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# Table of Contents, January-March 2022

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# Nutritional and Shelflife of Moi-Moi in Biodegradable Material Treated with Natural Spice (Garlic)

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**ABSTRACT**

Moi-Moi is a steamed gel from cowpea with a short shelf life. This study was based on the use of biodegradable packaging material pre-coated with garlic paste as antimicrobial agents to extend the shelflife of Moi-Moi. The Moi-Moi was prepared from cowpea by steeped method. 50ml paste was dispensed in tin can, steamed in a pressure cooker for 15 min. The Moi-Moi was removed and cooled. Garlic used as antimicrobial agent was cleaned and mashed into paste. The garlic extract 0 g, 40g, and 80 g were applied in a thin layer on saviet (50 $mm^2$), dried(35°C±2) and used as inner lining of the packaging material. The packaged samples were kept on shelf at ambient (33°C±2). The nutrient composition were carried out at 0 and 24h. The shelflife of the products were studied through physical examination and microbial assessment. Some of the nutritional composition of Moi-Moi decreased significantly ($p>0.05$) during the storage between 0 and 24 h. The crude protein 0 g treated sample showed slight increase (9.92 – 10.06 %) while 40 and 80 g treated samples showed decrease from 0 to 24 h.. The colony growth (cfu/g) increased with storage time. The colony count was low in 80g treated sample followed by 40g and control respectively. The physical examination showed that till 72h, the 80g treated sample was found edible considering the characteristics. Beyond 48h, 40g treated sample was not edible while beyond 24h, the control (0g) was not edible. Garlic showed potential to increase shelflife of Moi-Moi but the extension is limited.
**KEYWODS:** Moi-Moi, Shelf-life, Biodegradable material, Garlic, Antimicrobial agent

## 1.0 INTRODUCTION

Moi-Moi or moin-moin is a popular ready to eat steamed gel produced from cowpea paste in Nigeria and West Africa [1]. It is produced by wet milling dehulled beans or cowpea flour and mixed with water, vegetable oil and seasonings into a homogenous slurry or paste, wrapped or packaged in leaf pouches or other packaging materials like aluminum containers and steamed. During steaming, the paste solidifies into irreversible gel between due to hydration of complex carbohydrate, protein gelation and curdling of complex carbohydrate.

However, this freshly prepared Moi-Moi product has short shelf life of about a day at ambient temperature. The perishability could be as a result of high moisture content and nutritional components of Moi-Moi which might have been good source of nutrients to microorganisms that cause spoilage [2]. The current trend of craving for convenient foods that can easily be gotten on shelf in the supermarket necessitate improving on processing and preservation of Moi-Moi for prospective consumers of the product.

In the quest for healthy foods, more and more consumers are shunning foods laden with chemical additives and preservatives in favour of what they perceive to be cleaner and greener foods. It has been reported that chemicals which are used as preservatives have side effects. The reaction of preservatives and packaging materials could be very mild to life-threatening [3,4]. Canning of Moi-Moi has been reported but this is a sophisticated technology of packaging cooked beans in cans. The packaged beans are usually in brine, sugar or tomato purees [2,5]. The technology is considered expensive with standard of living of an average Nigerian.

The prevention of the growth of spoilage microorganisms that is responsible for the deterioration of the product using natural antimicrobial agents has been reported. Studies had confirmed that the growth of both gram-positive and gram-negative food borne bacteria, yeast and mold can be inhibited by garlic, onion, cinnamon, cloves, thyme, sage, and other spices [6,7]

Based on convention, these antimicrobial agents are usually incorporated directly into the food. This method has many disadvantages as a result of concerns about their side effects (safety). Another major reason is that since food spoilage occurs primarily on the surface, incorporation of relatively large quantities of the agents in the bulk

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of the food is not justified and lastly some of the agents posses a distinct flavour that may be rendered to the food flavor when in excess [6].

However, since food spoilage occurs primarily on the surface, packaging materials in which the antimicrobial agent is added as protective barrier or coated on the internal surface of the packaging material can increase the shelf-life of packaged product by extending the lag phase and reducing the growth rate of spoilage microorganisms. The main objective of this research is to improve the shelf life stability of Moi-Moi using biodegradable packaging materials treated with natural spices.

## 2.0 MATERIALS AND METHODS

### 2.1. Materials

Cowpea (a local variety "Kanannado Brown") for the preparation of *Moi-Moi* was obtained from Central market in Gashua, Yobe State. Other materials such as soviet, biodegradable material, garlic vegetable oil (Turley brand$^{TM}$), and pepper were also purchased from Gashua. The reagents for microbial and proximate analysis were analar grade from Microbiology Laboratory, Federal University Gashua.

### 2.2 Design of the experiment

*Moi-Moi* was produced as described by [1] from wet milled cowpea. Garlic used as antimicrobial agent was washed, drained, and mashed into paste. The garlic extract 0 g, 40 g, and 80 g were applied in a thin layer on the saviet (50 mm$^2$), dried in oven at ambient 35°C±2 and used as inner lining of the packaging material to test the potency of the garlic extract against invasion of spoilage microorganisms. The sensory and nutrient evaluation were conducted in 0 and 24 h on the samples. The shelflife of the products were studied through physical observations and microbial assessment.

### 2.3 Preparation of Moi-Moi

Moi-Moi was preparation as described by [8] with little modification in the recipe. Cowpea variety local variety "Kanannado Brown" (500 g) was steeped in water for 5 min and dehulled. Other ingredients: dried pepper (50 g), onion (50 g), salt (2 g) and 100 ml of groundnut oil (Turkey brand$^{TM}$) were cleaned wet milled with the dehulled cowpea to form a smooth paste. The paste is thoroughly mixed for uniformity and 50 ml of the paste were dispensed in tin of the same volume and steamed for 15 min to form pudding. The Moi-Moi was allowed to cool at room temperature before packaging in antimicrobial treated packaging material.

**Preparation of the natural preservatives and packaging material**

The garlic is sorted and the bran was removed manually. A wooden mortar and pestle was used for crushing the garlic into a smooth paste. The extracts was applied in a thin layer on the saviet which was used as inner lining of the packaging material at different levels of concentrations (0 g, 40 g and 80 g to 20 mm$^2$) and dried in oven at 35°C±2. The packaging material without garlic paste coating was used as control. Moi-Moi were packaged and kept on shelf at ambient. The proximate analysis was done at 0 and 24 h, this could not be continued due to spoilage of control sample (0g). Physical examination and microbial analysis were carried out up to 72h when the Moi-Moi still have good sensory quality.

**Nutrient composition of Moi-Moi**

Determination of proximate composition; moisture, crude fat, crude protein, ash and crude fibre were determined using standard methods as described by [9]. The total carbohydrate was obtained by difference.

**Physical examination and microbial analysi**

Changes in physical sensory parameters such as colour, texture, growth were used to monitor rate of spoilage. The microbial profiles of the cowpea product were monitored at every 24 h after production as described by [10]. The microbial analysis i.e total plate and fungi were monitored on daily basis until the products deteriorate. Colony characterisation was done using Macconkey agar, eosyn methyl blue agar, brilliant green agar and potato dextrose gar.

**Statistical analysis**

Data were subjected to variance test at 5% significance 5 % and lack of fit test.

## RESULTS AND DISCUSSION

**Nutrient composition of *Moi-Moi* (bean pudding)**

The results of proximate composition of *Moi-Moi* determined at 0 and 24 hours are provided in Table 1 and 2 respectively. The moisture content of the *MOI-MOI* varied significantly ($p<0.05$) with levels of garlic extracts

substitution. The moisture in 0 g treated Moi-Moi increased from 54.20 - 62.60 % within 24h while other revealed reductions from 55.87 – 54.41 %, and 52.98 – 53.72 % at 40 g and 80 g treatments respectively. The moisture content can be used as a pointer to the rate at which deterioration occurs in *Moi-Moi* samples resulting in the early decomposition. Reduction in moisture from 0 to 24h could be attributed to the absorbent characteristics of packaging material [11]. The recipes for the preparation could cause the variation. High moisture content increases water activity and spoilage of food. The crude protein 0 g treated sample showed slight increase (9.92 – 10.06 %) while 40 and 80 g treated samples revealed steadily decrease from 0 to 24 h. The invasion of microbe might contribute to protein recorded in control (0g). Processing methods and variety of cowpea used might contribute to the variation. The average protein recorded in this research is related to reports of [1,11].
Ash is a representation of general mineral composition of food. Ash increased significantly at 0, 40 and 80 g treatments. The result of the ash content revealed that there was a significant differences at $p<0.05$. These results are in agreement with the findings of [12].
The crude fibre and lipid contents decreased from 0 to 24h of storage for all the levels of treatments. The vegetable oil used in the preparation was high and this reflected in the results. According to [13], the fat content of most legumes ranged from 0.6 to 5.0 %. The reason for variation might be because of method of production and variety of cowpea.

**Table 1: Result of proximate composition in *Moi-Moi* with varying preservative (g/100g) with 12 hours**

| Sample (g) | Moisture, % | Ash, % | Crude fibre, % | Crude protein,% | Crude lipid, % | NFE, % |
|---|---|---|---|---|---|---|
| 0 | 54.20±0.13$^{b}$ | 2.13±0.02$^{b}$ | 1.39±0.01$^{b}$ | 09.92±0.06$^{b}$ | 05.46±0.10$^{a}$ | 26.90±0.12$^{b}$ |
| 40 | 55.87±0.60$^{a}$ | 2.50±0.07$^{a}$ | 1.73±0.14$^{a}$ | 10.82±0.23$^{a}$ | 04.20±0.37$^{b}$ | 24.88±0.97$^{c}$ |
| 80 | 52.98±0.22$^{c}$ | 2.18±0.11$^{b}$ | 1.58±0.13$^{ab}$ | 09.62±0.14$^{c}$ | 04.76±0.52$^{ab}$ | 28.88±0.08$^{a}$ |

Mean ± SD with the same superscript are not significant different (P>0.05)

**Table 2: Result of proximate composition in *Moi-Moi* with varying preservative (g/100g) with 24 hours**

| Sample (g) | Moisture % | Ash, % | Crude fibre, % | Crude protein,% | Crude lipid, % | NFE, % |
|---|---|---|---|---|---|---|
| 0 | 52.60±0.05$^{b}$ | 2.30±0.09$^{b}$ | 1.20±0.01$^{c}$ | 10.06±0.01$^{c}$ | 04.97±0.03$^{a}$ | 23.47±0.07$^{a}$ |
| 40 | 54.41±0.22$^{a}$ | 2.59±0.02$^{a}$ | 1.54±0.04$^{a}$ | 10.56±0.06$^{a}$ | 03.68±0.09$^{c}$ | 27.90±0.28$^{c}$ |
| 80 | 53.72±0.64$^{c}$ | 2.14±0.05$^{b}$ | 1.32±0.02$^{b}$ | 09.31±0.28$^{b}$ | 04.61±0.17$^{b}$ | 28.90±0.82$^{b}$ |

Mean ± SD with the same superscript are not significant different (P>0.05)
Keyword: Nitrogen Free Energy

**Antimicrobial effect of garlic treated packaging material on bacterial growth in moi-moi**
The result of bacterial count in the treated samples at 24 and 48 hours are presented in Table 3. It was observed that sample with 80 g of treatment has the lowest growth compare to 40 g and control (0g). The sample without treatment which serves as the control had the highest growth. Bacterial invasion is responsible for spoilage of food. The analysis was discontinued after 48 h because of deterioration in the control and 40 g treated samples. The observation revealed the higher the treatment, the more the microbial growth retardation. Deterioration of food quality occurs during processing and storage. Spices are recognized to stabilize foods from microbial deterioration [14].

**Table 3: Bacteria colony count at 24 and 4 h of storage**

| Treatments | CFU/g at 24 h | CFU/g at 48 h |
|---|---|---|
| 0g | $2.7 \times 10^{7}$ | $1.25 \times 10^{9}$ |
| 40g | $77.02 \times 10^{3}$ | $2.18 \times 10^{4}$ |
| 80g | $0.15 \times 10^{1}$ | $1.47 \times 10^{2}$ |

The colony characterizations of the samples were conducted. The results for 12 h and 24 h are presented in Table 4 and 5. Staphylococcus specie, E. Coli, and Aspergillus were found in the control (0g) and Staphylococcus specie and Aspergillus were found in 40g treated samples at 12 h of storage on shelf while non was found in 80g.
After storing the sample at room temperature for 24 h, Escherichia coli/ Aspergillus specie was confirmed in 0g. Staplylococuss and Aspergillus were suspected in 40 and 80g has non 24 h. The physical observation during the storage showed that sample treated with 80 g of garlic paste had good appearance without any physical growth and non-slimy for 84 h. The reduction in microbial growth and physical observation has shown that garlic as a spice can elongate the shelflife of Moi-Moi.
From the study findings, garlic was found to be more effective in preventing food spoilage. This is in tandem with findings by [15], garlic was found to exhibit a wide spectrum of antibacterial activity against Gram-negative and

Gram-positive bacteria including species of Escherichia, Salmonella, Staphylococcus, Streptococcus, Klebsiealla, Proteus, Bacillus and Clostridium. All this is due to allicin properties of garlic. The antimicrobial effect of allicin is due to its chemical reaction with thiol groups of various enzymes [15].

**Table: 4: Colonies characterization at 12 hour**

| Sample (g) | MCA | EMB | BGA | PDA | Suspected organism |
|---|---|---|---|---|---|
| **0g** | Non lactose fermenting colonies, opaque with smooth surface and smooth edge. Pink mucoid colonies with rough edge | Green metallic sheen | Pink smooth colonies | Greenish hairy colonies with branches | Staphylococcus specie/Aspergillus specie/E. coli |
| **40g** | Non lactose fermenting colonies, opaque with smooth surface and smooth edge | No growth observed | No growth observed | Black hairy-like colonies with branches | Staphylococcus specie/Aspergillus specie |
| **80g** | Rough edge and surface | No growth observed | No growth observed | No growth observed | Nil |

Keywords: MCA; Macconkey Agar EMB; Eosyn methyl blue agar BGA; Brilliant green agar PDA; Potato dextrose gar

**Table 5: Colonies characterization at 24 hour**

| Sample (g) | MCA | EMB | BGA | PDA | Suspected organism |
|---|---|---|---|---|---|
| **0g** | Pink lactose fermenting colonies, opaque with smooth surface and smooth edge | Green metallic sheen | Deep pink colonies with rough surface and rough edge | Greenish hairy colonies with branches | Escherichia coli specie/Aspergillus specie |
| **40g** | Non lactose fermenting colonies, opaque with smooth surface and smooth edge | No growth observed | No growth observed | Black hairy-like colonies with branches | Staphylococcus specie/Aspergillus specie |
| **80g** | Rough edge and surface | No growth observed | No growth observed | No growth observed | Nil |

Keywords: MCA; Macconkey Agar EMB; Eosyn methyl blue agar BGA; Brilliant green agar PDA; Potato dextrose gar

**Table 6: Physical examination of control (0g) treated packaging material**

**Sample: 0 gram**

| Storage | Appearance | Odor | Texture |
|---|---|---|---|
| **0-24h**<br>**24-48h**<br>**48-72h**<br>**72-96h** | Orange yellow and smooth,<br>Slimy with whitish growth<br>Covered with growths and slimy<br>Completely covered with whitish growth | Typical fresh Slightly<br>Repugnant Offensive<br>Offensive | Firm to touch<br>Slightly fresh<br>Marshy<br>Marshy |

**Table 7: Physical examination of 40g treated packaging material**

**Sample: 40gram**

| Storage | Color | Odor | Texture |
|---|---|---|---|
| **0-24h**<br>**24-48h**<br>**48-72h**<br>**72-96h** | Orange yellow and smooth<br>Orange yellow with moisture<br>Covered with growths and slimy<br>Covered with growths and slimy | Typical fresh<br>Slightly fresh<br>Repugnant<br>Offensive | Firm to touch<br>Slightly firm<br>Soft<br>Marshy |

**Table 8: Physical examination of 80g treated packaging material**

| Storage | Appearance | Acceptance | Odor | Texture |
|---|---|---|---|---|
| **0-24h** | Orange yellow and smooth | Edible | Typical fresh | Firm to touch |
| **24-48h** | Orange yellow and smooth | Edible | Typical fresh | Firm to touch |
| **48-72h** | Orange yellow with moisture | Edible | Fresh | Slightly soft |
| **72-96h** | Slightly slimy with completely covered whitish growth | Completely not edible | Repugnant and offensive | Marshy |

The physical examination showed that till 72h, the 80g treated sample was still found edible considering the characteristics. Beyond 48h, 40g treated sample was not edible while beyond 24h, the control (0g) was not edible.

## CONCLUSION

The nutritional and shelflife stability of moi-moi packaged in biodegradable packaging materials was affected by the levels of garlic treatment. The colony growth (cfu/g) increased with storage time. However, the colony count was low in 80g treated sample followed by 40g and control respectively. The physical examination showed that till 72h, the 80g treated sample was still found edible considering the characteristics. Beyond 48h, 40g treated sample was not edible while beyond 24h, the control (0g) was not edible. This research work revealed that the treated biodegradable packaging material had impact on the moi-moi by increasing the shelf life. *Moi-Moi* packaging material treat with 80g can extend the shelflife for more than three days compare to control that could not be edible after 24h.

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# Weed Management in Dry Direct Seeded Rice for Enhancement of Production

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**ABSTRACT**

Dry direct-seeded rice (*Oryza sativa* L.) is an enchanting alternative to transplanted rice, as it saves the peonage of raising seedlings and transplanting, lessening labor and cost of cultivation. As direct-seeded rice stands in the farm for a longer duration than transplanted rice so weed control is one of the major challenges for its success. An field experiment was conducted at Bangladesh Rice Research Institute, Bangladesh during Aus season of 2014, to evaluate effectiveness of different weed management practices; weedy, hand weeding, pre to post and post-emergence herbicides; pretilachlor + pyrazosulfuran ethyl and bispyribac sodium followed by one hand weeding on the performance of dry direct-seeded rice in RCB design with three replications. Results showed that yield and yield attributing parameters and weed dynamics were significantly affected and the trend of higher production influence by weed management practices. Among the weed control practices, *Cyperus difformis* and *Scripus maritimus* were effectively control by pretilachlor + pyrazosulfuran ethyl along with one hand weeding whereas Bispyribac sodium along with one hand weeding effectively control both *Cyperus difformis*, *Scripus maritimus* and also *Echinochloa colonum* in direct dry seeded rice.
**KEY WORDS**: Direct seeding, weed management, hand weeding, weed density, rice.

## INTRODUCTION

Rice (*Oryza sativa* L.) is the key source of food for over half of the world population, especially in Bangladesh. It is the great source to nutritional calories, providing 35-80% of total calorie uptake [1]. Rice production desires to be improved by 50% or more above the present production level to meet up the increasing food demand [2, 3]. More than 20% people of Bangladesh are under poverty line and rice is the main carbohydrate, protein, vitamins and minerals source of their daily diet. In Bangladesh, rice is commonly grown by transplanting seedling into puddle soil. Higher water requirements and increasing labor costs are the major problems of the traditional rice production system. Direct seeded rice cultivation, growing rice without standing water, can be a good-looking alternate. Direct seeding rice avoids the puddling and maintains continuous moist soil conditions and thus reduces the overall water demand for rice culture. Weed infestation continues to be a serious problem in dry seeded rice. Aerobic soil environment and dry-tillage practices, besides alternate wetting and drying situations, are favorable for germination and growth of highly aggressive weeds, which is the reason of grain yield losses of 50–91% [4, 5]. The threat of crop yield failure due to struggle from weeds by direct seeding methods is higher than for transplanted rice because of the deficiency of the size differential among the crop and weeds and the suppressive effect of standing water on weed development at crop establishment [6]. Weeds compete for nutrient, space, sunlight and consume the available moisture with crop plant resulting in crop yield reduction [7, 8]. The common practice of weed control in rice field is hand pulling which makes the practice to be labour intensive and many a times not satisfactorily executed. As a result, yields in farmers' fields are lower than the well managed researchers' fields. However, weed-crop competition is abundant, natural and undesirable in agricultural plant communities. Therefore, the degree of weed control depends on costs or benefits and the resources available. So weed management are component technologies essential to the control of weeds in direct seeding of rice. Herbicides are one of the most important tools for managing weeds in direct seeded rice systems. Herbicides in particular are an important tool of weed management, but hand weeding is either partially or extensively practiced in country. Timely weed control is of vital importance to increase rice productivity [9]. Several pre and post emergence herbicides have been reported to provide a fair degree of weed control in direct seeded rice [10, 11]. Thus, it is crucial to upgrade the direct seeded rice technology along with effective weed management and make it more cost effective, environment and farmer's friendly. Therefore, the present study was undertaken to determine effective weed control management system in direct seeded rice cultivation.

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## MATERIALS AND METHODS

A field experiment was conducted at Bangladesh Rice Research Institute (BRRI), Gazipur field laboratory during Aus season of 2014 to find out an appropriate method of weed management with its impacts on yield of rice. The soil of the experimental site was non-calcareous dark grey flood plain with pH around 6.2 and low in organic matter (1.2%). In direct seeding method, seeds of BRRI dhan43 were sown in line on 22th April, 2014 and line to line distance 20 cm with continuous seeding. The experiment was carried out with four treatments viz. i) Pre to post emergence herbicide followed by one hand weeding, ii) Post-emergence herbicide followed by one hand weeding, iii) Hand weeding at 15, 30 and 40 days after sowing (DAS), and compared with iv) Control (unweeded). The pre to post -emergence herbicide: Pretilachlor + Pyrazosulfuran ethyl @ 800 g/ha applied at 3 days after sowing (DAS) and post-emergence herbicide: Bispyribac sodium @ 150 g/ha applied at 5 DAS with the help of a knapsack sprayer. In herbicide treated plot one hand weeding was done at 25 DAS. The treatments were distributed following RCB design with three replications. The phytotoxicity of the weedicide to rice plants was determined by visual observations (yellowing leaves, burring leaf tips, stunting growth etc). The degree of toxicity on rice plant was measured by the following scale used by [12].
1. No toxicity
2. Slightly toxicity
3. Moderate toxicity
4. Severe toxicity
5. Toxic (plant kill)

The rating of toxicity was done within 7 days after application of herbicides. It was observed three times at 3, 5 and 7 days after application of herbicide and the mean rate was calculated from 10 sample plants of a unit plot.

Data on weed density and dry weight were taken from each plot at 35 DAS. The weeds were identified species-wise. Dry weights of weeds were taken by drying them in electric oven at $60^0$ C for 72 hours followed by weighing by digital balance. Relative weed density (RWD), relative weed biomass (RWB) and weed control efficiency (WCE) of different weed control treatments were calculated with the following formulas [13, 14]:

$$\text{RWD (\%)} = \frac{\text{Density of individual weed species in the community}}{\text{Total density of all weed species in the community}} \times 100$$

$$\text{RWB (\%)} = \frac{\text{Dry weight of a given oven dried weed species}}{\text{Dry weight of all oven dried weed species}} \times 100$$

$$\text{SDR (\%)} = \frac{\text{RWD (\%)} + \text{RWB (\%)}}{2}$$

$$\text{WCE (\%)} = \frac{\text{(Dry weight of weeds in weedy check plots - Dry weight of weeds in treated plots)}}{\text{Dry weight of weeds in weedy check plots}} \times 100$$

Data on panicle no. $m^{-2}$, grains $panicle^{-1}$ and grain yield were collected according to the protocol of [15]. Graphical representation of the data was carried out using MS-Excel. The data was subjected to statistical analyses following [15] using Crop-Stat 7.2 statistical program.

## RESULTS AND DISCUSSION

### Phytotoxicity of herbicides on rice plant

The degree of toxicity of the weedicide to rice plants and the symptoms created on plant are offered in Table 1. It is observed that phytotoxicity symptoms were not more prominent for using pretilachlor + pyrazosulfuran ethyl @ 800 g $ha^{-1}$ and bispyribac sodium @ 150 g $ha^{-1}$. Phytotoxicity of rice plant found by combined herbicide is less which is similar to the findings of [14, 16].

**Table 1. Rating of herbicide toxicity on rice plant under different treatments in Aman**

| Treatments | Rating | Symptom observed in rice field |
|---|---|---|
| **Pretilachlor + pyrazosulfuran ethyl @ 800 g ha$^{-1}$ (280 g a.i. ha$^{-1}$)** | 1.15 | No toxicity |
| **Bispyribac sodium @ 150 g ha$^{-1}$ (30 g a.i. ha$^{-1}$)** | 1.14 | No toxicity |

### Weed infestation

Experimental field was infested with different types of weeds. The relative density of these weed species was also dissimilar (Table 2). Different weed species were observed in control (unweeded) plot where most dominating weeds were sedges and grassess. Among the weed species maximum relative weed density (RWD) was observed for *Echinochloa colonum* (31.60%), *Scripus maritimus* (30.83%) and *Cyperus difformis* (28.72%), respectively. Higher weed biomass (RWB) was observed for *Echinochloa colonum* (36.50%), *Scripus maritimus* (28.91%) and *Cyperus difformis* (26.63%), respectively. So grass and sedge weeds are dominant in dry direct rice cultivation which is similar to the findings of [17, 18].

**Table 2: Weed composition, Relative density (RWD), Biomass (RWB) and Summed dominance ratio (SDR) in the untreated control plots**

| Name of Weed Species | Family | Class | RWD (%) | RWB (%) | SDR (%) |
|---|---|---|---|---|---|
| ***Echinochloa colonum*** | Poaceae | Grass | 31.60 | 36.50 | 34.05 |
| ***Cynodon dactylon*** | Poaceae | Grass | 8.19 | 6.73 | 19.96 |
| ***Paspalum comersoni*** | Poaceae | Grass | 12.79 | 9.32 | 11.06 |
| ***Cyperus difformis*** | Cyperaceae | Sedge | 28.72 | 26.63 | 27.67 |
| ***Scripus maritimus*** | Cyperaceae | Sedge | 30.83 | 28.91 | 29.87 |
| ***Fimbristylis miliaceae*** | Cyperaceae | Sedge | 17.42 | 18.79 | 18.10 |
| ***Cyanotis axillaris*** | Commelinaceae | Broad leaf | 19.67 | 18.59 | 19.13 |
| ***Euphorbia hitra*** | Euphorbiaceae | Broad leaf | 10.67 | 12.04 | 11.35 |

### Weed ranking

The summed dominance ratio (SDR) is an important indicator of showing ranking of weeds. Figure 1 represents SDR of infested weeds. The three most dominant weeds at 35 DAS were *Echinochloa colonum* (34.05%), *Scirpus maritimus* (29.87%) and *Cyperus difformis* (27.67%). So broad leaf weeds were less dominant than other weeds.

### Weed control efficiency (WCE)

*Echinochloa colonum* was effectively control by Bispyribac sodium followed by one hand weeding (78.51) whereas Pretilachlor + Pyrazosulfuran ethyl with one hand weeding (71.32). Both herbicide control *Cyperus difformis* effectively (more than 80%). *Scripus maritimus* was control by both herbicides similarly. But herbicides had less effect on *Cynodon dactylon, Euphorbia hitra* and *Cyanotis axillaris*, compared to other weeds. The WCE of hand weeded plots was more than 80%. Hand weeded treatment easily control *Echinochloa colonum*, *Cyperus difformis, Scripus maritimus* and *Fimbristylis miliaceae* (Table 3) which was more effective than herbicide treatment. But three times hand weeding is more laborious and consequently more costly than herbicide application with one hand weeding. However, the highest weed control was given by hand weeding. These findings are in agreement with [19].

**Table 3: Weed control efficiency different herbicides and manual weeding in direct dry seeded rice**

| Name of weeds | $W_1$ | $W_2$ | $W_3$ |
|---|---|---|---|
| ***Echinochloa colonum*** | 71.32 | 78.51 | 82.63 |
| ***Cynodon dactylon*** | 26.51 | 29.63 | 70.27 |
| ***Paspalum comersoni*** | 56.49 | 59.54 | 78.42 |
| ***Cyperus difformis*** | 80.56 | 80.97 | 83.85 |
| ***Scripus maritimus*** | 79.87 | 81.23 | 82.70 |
| ***Fimbristylis miliaceae*** | 74.63 | 72.39 | 80.54 |
| ***Cyanotis axillaris*** | 35.75 | 43.62 | 59.36 |
| ***Euphorbia hitra*** | 25.73 | 32.85 | 79.53 |

$W_1$= Pretilachlor + Pyrazosulfuran ethyl with one hand weeding, $W_2$= Bispyribac sodium with one hand weeding and $W_3$= Hand weeding

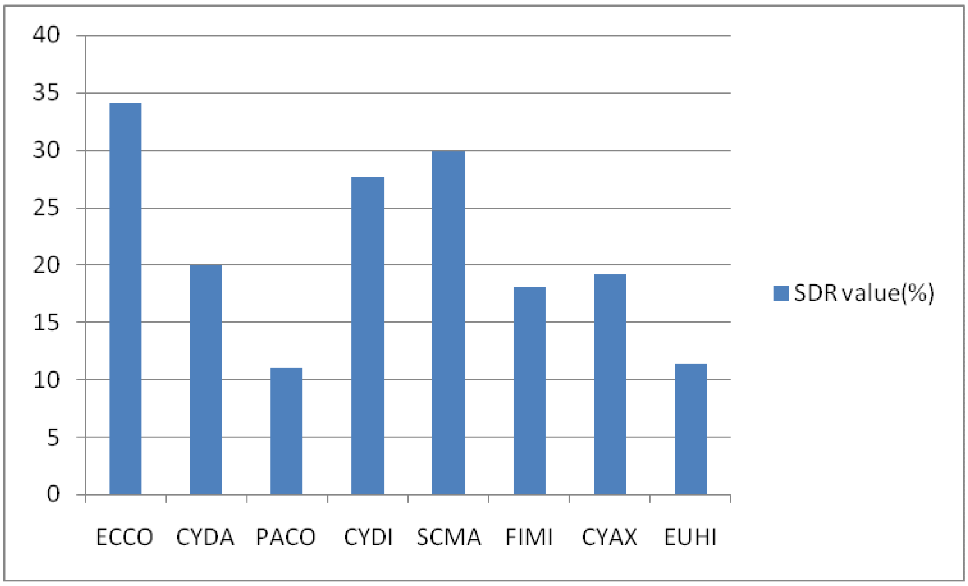


**Figure 1: Summed dominance ratio (SDR) of infesting weeds**

[ECCO= *Echinochloa colonum,* CYDA= *Cynodon dactylon,* PACO= *Paspalum comersoni,* CYDI=*Cyperus difformis,* SCMA=*Scirpus maritimus,* FIMI= *Fimbristylis miliaceae,* CYAX= *Cyanotis axillaris,* EUHI= *Euphorbia hitra*]

**Plant height**

The effect of weed management system on plant height showed that there is no significant effect on plant height irrespective of different days after sowing (Figure 2). Its indicate that weed management system have no significant effect on suppressing plant height although unweeded condition produced little lower plant height than weed free and other weed management systems.

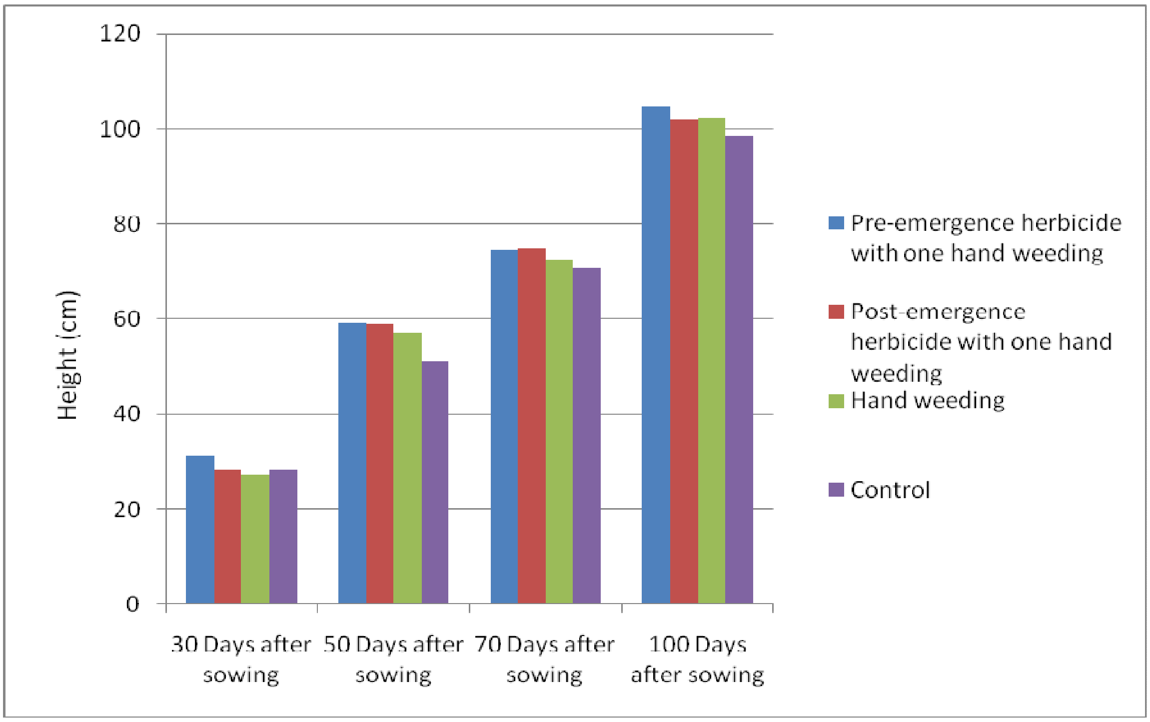


**Figure 2: Plant height at different days after sowing on different weed management system**

**Dry weight**

The effect of weed management system on plant dry weight showed that there is no significant effect on weight irrespective of 30 DAS (Figure 3) but later stage at 50 DAS, 70 DAS and 100 DAS there was significant difference between treated plots and unweeded plot.

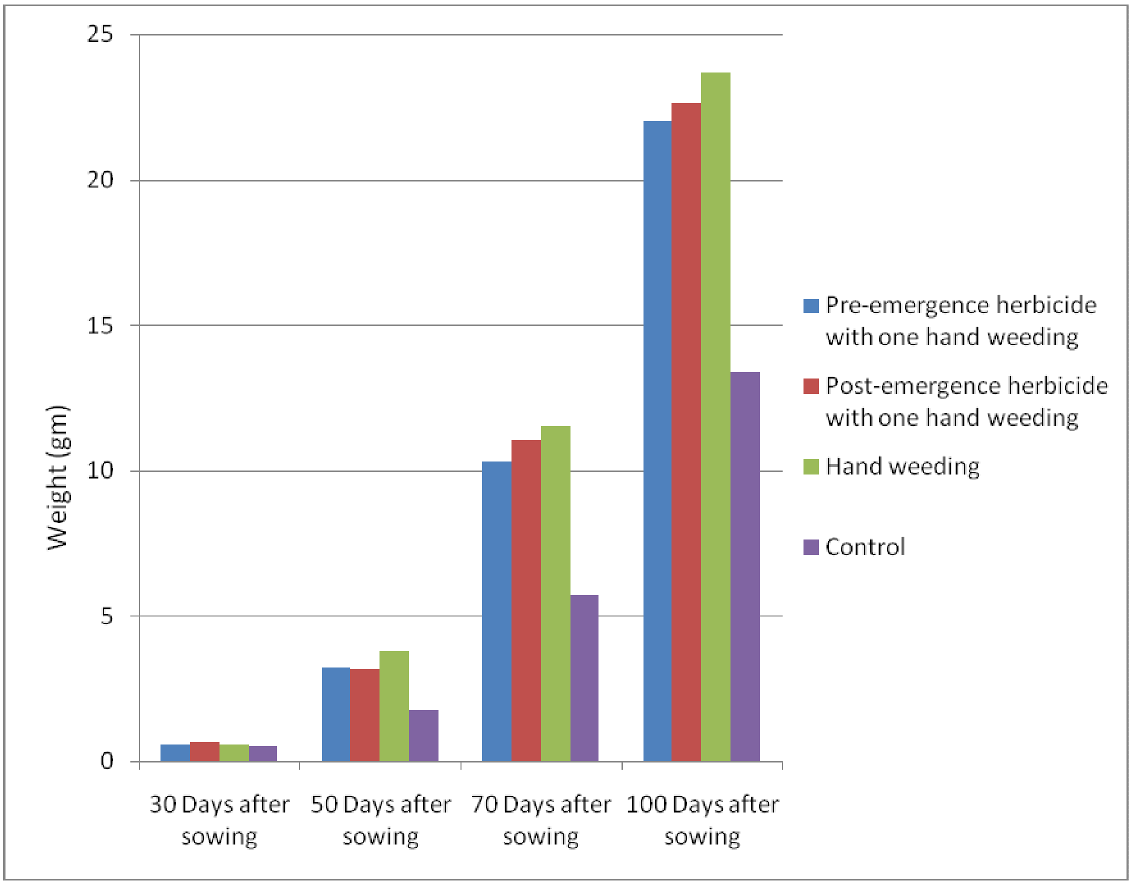


**Figure 3: Dry matter production at different DAS in different weed management system during Aus season, 2014**

**Yield and yield attributes**

Results of yield and yield characters were presented in table 4. Results indicated that the highest panicle $m^{-2}$ was observed in hand weeding treatment. Grains $panicle^{-1}$ was highest in hand weeding treatment irrespective of control treatment followed by pre to post -emergence herbicide with one hand weeding, post-emergence herbicide with one hand weeding and pre-emergence one hand weeding treatment. The minimum number of panicles $m^{-2}$ in the control plot was the result of higher competition for nutrient, air space, light and water between crop plants and weeds, which is similar to the findings of [20]. In this study, the number of panicle $m^{-2}$, number of grains $panicle^{-1}$ were severely reduced by weed competition, similar result finding by and [14]. Competition with weed may reduce the panicle length which indirectly reduced the number of grains $panicle^{-1}$. The variation of grain yield among the treatments was statistically significant, highest grain yield was found in hand weeding treatment over control (unweeded) treatment. Weeds caused severe reductions to yields which were similar to the finding by [21].

**Table 4: Performance of the integrated weed control option for increasing yield of rice**

| Treatments | Panicle $m^{-2}$ | Grains $panicle^{-1}$ | Panicle length | Sterility (%) | Grain yield (t $ha^{-1}$) |
|---|---|---|---|---|---|
| **Pre-emergence herbicide with one hand weeding** | 231 | 71 | 22.86 | 22.47 | 3.01 |
| **Post-emergence herbicide with one hand weeding** | 237 | 69 | 21.37 | 21.37 | 3.07 |
| **Hand weeding** | 237 | 75 | 19.82 | 19.82 | 3.18 |
| **Control** | 143 | 45 | 19.53 | 28.16 | 1.27 |
| **LSD $_{(0.05)}$** | 19.86 | 7.88 | 1.87 | 4.12 | 0.23 |
| **CV (%)** | 4.7 | 6.1 | 4.3 | 9.0 | 4.3 |

## Conclusion

The area under direct-seeded rice systems is expected to increase in the future because of labor and water shortages. Weeds, however, are the major constraints to direct-seeded rice production. To achieve effective, long-term, and sustainable weed control in direct-seeded systems, there is a need to integrate different weed management strategies. Based on the results, yield, yield attributing parameters and weed dynamics were greatly influenced by different weed management practice in higher production and lower weed dynamics in different growing stage of direct-seeded rice. It can be concluded from these studies that in direct dry seeded rice an effective control of weeds and ultimately a higher paddy yield could be achieved with application of pretilachlor + pyrazosulfuran ethyl or bispyribac sodium with hand weeding treatment.

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