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# Brown manuring: Effect on agroecosystem

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**Abstract**
The efficient nutrient management is crucial to achieve crop yield sustainability. Organic manures can play in important role in achieving sustainability. But these manures are bulky in nature and low in nutrient content, hence the replacement is highly required. Green manure, another possible option of providing nutrients to crops from organic sources, but it has got many limitations as it requires crop cycle of about 45-60 days from sowing to breakdown with suitable temperature and optimal moistness after incorporation. The only option available is brown manuring which can of supply almost all nutrients to the crops which are considered advantageous for weed management as well as improving soil properties which ultimately leads to increase crop yield by influencing over all Agroecosystem. Brown manuring combining with pre-emergence herbicide(s) significantly improves the soil physico-chemical properties, growth and ultimate yield of crops, weed control efficiency, nutrient use efficiency and the net return with B:C ratio. Impact of Brown manuring on Agroecosystem is reviewed in the present study.

**Keywords:** Agroecosystem, brown manuring, net returns, nutrient and weed management, soil health and yield sustainability

## Introduction
Climate is changing, all cropping regions are affecting and farmers are seeking to make the most use of the rain that falls. Soils and cropping are suffering similarly as becoming more intense to meet world food needs and falling profit margins, leading to declining soil structure and in some cases lower soil carbon levels (Chan *et al.*, 2003) [3]. Charges of fuel, herbicides, fungicides, and fertilizers are increasing although revenues from crops are rising slowly, leading to poor returns per unit input and poorer profit margins (Hogan and Morris, 2010) [6]. The use of green and brown manure crops to break pest cycles and improve nutrition is less well documented and has not received comprehensive recent reviews as compare to the break crops (Roper *et al.*, 2012) [17]. Brown manuring is a technique to grow extra crop in standing field crop and kill them with the help of herbicide for us its residue as a manuring. After killing extra crop the color of residue become brown so it called brown manuring. Brown manuring is a 'no-till' version of green manuring, using a non-selective herbicide to desiccate the crop (and weeds) at flowering stage instead of using cultivation to remove it (Preston, 2019) [15]. A follow-up herbicide treatment may be required to control survivors. The plant residues are left standing, helping to retain surface cover and soil structure alongside increasing soil organic matter.

## Concept of brown Manuring


In mulching; option of brown manuring, crop or pasture is mowed, slashed or cut with a knife roller and left on the soil surface which reduces soil evaporation. Mulched residues break down more rapidly than for normal brown manuring because of the increased contact with soil and smaller pieces (Edwards, 2020) [5]. India has enough potential of organic wastes which can be converted into composts and organic manures and used in crop fields. But the huge quantity of organic waste is not properly and scientifically converted into composts and lost by various means. Besides, carrying cost of the low-value bulky organic manures is also expensive. The option like green manuring may be tried to add organic manure in soil, it needs some time to decompose after incorporation into the soil.

The decomposition process in green manuring require high temperature and adequate moisture which may not be affable all over the year in the country. Therefore, brown manuring can be a viable option which is free from these limitations (Maitra and Zaman, 2017) [10]. To evaluate brown manuring for profitability and sustainability, we discussed benefits of brown manuring and then deliberate the need to integrate these practices into Agroecosystem.

**Table 1:** Difference between Green manuring and Brown manuring

| Green manuring | Brown manuring |
|---|---|
| It refers to the incorporation of a manure crop by tillage prior to seed set usually around flowering | It is a no till version of green manuring, where herbicides are used to kill the manure crop and weeds |
| Risk of Surface erosion | The plants are left standing, providing protection to lighter soil at risk from erosion |
| Moisture is necessary for incorporation and decomposition | Moisture is conserved |
| Microbial population is necessary for decomposition | Chemical desiccation |

**Crops suitable for brown manuring**

**Non leguminous crops**: The non-leguminous crops used as a green manuring crop which provide only organic matter to the soil. These are used to a limited extent. Example: Niger, Wild indigo etc.

**Leguminous crops**: Crops provide nitrogen as well as organic matter to the soils. Legumes can fix atmospheric nitrogen with the help of its nodule bacteria. The legumes are preferably used in green manuring crops Example: Sun hemp, Dhaincha, Mung, Cowpea, Lentil etc.

**Benefits:**

- As most of the Indian farmers are resource poor, this technology can add more benefit with very marginal input cost.
- Brown manuring increases the soil organic carbon content, there by supplying required nitrogen for the crop plants. Thus, a part of nitrogenous fertilizer (up to 25%) can be replaced by brown manuring.
- It also increases the crop yield as shown in our experiments, thereby improving the economic benefits of the farmers.
- It also improves the soil health parameters like organic carbon content and earthworm population of the soil.
- Brown manuring reduces the weed population in the early stage due to its high growth rate and competition with the weeds.

**Effects on Agroecosystem**

Brown manuring affecting all the phases of agriculture starts from soil to crop to yield. Meanwhile little works have been done in this field, this article emphasis to address the potential of brown manuring on soil health, in maximizing yield, controlling weeds, nutrient use efficiency and over all economics based on a reasoned analysis of the literature on this subject published along with a highlight on the benefits of brown manuring.

**Effects of brown manuring on physico-chemical properties of soil**

Brown manuring has its waves on soil physico-chemical properties. Zero tillage with Sesbania as brown manuring in rice significantly increases organic carbon (0.55%), hydraulic conductivity and decreases the bulk density (Singh *et al*, 2009) [27]. This was due to rice, wheat residue and brown manuring effect of sesbania on soil properties. Sesbenia seed sown @ 25 kg/ha and after 35 days sowing, foliar application of 2,4-D (sodium salt) @ 625 g in 500 liter of water sprayed on the crop (Singh *et al*, 2009) [27]. The soil organic carbon was increased by 0.03-0.05 per cent due to brown manuring (Khan, 2013) [7]. The highest concentrations of total N, soil organic carbon, porosity, soil organic matter, soil microbial biomass carbon, and soil microbial biomass nitrogen were recorded with direct seeded aerobic rice + sesbania brown manuring no tilled wheat and also lowest soil bulk density and total soil porosity at 0-5 cm depth were recorded with the same treatment (Nawaz *et al*., 2016) [13]. Indeed, sesbania is a fast-growing and high biomass producing legume crop, which can fix a large amount of atmospheric nitrogen into plant usable form (Kwesiga *et al*., 1999 and Orwa *et al*., 2009) [9, 14]. Samant (2017) [18] revealed that the improved practice of brown manuring recorded 0.14% and 13.4% higher increased in soil organic carbon and available nitrogen respectively. The organic carbon status of the soil (Table 2) increased after the harvest of rice at the end of each year. The brown manure practice contributed to an increase of 0.14% organic carbon content after the harvest of rice.

**Table 2:** Effect of Brown manuring on soil organic carbon and post-harvest available Nitrogen (Samant, 2017) [18].

| Year | Initial organic carbon content of soil (%) | Organic carbon content after harvest (%) | % of increase in organic carbon | Initial soil available nitrogen content (kg/ha) | Soil available nitrogen content after harvest(kg/ha) | % of increase in soil available nitrogen content |
|---|---|---|---|---|---|---|
| 2014 | 0.54 | 0.69 | 0.15 | 283.0 | 320.2 | 13.1 |
| 2015 | 0.58 | 0.71 | 0.13 | 285.38 | 324.6 | 13.7 |
| Mean | 0.56 | 0.70 | 0.14 | 284.19 | 322.4 | 13.4 |

**Effects of brown manuring on growth and yield of crops**

Aslam *et al.* (2008) [2] revealed that paddy yield with direct seeding and brown manuring (4.23 t/ha) was significantly higher than direct seeding without brown manuring (3.36 t/ha). Sharma *et al.* (2008) [22] narrated that direct seeding with Sesbania spp. co-culture as a brown manuring yielded (3.65 t/ha) which was at par, compared to conventional transplanting (3.69 t/ha) and significantly higher than direct seeding without brown manuring (3.24 t/ha). Gill and Walia (2014) found that Grain yield of direct seeded rice with brown manuring Sesbania was statistically at par with conventional transplanting of rice. Brown manuring practice is introduced in the fields where Sesbania spp. @ 20 kg/ha is broadcast three days after rice sowing and allowed to grow for 30 days and was dried by spraying 2,4-D ethyl easter which supplied up to 35 kg/ha N, dry matter and higher yield by 4-5 q/ha due

to addition of organic matter in low fertile soils (Sharma, 2014 and Singh, 2014) [21, 23, 24]. Sarangi *et al*. (2016) [19] conducted an experiment to study effects of replacing 25% of nitrogenous fertilizer by brown manuring in direct seeded rice and observed that the plant height (1.57%), effective tiller number (9.09%), organic carbon content (13.04%) and grain yield (7.91%) were increased in the brown manuring plots as compared to farmers practice. Samant (2017) [18] found that the improved practice of brown manuring in direct seeded rice recorded higher plant height (89.97 cm), tiller/plant and grain yield of 30.2 q/ha which was 16.15% higher than that of farmers practice (Table 3). The improved practice also produced higher straw yield 33.59 q/ha and harvest index (47.34%).

**Table 3:** Effect of brown manuring on yield (Samant, 2017) [18].

| Year | Yield (q ha$^{-1}$) | | Straw (q ha$^{-1}$) | | Harvest index (%) | | % of increase in grain yield over local check |
|---|---|---|---|---|---|---|---|
| | IP | FP | IP | FP | IP | FP | |
| 2014 | 31.8 | 27.3 | 34.0 | 28.7 | 48.33 | 48.75 | 16.48 |
| 2015 | 28.6 | 24.7 | 33.18 | 29.4 | 46.29 | 45.66 | 15.78 |
| Mean | 30.2 | 26.0 | 33.59 | 29.05 | 47.34 | 47.23 | 16.15 |

IP: Improved technology (Brown manuring); FP: Farmer's practice (Indiscriminate use of chemical fertilisers)

**Effects of brown manuring on weed density**

Maity and Mukherjee (2011) [12] conducted an experiment on effect of brown manuring on direct seeded kharif rice and they indicated that among the herbicides + cultural methods of weed control, combination of butachlor + brown manuring + 2,4-D application at 40 DAS recorded lowest weed dry weight at 60 DAS leading to highest value of weed control efficiency of 86.0% in 2006 and 88.15% in 2007 at 60 DAS. Butachlor + brown manuring+2,4-D was able to reduce weed pressure as brown manuring acted as a cover crop in suppressing weed growth effectively at the initial growth stage. Angadi *et al.* (1993) [1], Sharma and Ghosh (2000) [20] and Yadav (2004) [26] also reported similar results. Brown manuring helps smothering weeds (Gaire *et al.*, 2013). A lower broad-leaved weed density and dry weight were observed with Sesbania spp. and other brown manuring species than the surface mulch. Intercropping of brown manuring crops with rice reduced weed densities by about 40-50 per cent (Rehman *et al*., 2007). Singh *et al*. (2007) reported that application of wheat residue mulch at 4 t/ha and Sesbania intercropping for 30 days were equally effective in controlling weeds in dry-seeded rice. Dubey, 2014 [4] evolved that application of butachlor and brown manuring was able to reduce weed pressure, as brown manuring acted as a cover crop in suppressing weed growth effectively in rice field. Nawaz *et al*. (2017) [13] evaluate the impact of Sesbania brown manuring in direct-seeded aerobic rice (DSAR) and of rice residue mulch in no-tilled wheat (NTW) on soil health, weed dynamics and system productivity. They detected that Sesbania brown manuring in direct-seeded rice decreased the weed density 41–56%.

Ramachandran *et al.* (2012) [16] concluded that brown manuring helped in suppressing the weeds up to 50% of total weed population on the account of the shade effect of killed manure crop till 45 days after sowing which is considered as the critical period of crop weed competition in *rabi* maize (Table 4). They also observed significantly positive impact of brown manuring on productivity and net return of maize.

**Table 4:** Effect of brown manuring on weed density (Ramachandran *et al*., 2012) [16].

| Treatment | Density of weeds at 60 DAS (no./m$^2$) |
|---|---|
| Mechanical weeding by hand hoe at 20 and 35 DAS | 19.82 |
| PE Alachlor 1 kg ai/ha + mechanical weeding at 35 DAS | 18.48 |
| Intercropping Dhanicha and in situ incorporation at 35 DAS | 25.66 |
| Brown manuring | 25.66 |
| PE Alachlor 1kg ai/ha + Intercropping Dhanicha and in situ incorporation at 35 DAS | 14.19 |
| PE Alachlor 1kg ai/ha + brown manuring | 10.52 |
| Un-weeded check | 101.65 |
| LSD (P=0.05) | 0.054 |

**Effects of brown manuring on nutrient use efficiency**

The practice of brown manuring can replace 25 per cent of nitrogenous fertilizer with the overall soil health (Sarangi *et al.*, 2016) [19]. Growing of direct seeded rice + brown manuring increased the available nitrogen (102 kg/ha), available phosphorus (22.1 kg/ha), available potassium (265.9 kg/ha) in soil compared to transplanted rice (Singh *et al*, 2009) [27]. Sesbania crops were knocked down by herbicide after 30 days when it is tender and succulent so as to get maximum response and makes N available immediately after application. Nutrient use efficiency (NUE) was positively influenced by weed management practices. Among the integrated weed management practices (Table 5), nutrient use efficiency of N (50.00 and 64.67 kg grain yield/kg nutrient applied), P (229.36 and 296.64 kg grain yield/kg nutrient applied) and K (90.36 and 116.87 kg grain yield/kg nutrient applied) was highest under butachlor 1.5 kg/ha + brown manuring + 2,4-D 0.5 kg/ha treated plots during both the years of investigation (Maity and Mukherjee, 2011) [12].

**Table 5:** Effect of treatments on nutrient use efficiency of dry direct seeded kharif rice (Maity and Mukherjee, 2011) [12].

| Treatment | Nutrient use efficiency (kg grain yield/kg nutrient applied) | | | | | |
|---|---|---|---|---|---|---|
| | N | | P | | K | |
| | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 |
| Butachlor + brown manuring+2, 4-D | 50.00 | 64.67 | 229.36 | 296.64 | 90.36 | 116.87 |
| Pretilachlor + brown manuring+2, 4-D | 42.83 | 61.67 | 196.48 | 282.87 | 77.41 | 111.45 |
| Pendimethalin + brown manuring+2, 4-D | 41.83 | 53.17 | 191.90 | 243.88 | 75.60 | 96.08 |
| Benthiocarb + brown manuring + 2, 4-D | 35.83 | 51.83 | 164.37 | 237.77 | 64.76 | 93.67 |
| Butachlor+hoeing+2, 4-D | 35.00 | 53.83 | 160.55 | 246.94 | 63.25 | 97.29 |
| Pretilachlor+hoeing+2, 4-D | 33.67 | 52.50 | 154.43 | 240.83 | 60.84 | 94.88 |
| Pendimethalin+hoeing+2, 4-D | 31.83 | 48.00 | 146.02 | 220.18 | 57.53 | 86.75 |
| Benthiocarb+hoeing+2, 4-D | 31.50 | 46.50 | 144.50 | 213.30 | 56.93 | 84.04 |
| Farmer's practice | 50.50 | 65.00 | 231.65 | 298.17 | 91.27 | 117.47 |
| Complete weed free situation | 52.33 | 66.33 | 240.06 | 304.28 | 94.58 | 119.88 |
| Season long weedy condition | 8.50 | 19.17 | 38.99 | 87.92 | 15.36 | 34.64 |

**Effects of brown manuring on economics of different crops**

The highest net returns (INR 19,029/ ha) and benefit: cost ratio (1.19) was also recorded in same treatment (Kumar and Mukherjee, 2008) [8]. Maity and Mukherjee (2009) [11] evaluated that among the integrated weed management practices butachlor 1.25 kg/ha + brown manuring + 2, 4-D 0.5 kg/ha registered highest net return (21954 and 20494 ₹/ha) as well as benefit: cost ratio (1.30 and 1.22), during both the years. This might be owing to high weed control efficiency with least man days' engagement and higher grain yield. Brown manuring practice recorded the higher gross return of 45146 ₹/ha and profitability (143.66 ₹/ha day) with additional net return of 5271 ₹/ha over farmers practice. Higher B:C ratio (1.47) was found in improved practice due to higher net return as compared to local check (1.31) attributed to more grain production (Samant, 2017) [18]. Nirmala (2012) found that This might be owing to high weed control efficiency with least man days' engagement and higher grain yield. Brown manuring practice recorded the higher gross return over farmers practice. Ramachandran *et al.* (2012) [16] observed that pre emergence application of Alachlor 1 kg ai/ha with brown manuring gave the highest net return of 45,993 ₹/ha and benefit: cost ratio (3.61).

Maity and Mukherjee (2011) [12] determined that among the integrated weed management practices butachlor 1.5 kg/ha + brown manuring + 2, 4 - D 0.5 kg/ha registered highest net return (11889 and 19029 ₹/ha) as well as benefit : cost ratio (0.74 and 1.19) during both the years (Table 6). This might be owing to high weed control efficiency with least man day's engagement and higher grain yield. The lower net return (5738 and 12983 ₹/ha) and benefit : cost ratio (0.26 and 0.58) in farmers' practice might be due to more man days engaged at 15, 30 and 50 DAS and that in turn considerably increased cost of cultivation.

**Table 6:** Effect of treatments on economics of dry direct seeded kharif rice (Maity and Mukherjee, 2011) [12].

| Treatment | Net returns* (₹/ha) | | B:C ratio | |
|---|---|---|---|---|
| | 2006 | 2006 | 2007 | 2007 |
| Butachlor+brown manuring+2, 4-D | 11889 | 19029 | 1.19 | 1.19 |
| Pretilachlor+brown manuring+2, 4-D | 8374 | 17429 | 1.08 | 1.08 |
| Pendimethalin+brown manuring+2, 4-D | 7386 | 12976 | 0.78 | 0.78 |
| Benthiocarb+brown manuring+2, 4-D | 4492 | 12352 | 0.74 | 0.74 |
| Butachlor+hoeing+2, 4-D | 5397 | 14722 | 0.98 | 0.98 |
| Pretilachlor+hoeing+2, 4-D | 4537 | 13902 | 0.91 | 0.91 |
| Pendimethalin+hoeing+2, 4-D | 3254 | 11379 | 0.73 | 0.73 |
| Benthiocarb+hoeing+2, 4-D | 3090 | 10650 | 0.68 | 0.68 |
| Farmer's practice | 5738 | 12983 | 0.58 | 0.58 |
| Complete weed free situation | 2888 | 9898 | 0.38 | 0.38 |
| Season long weedy condition | - 6239 | - 9.00 | 0.00 | 0.00 |
| LSD (P=0.05) | - | - | - | - |
| S. Em± | - | - | - | - |

*Sale price of output (₹/t): Rice grain – 7500, rice straw – 1000; Input price (₹/kg): Rice seed – 10, Seed of *Sesbania rostrate* – 10, Urea – 4.78, SSP – 3.22, MOP – 4.45; Herbicides (₹/l): Butachlor – 180, pretilachlor – 480, pendimethalin – 584, benthiocarb – 384, 2,4-D sodium salt – 220; labour wage – 75.10 ₹/man/day.

**Conclusion**

Brown manuring is a technique where plant material is returned back to the Agroecosystem to recover soil fertility and available nutrients in consort with soil physical and biochemical property and farmer's economics. It also conserves the soil water, reduces the weed and disease problems along with counterbalance of greenhouse gas emissions. As chemical fertilizer cost is increasing progressively; brown manuring is an unconventional approach for higher productivity and thereby more benefits to the farmers. As the brown manuring practice is eco-friendly and improves the overall Agroecosystem it should be widely supported by the extension agencies to realize its benefits for the farming community of the nation.

**References**

1. Angadi VV, Umapathy PN, Nayak GV, Patil VC, Chittapur BM. Integrated weed management in direct seeded rainfed rice of Karnataka. Integrated weed management for sustainable agriculture. Proc. Int. Symp.

by Ind. Soc. Weed Sci., held at Hisar, India, during 18-20 November 1993;3:6-9.
2. Aslam M, Hussain S, Ramzan M, Akhtar M. Effect of different stand establishment techniques on rice yield and its attributes. J. Anim. Plant Sci 2008;18:79-82.
3. Chan KY, Heenan DP, So HB. Sequestration of carbon and changes in soil quality under conservation tillage on light-textured soils in Australia: A review. Aust. J. Exp. Agric 2003;43:325-334.
4. Dubey RP. Integrated weed management - an approach. In: Training Manual Advance Training in Weed Management, held at DWSR, Jabalpur, India 2014, pp. 19-21.
5. Edwards T. Carbon farming: green and brown manuring. Agriculture and Food 2020. Retrieved from: https://www.agric.wa.gov.au/carbon-farming/carbon-farming-green-and-brown-manuring
6. Hogan L, Morris P. Agricultural and food policy choices in Australia. In "Sustainable Agriculture and Food Policy in the 21st Century: Challenges and Solutions". Australian Bureau of Agricultural and Resource EconomicsdBureau of Rural Sciences (ABARE-BRS) Conference Paper 2010, pp. 27.
7. Khan AR. Modern conservation techniques for empowering women: problems andprospects. Lecture delivered during model training course on Gender perspective in Integrated Farming System w.e.f Jan 17-24 at ICAR Research Complex for Eastern Region, Patna, Bihar 2013.
8. Kumar MS, Mukherjee PK. Integrated weed management in dry direct-seeded rainy season rice (*Oryza sativa* L.). Indian J. Agron 2008;53:107-111.
9. Kwesiga FR, Franzel S, Place F, Phiri D, Simwanza CP. *Sesbania sesban* improved fallows in eastern Zambia: Their inception, development and farmer enthusiasm. Agroforestry Systems 1999;47:49-66. DOI: 10.1023/ A:1006256323647.
10. Maitra S, Zaman A. Brown manuring, an effective technique for yield sustainability and weed management of cereal crops: A review. International Journal of Bioresource Science 2017;4:1.
11. Maity SK, Mukherjee PK. Effect of brown manuring on grain yield and partial factor productivity of nutrients in dry direct seeded summer rice (*Oryza sativa* L.) under Teraiagro-ecological region of West Bengal. J. Crop and Weed 2009;5(2):31-35.
12. Maity SK, Mukherjee PK. Effect of Brown Manuring on Grain Yield and Nutrient Use Efficiency in Dry Direct Seeded Kharif Rice (*Oryza sativa* L.). Indian Journal of Weed Science 2011;43(1-2):61-66.
13. Nawaz A, Farooq M, Lal R, Rehman A, Hussain T, Nadeem A, *et al*. Influence of sesbania brown manuring and rice residue mulch on soil health, weeds and system productivity of conservation rice–wheat systems. Land Degrad. Develop 2016. DOI: 10.1002/ldr.2578.
14. Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A. Agroforestry database: A tree reference and selection guide version 4·0. Retrieved from:www.worldagroforestry.org/treedb2/AFTPDFS/Carica_papaya.pdf.
15. Preston A. Integrated weed management workshop handbook 2019. Retrieved from: https://www.lls.nsw.gov.au/__data/assets/pdf_file/0008/1218158/IWM2019-handbook-V4-AP.pdf. pp-36.
16. Ramachandran A, Veeraman A. Effect of brown manuring on weed dynamics, available soil moisture and growth attributes in irrigated maize. Madras Agric. J 2012;100(7):656-659.
17. Roper M, Stephen M, Poole ML. Green and Brown Manures in Dryland Wheat Production Systems in Mediterranean-Type Environments. Advances in Agronomy 2012;117:275-313.
18. Samant TK. A study on effect of brown manuring on growth, yield, economics and soil fertility in direct seeded rice (*Oryza sativa* L.). J. Bio. Innov 2017;6(4):637-643.
19. Sarangi DR, Sahoo TR, Sethy S, Chourasia M, Prasad SM, Mohanta RK. Effect of replacing a part of nitrogenous fertilizer by brown manuring in direct seeded rice. Oryza 2016;53(2):226-228.
20. Sharma AR, Ghosh A. Effect of green manuring with *Sesbania aculeata* and nitrogen fertilization on the performance of direct-seeded flood-prone lowland rice. Nutrient Cycling in Agro-ecosystems 2000;57:141-153.
21. Sharma AR. Weed management in conservation agriculture systems- problems and prospects. National Training on advances in Weed Management 2014, pp. 1-9.
22. Sharma DP, Sharma SK, Joshi PK, Singh S, Singh G. Resource conservation technologies in reclaimed alkali soils. Technical Bulletin 1/2008. Central Soil Salinity Research Institute, Karnal 2008. http://www.cssri.org.
23. Singh GJ, Singh WS. Influence of FYM, Brown Manuring and Nitrogen Levels on Direct Seeded and Transplanted Rice (*Oryza sativa* L.): A Review. Research Journal of Agriculture and Environmental Management 2014;3(9):417-426.
24. Singh R. Weed management in major kharif and rabi crops. National Training on Advances in Weed Management 2014, pp. 31-40.
25. Singh S, Chhokar RS, Gopal R, Kumar V, Singh M. Integrated weed management – a key for success of direct seeded rice in the indo-gangetic plains. Adv Agron 2009;111:297-413.
26. Yadav RL. Enhancing efficiency of fertilizer N use in rice-wheat systems of Indo-Gangetic Plains by intercropping *Sesbania aculeata* in direct seeded upland rice for green manuring. Bioresource Technol 2004;93:213-215. 2.1 Fruit Selection
27. Freshly mature papaya (Vt.Red Lady.) were Collected from the Farm of KVK Mahasamund.