fibre Yield (q/ha)
N:P:K levels			
60: 30:30 kg /ha	350	2.06	26.79
60: 30:30: kg /ha+ S 30 kg/ha	371	2.34	29.90
80 : 40:40 kg /ha	366	2.05	27.85
S.Em ±	6.342	0.0734	2.185
CD (5%)	13.165	0.114	4.23
Water conservation methods			
Rainfed Sowing (W1)	355	1.81	26.33
Sowing in furrow (W2)	359	2.10	27.85
Rainfed Sowing + Soil mulch with Agricultural Weeder with Nail assembly(W3)	373	2.54	**30.36**
CD (5%)	16.083	0.202	**6.37**
Interaction			
S.Em ±	12.34	0.1454	**4.8065**
CD (5%)	**25.857**	**0.331**	**9.237**

Technology spread (area covered/no. of benefited farmers/name of the scheme through which it has been spread etc.)

This eco-friendly weed control tool is operating in different jute and mesta growing states of the country in different field and horticultural crops (jute, mesta, sunnhemp, upland rice, different pulses, oil seed and other horticultural crops). During 2017-2020 total area covered is around 20000 ha and around 1 lakh farmers got benefit through spread of this technology under NFSM (commercial crops), Dep't ,of Agril, Govt. of WB, ICAR-CRIJAF, DAC&FW, Ministry of Ag. & FW and ICARE, Min. Of Textiles Govt. Of India, AINPJAF etc. Till now around 55000 numbers of "Agricultural Weeder with Nail assembly" have been distributed to the jute farmers of West Bengal byDep't. of Agril. Govt. of WB. It reduced the cost of weeding up to 90% (Rs.15000 to 20000/ha). In transplanted rice it saves 30 man days/ha. It saves one irrigation by maintaining better soil moisture through soil mulching.

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Feedback from farmers in detail:

Framers' are using this low draft (12-15 kg) weed control tool round the years for different crops in their crop husbandry. It is used by youngsters, women (Photo 7) and aged persons also for its low energy requirement It reduced the cost of weeding up to 90% (Rs.15000 to 20000/ha). It saves 60-90 man days /ha in farmer's fieldover manual weeding process. In transplanted rice it saves 30 man days/ha.The tool controlled composite weed flora (grass, broad leaves and. *Cyperus* spp.) in jute, mesta, sunnhemp, upland rice, different pulses, oil seed and other horticultural crops (Photo 8a to 8f). It saves one irrigation by maintaining better soil moisture through soil mulching. Farmers' have been able to avoid herbicide to control weeds using this tool. It has reduced dependence on manpower during critical hours of weeding and increased self-reliance in crop weed management. Under limited irrigation/rain fed/deficit rainfall situation (45-50%) it improves jute fibre yield up to 12%. It pulverizes the soil well and

promotes aeration in soil for quick seedling establishment. It produced 33 to 40 quintal jute fibre/ ha, 4.5 to 5 tonnes of upland and transplanted land rice, 3.0 to 4.5 tonnes of wheat and 15 q mustard/ha under farmers field and at ICAR-CRIJAF in different years.

CONCLUSION:

The tool has been largely adopted by the farmers for weed control across the jute growing states of the country in different field and horticultural crops. Till date nearly 55000 pieces has already been sold for its distribution by Govt. of WB, Deptt. of Agriculture, NFSM-CC (Jute) . It reduces the weeding cost by 85-90% (by Rs.15000 to 20000/ha), saves 60-90 mandays per ha. The tool has reduced the age old drudgery of weed management operation due to its low draft (12-15 Kgs). Addition of a boat replacing its front wheels and two conical rotors in the main frame of the tool, make it suitable to control weeeds in transplated rice field also.It has minimized the dependency on manual l~~o~~abour and chemical herbicides and thus is an eco-friendly tool. Youngsters, ladies and aged persons can easily operate the tool. It reduces poverty of resource poor farmers by reducing cost of cultivation and improving crop yield. Increases crop yield under limited irrigation/deficit rainfall condition.

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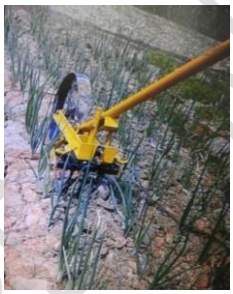
Photo 7. Women working with Agricultural Weeder with Nail assembly in jute and mustard

Photo 8. Agricultural Weeder with Nail assembly in other field and horticultural crops

a) Mechanical weeding in upland direct seeded rice (DSR) and transplanted rice

b) Mechanical weeding in wheat



c) Onion

d) Chilli

e) Bengal gram (Chick pea)

f) Coverage of Agricultural Weeder with Nail assembly in farmers field by Bengali leading newspaper "Ananda Bazar Patrika"

~~Commercialisation~~Commercialization of the tool by MOU with ICAR-CRIJAF: i) M/s. Krishi Udyog, Samabaya Pally, Bally, Howrah, W.B. Pin-711205, 2014. Mob: 9432580161.

Email: krishiudyog100@gmail.com. ii) M/s. Creative Displayers, 55(26) S.N. Banerjee Road, Barrackpore, W.B. Pin-700120, Mob: 9830543631.email: sanjib_b2@yahoo.com

REFERENCES:

1.Chakraborty, A.K. D. Datta, S.P. Mazumdar, A.K. Ghorai, N.M. Alam and R.K. De (2021).Improvement in Hydrothermal Regime and Soil Aeration in Jute Field under Temporary Drought Condition. *Jaf News.* **19** (1) 3.

2.Bikas Mandal and Dhiman Mukherjee (2018). Influenced of different Weed Management Practices for Higher Productivity of Jute (Corchorus olitorius) in West Bengal. : *IJBS*: **5**(1): 21-26.

3.Ghorai, A.K., D.K. Kundu and D. Barman (2016-17).Irrigation methods and soil water conservation practices for improving water productivity in jute. CRIJAF Annual Report (TMJ MM 5.0) 2016-17. pp 27-28

4.Ghorai, A.K. (2014-15).Irrigation methods and soil water conservation practices for improving water productivity in jute. CRIJAF Annual Report(TMJ MM 5.0) 2014-15. pp 33

5.Ghorai, A.K**;** Mukesh Kumar and C.S. Kar (2016).Intercropping in jute with green gram for weed smothering. **Ind.J. weed sci**. **48**(3): 343–344

6.Ghorai, A.K. (2019). CRIJAF Jute-Paddy Weeder for Weeding in Both Jute and Paddy. *Jaf News* **17(**1):19-20

7 Ghorai,A.K.; Mukesh Kumar, Jha,S.K., Shamna A; Jagannadham, G; Amarjyoti,P. and Subhasish Paul (2014). Cost effective methods for weed management in jute (*Corchorus spp*) and mesta (*Hibiscus spp*) (2014).. Paper presented in "International conference on natural fibres", held in Kolkata, WB, and India from 1-3rd Aug.2104. pp 109

8.Ghorai, A.K.; Saha, S.; Saren, B.K; P.K. Hembram; B.K. Mandal; J.G. Thokle; S.R. More, T.Srilata, G.Jagannadham, M.K. Tripathi Shailesh Kumar, D.K. Kundu and B.S. Mahapatra (2013). Drought Management of jute and mesta crop under deficit rainfall. Technical bulletin No.5/2013. PP 67

9. Ghorai, A.K., G. Jagannadham, S.R. More,D.K. Kundu and B.S. Mahapatra (2012). Drought management in jute (*corchorus olitorius*) and mesta (H*ibiscus spp*) under changing climate. In proceeding of National seminar on Indian Agriculture: "Preparedness for climate change**"** IARI New Delhi (24-25 March' 2012). ISAS-II-22, pp-84-86.

10.Ghorai,A.K., Chowdhury , H , R.K. De and B.S. Mahapatra (2010). Mechanised weed management in jute. *Jaf News* **8**(1)20-21.

11.Ghorai, A.K., H.K. Choudhury, R.K. De and B.S. Mahapatra (2009). Integrated weed management of jute and mesta. Proceed. National symposium on weed threat to environment environment, biodiversity and agricultural productivity, held at TNAU, Coimbatore (Tamil Nadu), August 2-3 pp.151.

12. Shailesh Kumar, Shamna A, S.K. Jha and A.K. Ghorai (2015). CRIJAF Nail weeder an Innovative tool for weed management. Presented in 25th Asian–Pacific Weed Science Conference, Held at Hyderabad, India, from 12-16th Oct. PP-85

13. Singh Rameswar (2014). Manually operated Nail Weeder, in book:AgriculturalEngineering II. Agricultural technologies. Pp- 17 .www.icar.org.in, ICAR New Delhi.

14. Singh, A.K.; S.K. Jha, B.Majumdar, M.L Roy, S. Sarkar and A.K. Ghorai (2019). Impacts of climate smart jute farming on resource use efficiency, productivity and economic benefits in rural Eastern India.*Outlook in agriculture*.**48** (1)75-82.