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ARTICLE

Effect of Dates and Methods of Sowing with and without Hydropriming on Growth, Phenology and Yield of Sorghum under Semi Arid Conditions of Eritrea

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ABSTRACT

A study was carried out at the research farm of Hamelmalo Agricultural College during summer 2015 to study the effect of dates and methods of sowing with and without hydro-priming on growth, development and yield of sorghum. The experiment consisted of 2 factors- three dates of sowing viz. D0 (Sowing before the onset of first summer rain, June 30), D1 (Sowing with the onset of first summer rains, July 7) and D2 (Sowing after the onset of summer rains, July 14) and three methods of sowing viz. SP (Direct sowing with hydro seed priming), TR (Transplanting) and DS (Direct sowing without hydro seed priming). The experiment was conducted in split plot design with 4 replications by keeping dates of sowing in the main plots and methods of sowing in the sub plots. The data on growth parameters, crop phenology, yield components and yield were recorded. The data were analysed using GENSTAT software and inferences were drawn by using LSD at 5% level of significance. Sowing methods significantly affected leaf area and leaf area index but sowing dates and their interaction with sowing methods did not show significant difference. Stand count, plant height, phenological parameters, thousand grain weight, grain and biomass yield were significantly affected by the sowing dates and methods but no significant difference in their interaction on all the parameters except in stand count and phenological parameters. Sowing before the onset of first summer rains (D0) resulted in significantly highest grain yield. Among the sowing methods, transplanting resulted in significantly higher grain yield seconded by direct sowing with hydro seed priming. Transplanting is less profitable and practicable as it is more laborious and difficult to apply in larger areas.

1. Introduction

Sorghum (*Sorghum bicolor L.*) belonging to the family *Poaceae* is an indigenous crop of Africa and is the most important staple food of many rural communities in the drier regions of Africa and Asia. It is a major source of calories and proteins for millions of people. In Eritrea, it is the main crop for human consumption which is cul-

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tivated in six administrative zones: Gash Barka, Anseba, Debub, Maekel, Northern Red Sea (NRS) and Southern Red Sea (SRS) with a total area of cultivation, production and productivity 224,559 ha, 121,714 tonnes and 0.54 t/ha, respectively in average of three years (2013-2015) [1]. It is used to make human foods like porridge, pop-roasting, traditional flat bread (*Qicha* & *Injera*) and traditional drink (*Siwa*) and a source of raw material for beer industry. It is also used as feed for animals, fuel for cooking, construction material for huts and mats.

The total area for field crops in this sub zone during the year 2013 and 2014 was 9100 ha and 9243 ha, respectively. Out of these a total of 2850 ha in 2013 and 2764 ha in 2014 was occupied by sorghum with an average yield of 1.7 and 4.57 q/ha, respectively [2].

The productivity of sorghum in semi-arid regions of Eritrea is lower than the world. This is attributed to poor crop establishment, low and erratic distribution of rainfall and poor crop management. Among these, crop establishment is often poor in the semi-arid tropics of Eritrea. Adequate crop stand establishment is essential for efficient use of water and light, which is a pre-requisite for success of crop production. Poor seedling establishment or crop stand results in lower yield. In such cases the surface layer of soil dries quickly and temperature rises rapidly. The formation of surface crust and hard layers in the soil surface could form impermeable barriers to shoot emergence and root penetration, respectively. In addition the plant eventually emerges often slowly and becomes highly susceptible to abiotic and biotic stresses [3].

The major reasons for low yield are drought stress, inadequate supply of agricultural inputs, poor soil fertility, lack of improved varieties, high infestation of insect pests and diseases, severe weed infestation including parasitic weed like *Striga* and poor crop management practices. Even though sorghum and pearl millet are drought tolerant crops under semi-arid conditions, the production is most of the time challenged by erratic rainfall pattern often characterized by total failure or delay in the on-set and early cessation of the rain fall during the main rainy season (June-September). It is critical to provide farmers with various techniques to enable them to minimize the risk of losing their harvests so that food security could be achieved [4].

The crop management techniques that help for better crop establishment, higher yield and resistance to biotic and abiotic stress in arid regions of the tropics for sorghum production are seed priming and transplanting which have proved to be better techniques compared to direct sowing without priming [5].

Hydro seed priming was found to improve crop establishment, reduce disease infestation and improve the productivity of the crop compared to non-primed seeds. Studies carried out on hydro seed priming has proved that the seed could germinate early, root and shoot development could start rapidly and grow more vigorously compared to non-primed seeds. Date of sowing is another constraint affecting the production of sorghum. There are farmers in Hamelmalo area who plant their crops before the onset of summer rains whereas others delay the sowing until they receive rainfall 2-3 times which affects the yield of sorghum.

Since it is difficult to decide on the date of sowing based on calendar dates due to erratic rainfall situation and distribution in semi-arid and arid areas, it is better to plant crops based on the number of rains particularly before the start of the rainy season so that the crop could utilise the first flush of rainfall for crop growth and development. According to [6] the preferable sowing time for sorghum varies from the end of June to 2nd week of July, depending on the location, climate and variety. Sowing sorghum during the end of June before the start of rains is preferable because it helps the crop to utilise the first flash of nitrogen and first drop of rainfall for its growth and development. Nitrogen is volatile and leaching takes place in continuous rainfall situation hence the crop will not be able to utilise the available nitrogen if the sowing date is delayed. Therefore keeping in view the above facts in mind the present investigation was carried out to find the effect of Dates and Methods of sowing on growth and yield of sorghum under semiarid conditions of Hamelmalo in Eritrea.

2. Materials and Methods

A field experiment was conducted during summer season of 2015 at the experimental farm of Hamelmalo Agricultural College located at latitude of 15^0 52' 18'' N; longitude of 38^0 27' 55'' E and altitude of 1280 m above mean Sea level in semi-arid conditions. The experiment was conducted in split plot design by assigning three dates of sowings viz before onset of first summer rains (June 30, D0), with the onset of the first summer rains (July 7, D1) and after the onset of the summer rains (July 14, D2) in main plots and three methods of sowing viz direct sowing without hydro-seed priming (DS), direct sowing with hydro-seed priming (SP), and Transplanting(TR) in subplots, each replicated four times. Most farmers of the area plant sorghum with the onset of summer rains (D1) which was kept as a check (control).

Hamelmalo variety of sorghum was sown in the experiment at a row spacing of 75 cm and plant spacing of

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20 cm in a gross plot area of 4.5 m x 3.0 m and net plot area of 3 m x 2 m.

Soil of the experimental field was sandy loam which comprises 59.8% sand, 26.6% silt and 13.6 % clay with pH of 8.28.

The area receives an average annual rain fall of 436.34 mm. During the year of experiment 2015 the area received 264.5 mm of rainfall which was poorly distributed and not sufficient. The crop received 1.2%, 38.4%, 53.3% and 7.% of rainfall in June, July, August and September, respectively.

In direct sowing with hydro seed priming, the seed was soaked in water for 10 hours and dried in shade in the morning hours and then planted immediately into the field. In transplanting the seeds were planted in a nursery bed (2 m x 1.5 m) in three different dates (17, 24 June & 01 July) that matched with the treatments and emerged in four days after sawing. Transplanting was carried out into the main field after the seedlings were grown for 10 days (seedlings with 2-3 leaves). However, in direct sowing without hydro seed priming, the seed was planted directly to the field without soaking it in water as practiced by farmers.

The data were analysed using GENSTAT software for the Analysis of Variance and LSD at 5% was estimated for mean comparison. The correlation analysis was worked out to see the relationship of the agronomic parameters with grain yield, biomass yield and harvest index.

A fertilizer dose of 41 kg N and 46 kg P_2O_5 per hectare was applied through di-ammonium phosphate. The fertilizer P was applied at sowing while N was applied in split with 1/3 dose at sowing and 2/3 at 35DAS. The fertilizer was applied in rows and incorporated to the soil.

The field was hand weeded twice with hand hoe.

2.1 Data Collected

2.1.1 Growth Parameters

The data on growth parameters like stand count, plant height, leaf area and leaf area index were recorded at their maximum values. Leaf area (LA) in m^2 was estimated by L X W x CF where L= length of the leaf, W= maximum width of the leaf and CF= correction factor which is estimated to be 0.75 for sorghum. It was measured on per plant basis manually by measuring the length and width of the leaves. Leaf area index was obtained by dividing the total leaf area of one plant by the land area covered under it.

2.1.2 Development Parameters

The data on crop development like date of heading/flowering and maturity were recorded. Heading date was recorded when 50% of the plants produced heads and the number of days taken from sowing up to heading were counted. Maturity date was recorded when 90% of the plants reached maturity stage and the number of days taken from sowing up to maturity was counted.

2.1.3 Yield and Yield Component

Yield components such as panicle length, panicle weight and thousand grain weight were recorded. The biomass yield, stover yield, grain yield and harvest index were recorded after harvesting and drying of the plot wise produce. Harvest index is expressed in per cent and calculated as HI= GY/BY x 100 where HI= harvest index, BY= biomass yield, GY= grain yield.

3. Results and Discussion

3.1 Effect on Growth

3.1.1 Effect on Stand Count (No./m^2)

There was a significant difference among the different sowing dates, sowing methods and their interaction on stand count of sorghum (Table 1). Sowing after the onset of summer rains resulted in the highest stand count followed by sowing before the onset of summer rains). Transplanting followed by direct sowing with hydro seed priming produced significantly higher stand count.

Direct sowing with hydro seed priming before the onset of summer rains gave the highest stand count followed by direct sowing with the onset of first summer rains. The lowest stand count was obtained with direct sowing without hydro seed priming after the onset of the first summer rains. This can be attributed to saturation of soil with water during 'sowing with the onset of summer rains' which enabled the seeds to get imbibed very fast and germinated sooner than sowing before the onset of summer rains. In sowing before the onset of summer rains (June 30) and Sowing after the onset of summer rains (July 14) the stand count was lower because of erratic and non-consistency nature of the rainfall which reduced the emergence of the crop.

Transplanting showed better stand count followed by direct sowing with hydro seed priming that emerged and established earlier than direct un-primed sown seeds which could be due to the effect of soaking that accelerated enzymatic activity in the seed. While comparing

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direct sowing with hydro seed priming and direct un-primed sowing, the plant population in direct sowing with hydro seed priming showed 10.5% increase compared to direct un-primed sowing.

Table 1. Effect of dates of sowing, methods of sowing and their interaction on growth parameters and phenology of sorghum

Treatment	SC	LA	LAI	PH	HD	MD
Dates of sowing						
D0	105.2	0.105	0.949	141.8	64	85
D1	109.1	0.109	0.980	137.9	66	86
D2	91.1	0.103	0.928	126	72	89
LSD (5%)	12.12	NS	NS	5.53	1.373	1.489
CV (%)	6.9	10.2	10.2	2.3	1.2	1
Methods of sowing						
SP	104.4	0.113	1.013	132.6	69	87
TR	106.4	0.098	0.885	145.9	61	82
DS	94.5	0.107	0.958	127.2	71	91
LSD (5%)	6.5	0.005	0.0488	10.84	1.098	0.705
CV (%)	6.9	10.2	10.2	2.3	1.2	1
Dates of sowing x Methods of sowing						
D0SP	111.5	0.113	1.021	143	64	85
D0TR	106.7	0.097	0.875	143.4	60	82
D0DS	97.2	0.106	0.950	139.1	68	87
D1SP	109.7	0.117	1.056	134.7	67	87
D1TR	109	0.099	0.891	152.5	62	80
D1DS	108.5	0.110	0.992	126.4	69	91
D2SP	92	0.107	0.964	120.1	76	90
D2TR	103.5	0.099	0.888	141.9	61	85
D2DS	77.7	0.104	0.932	116.1	77	92
LSD (5%)	14.03	NS	NS	NS	1.922	1.657
CV (%)	7.4	6	6	9.3	1.9	1
Grand Mean	101.8	0.106	0.9521	135.2	67	87

Note: D0- sowing before onset of summer rains; D1- Sowing with the onset of first summer rains; D2- Sowing after the onset of first summer rains; SP= direct sowing with Hydro seed priming; TR= Transplanting DS= Direct sowing without Hydro seed priming; SC=stand count; LA=-leaf area; LAI= leaf area index; PH=plant height; HD=heading date; MD=maturity date

The similar results were reported by [7,8] who also found that hydro seed priming gave the highest plant population.

3.1.2 Effect on Leaf Area (m^2/plant)

The data presented in Table 1 indicate that while leaf area was not significantly affected by sowing dates, method of sowing influenced the leaf area significantly.

The trend in leaf area at various days after sowing showed that the highest leaf area was at 60 DAS and then declined. Sowing with the onset of first summer rains (July 7) showed numerically highest leaf area at 60 DAS. Sowing after the onset of the first summer rains (July 14) which is a delayed sowing date showed higher leaf area until 60 DAS but after 80 DAS there was a reduction in leaf area which showed the lowest leaf area compared to the other sowing dates. These results are in agreement with the findings of [9,10] who reported that delayed sowing in sorghum cultivars showed a reduction in leaf number and leaf area. These findings are also in agreement with those of [13] who found out the highest leaf area in early July sowing.

Transplanting resulted in significantly highest leaf area at 60DAS. Direct sowing with hydro seed priming and direct sowing without hydro-seed priming showed the same trend even though direct sowing with hydro seed priming was slightly better than direct sowing without hydro seed priming during the growing period.

Transplanting with the onset of summer rains was better in leaf area until 60 DAS there after it declined tremendously. Direct sowing without hydro seed priming before the onset of first summer rains produced the lowest leaf area.

3.1.3 Effect on Leaf Area Index (LAI)

While the dates of sowing did not influence the LAI significantly, methods of sowing caused a significant difference in leaf area index (Table 1).

Sowing with the onset of the summer rains resulted in numerically highest leaf area index at 60 DAS.

Direct sowing with hydro seed priming showed significantly highest Leaf Area Index followed by direct seeding without priming.

Direct sowing with hydro priming after the onset of the first summer rains had numerically the highest Leaf Area Index followed by direct sowing with hydro seed priming before onset of summer rains.

3.1.4 Effect on Plant Height (cm)

Dates of Sowing

The final plant height was significantly influenced by sowing dates and methods of sowing (Table1). However, their interaction did not influence the plant height significantly.

Sowing before the onset of the summer rains and sowing with the onset of the summer rains. being statistically at par resulted in significantly higher plant height. It may be attributed to efficient utilization of both the first flash of rainfall and nitrogen than the late planted crops resulting in better growth [11].

Transplanting produced significantly tallest plants followed by direct sowing with hydro seed priming. It is because the transplanted seedlings were grown in nursery 10 days before the direct sowing with hydro seed priming and direct sowing without priming. Transplanting showed an increase in plant height than direct sowing with hydro

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seed priming and direct sowing without priming by 10% and 14%, respectively. The taller plant height observed in direct sowing with hydro seed priming could be due to early emergence, vigorous seedling establishment, tolerance to rainfall fluctuations, drought and efficient utilization of rain fall received during the growing season.

Dates of sowing and sowing methods interaction have not influenced plant height significantly. Transplanting with the onset of the summer rains produced numerically tallest plants followed by direct sowing with hydro seed priming before the onset of the summer rains (Table 1). Direct sowing with hydro seed priming gave taller plants than direct sowing without priming The above results are contrary to the finding of [12] who reported shorter plant height in transplanted crops due to transplanting shock in longer aged seedlings.

However, the results from direct sowing with hydro seed priming were in line with that of [13,14] who reported that plant height was better in hydro seed priming compared to direct sowing without priming.

3.2 Effect on Phenology

3.2.1 Days taken for Heading

Dates of sowing, methods of sowing and their interaction significantly influenced the days taken for heading (Table 1).

Sowing before the onset of the summer rains took significantly the lowest number of days to heading followed by Sowing with the onset of the summer rains. Sowing after the onset of the summer rains took significantly highest number of days to heading. Similar results were reported by [15] who also found a lesser number of days to heading by sowing the crop in dry soil conditions which is before onset of rains.

Transplanting took significantly lowest number of days to heading followed by direct sowing with hydro seed priming. Direct sowing without priming took significantly highest number of days to heading. The direct un-primed sown plants produced heading late due to lack of soil moisture towards the end of the growing season. These results are in agreement with those of [16] who also revealed that direct hydro seed priming produced heads earlier than direct un-primed sowings.

The data on interaction effect of sowing dates and method of sowing in Table1 reveal that irrespective of date of sowing, transplanting method took lesser number of days for heading as compared to direct methods of sowing with and without priming due to plantation of 10 days old seedlings. Irrespective of date of sowing, seed priming resulted in significantly early emergence of the heads due to its effect on faster initial growth of the seedlings compared to non seed priming. Irrespective of seed priming treatments, direct sowing before the onset of the summer rains resulted in significantly early heading than sowing after the onset of summer rains due to faster germination and growth of seedlings by utilization of first rain.

3.2.2 Days taken for Maturity

Dates of sowing, methods of sowing and their interaction significantly influenced the days taken for maturity (Table 1).

Sowing before the onset of the summer rains and sowing with the onset of the summer rains being statistically at par took a significantly lower number of days to maturity as compared to sowing after the onset of the summer rains. It can be attributed to faster rate of growth and development of the crop due to the first flash of rainfall and nitrogen in case of sowing before onset of rains and optimum moisture and temperature for growth in sowing with the onset of summer rains.

Transplanting was the earliest in maturity due to reduced length of growing season by raising seedlings in nursery compared to direct sowing with hydro seed priming. Direct sowing with un-primed seeds took the highest number of days to maturity. These results are in direct conformity with those of [17] who also reported that transplanted crops matured earlier than direct sown crop.

Data on interaction effect of sowing dates and methods presented in Table 1 revealed that irrespective of sowing dates transplanting method resulted in significantly earlier maturity over the direct sowing. While transplanting with the onset of the summer rains resulted in significantly earliest maturity, direct sowing without priming caused significantly latest maturity of the crop.

3.3 Effect on Yield Components

Panicle length, panicle weight and thousand grain weight were significantly influenced by dates of sowing and methods of sowing (Table 2). However, panicle weight was not affected significantly by the date of sowing.

Sowing before the onset of rains and with the onset of rains being at par produced significantly longer panicles and thousand grain weight compared to sowing after the onset of rains because of favourable moisture and temperature conditions for proper growth and development of the crop. Sowing before onset of rains produced numerically highest weight of panicles followed by sowing with the onset of summer rains.

Among the methods of sowing, transplanting resulted

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in significantly longer panicles, highest panicle weight and thousand grain weight over other methods of sowing due to benefit of ten days initial growth of seedlings in the nursery facilitating early flowering and maturity which enhanced the seed size. However, direct sowing with hydro seed priming was statistically at par with transplanting in influencing the panicle length and next best in panicle weight and thousand grain weight because it enabled imbibitions of water to initiate and facilitate earlier germination and better crop establishment ,growth and development of the crop. These findings are in agreement with those of [18] who also reported that seed priming increased the thousand grain weight as compared to non primed seeds.

Interaction of dates and methods of sowing did not significantly influence all the yield attributes of the crop. However, transplanting with the onset of summer rains resulted in numerically highest values of all the yield attributes.

3.4 Effect on Yields

Biological yield, grain yield and stover yields were significantly influenced by dates and methods of sowing. But the harvest index was not influenced significantly by them. Interaction of dates and methods of sowing did not influence significantly all the yields and harvest index (Table 2).

Table 2. Effect of dates of sowing, methods of Sowing and their interaction on yield & yield components of sorghum.

Treatment	GY	BY	SW	HI (%)	PL	PW	TGW
Dates of sowing							
D0	2569	8710	6140	28.86	22.65	74.6	22.30
D1	1875	7778	5903	23.94	22.47	71.3	21.92
D2	1339	5196	3857	24.77	19.43	58.4	20.00
LSD (5%)	460	468.4	186.3	NS	2.08	NS	1.47
CV (%)	13.8	3.7	2	12.4	5.60	11.2	4
Methods of sowing							
SP	1914	7022	5108	26.28	21.47	67.5	20.58
TR	2277	8192	5915	27.28	22.54	79.9	24.25
DS	1593	6469	4876	24.01	20.53	56.9	19.42
LSD (5%)	408.6	700.9	378.4	NS	1.427	6.49	1.415
CV (%)	13.8	3.7	2	12.4	5.60	11.2	4
Dates of sowing x Methods of sowing							
D0SP	2833	9000	6167	31.43	23.3	77.5	22.25
D0TR	2667	9125	6458	27.61	22.47	80	24.00
D0DS	2208	8004	5796	27.53	22.17	66.3	20.75
D1SP	1842	7550	5708	24.36	22.85	70	21.00
D1TR	2204	8788	6583	24.9	23.02	84.5	25.25
D1DS	1579	6996	5417	22.57	21.52	59.5	19.50
D2SP	1067	4517	3450	23.06	18.27	55	18.50
D2TR	1958	6663	4704	29.32	22.12	75.2	23.50
D2DS	992	4408	3417	21.92	17.9	45	18.00
LSD (5%)	NS	NS	NS	NS	NS	NS	NS
CV (%)	24.7	11.3	8.3	16.4	7.7	11.1	7.7
Grand mean	1928	7228	5300	25.86	21.52	68.1	21.42

Note: D0- sowing before onset of summer rains; D1- Sowing with the onset of first summer rains; D2-Sowing after the onset of the first summer rains; SP=direct seeding with Hydropriming; TR=Transplanting DS=Direct seeding without Hydropriming; GY=grain yield; BY=biomass yield; SW= stover weight; HI=harvestindex; PL=panicle length; Panicle weight; TGW=thousand grain weight

3.4.1 Effect on Grain yield (kg/ha)

Critical perusals of the data in Table 2 reveal that among the dates of sowing, sowing before the onset of summer rains resulted in significantly highest biomass yield(8710 kg/ha), grain yield (2570 kg/ha) and stover yield (6140 kg/ha) and numerically highest harvest index (28.86%) because of efficient utilization of first rain and the first flash of nitrogen in faster growth, development (Table1) and higher yield attributes (Table 2). Sowing with the onset of summer rains was the next best in producing higher yields. Sowing after the onset of rains produced the lowest yields because of the poorest growth, delayed development and production of lowest yield components. Similar findings were reported by [19,20] who reported 30% yield increment due to first drop of rainfall and flash of nitrogen utilized by the crop in sowing before the onset of the summer rains.

It can be noted that the dates of sowing with better biomass yield were also the better in grain yield (Table 2). Late sowing produced less biomass due to insufficient amount of rain fall at later stage there by reducing both the biomass and grain yield compared to the other sowing dates. The above results are in line with the findings of [21 and 22] who reported higher biomass yield in sowing before the onset of the summer rains over sowing with the onset of the first summer rains.

Among the methods of sowing, transplanting method resulted in significantly highest biomass yield (8192 kg/ha), grain yield (8192 kg/ha), stover yield (6140 kg/ha) and numerically highest harvest index (27.28 %) due to advantage of transplanting of 10 days old seedlings of sorghum which helped in better stand, faster growth and development of the crop resulting in higher yield components (Table 1 and 2). Both the direct methods of sowing being statistically at par were next best in influencing biomass yield, grain yield and straw weight. However, direct sowing with hydro priming of the seeds was superior to direct seeding without hydro priming in increasing all types of yields. Transplanting showed a grain yield increase of 18.9% and 42.9% compared to direct sowing with hydro seed priming and direct sowing without priming, respectively. Direct sowing with hydro seed priming gave a yield increase of 20.15% compared to direct sowing without hydro seed priming which gave the lowest yield.

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The results in this experiment are similar to the finding of [23] who reported a yield increase of about 59% in transplanting. [24] mentioned that the yield from direct sowing with hydro seed priming were higher with a range of 10.2% to 31% compared to direct sowing without hydro seed priming. The yield increment in transplanting and direct sowing with hydro seed priming were due to improved crop establishment, vigour of seedlings, early flowering and maturing before early withdrawal of rainfall resulting in higher panicle weights.

It was noted that direct sowing with hydro seed priming had lower smut infestation as the fungal spores are removed with water during soaking as compared to the other methods of sowing. These findings are in agreement with those of [25] who concluded that in direct sowing with hydro seed priming plants were more tolerant to diseases compared to non-primed ones.

The Coefficient of variation was higher for grain yield due to factors that were beyond control such as disease infestation, early withdrawal of rainfall and variation in management practices that resulted in bringing variation in the experiment. Despite that numerically, direct sowing with hydro seed priming before the onset of the summer rains was the best in grain yield (2833 kg/ha) followed by transplanting (2667 kg/ha) before the onset of the summer rains.

Interaction of dates of sowing and methods of sowing did not significantly influence the biomass yield, grain yield, stover weight and harvest index (Table 2). Cursory glance of the data reveals that transplanting and direct sowing with hydro seed priming before the onset of summer rains gave numerically higher biomass yield and grain yield due to higher plant population, taller plants, longer and heavier panicles. However, numerically higher stover yield was obtained with transplanting before onset or with the onset of summer rains. Direct sowing without seed priming after the onset of summer rains produced lowest biomass yield, grain yield and stover yield due to significantly lowest stand count and plant height and higher number of days taken for flowering and maturity (Table 1), which resulted in numerically lowest panicle length, panicle weight and thousand grain weight (Table 2).

4. Correlation Studies

The results of correlation studies made to find the relationship of biomass yield, grain yield and harvest index with the different growth, development and yield parameters have been presented in Table 3. The results of the study indicated that there was a negative and significant correlation between biomass yield vs heading and maturity date. The higher the biomass yield, lower the days taken to heading and maturity. The treatments with higher biomass took less number of days to heading and maturity.

The relationship between biomass and the other parameters was also positive and significant. This means that an increase in the values of stand count, plant height, panicle length and thousand grain weight resulted in higher biomass. The relationship of biomass yield with leaf area and leaf area index was positive but not significant.

Table 3. Correlation analysis on relationship between agronomic parameters and yield

Parameter	Biomass yield	Grain yield	HI
Stand count	0.549 (**)	0.359 (*)	0.04 (NS)
Leaf Area	0.092 (NS)	0.181 (NS)	0.22 (NS)
Leaf Area Index	0.092 (NS)	0.181 (NS)	0.22 (NS)
Plant Height	0.805 (**)	0.803 (**)	0.63 (**)
Days to heading	-0.784 (**)	-0.686 (**)	-0.41 (*)
Days to Maturity	-0.721 (**)	-0.624 (**)	-0.33(*)
Panicle Length	0.854 (**)	0.775 (**)	0.49 (*)
Panicle weight	0.746 (**)	0.686 (**)	0.42 (*)
Stover weight	0.965 (**)	0.77 (**)	0.35 (*)
Thousand Grain weight	0.790 (**)	0.766 (**)	0.56 (**)
Biomass yield	---	0.911 (**)	0.57 (**)
Grain yield	---	---	0.838 (**)

Note: (**)- Highly significant at 1% level; (*)- significant at 5% level; NS- Non significant.

These results were similar with findings of [26] who mentioned on the positive correlation between grain yield and biomass in sorghum. Furthermore, biomass yield was positively and significantly correlated with grain yield and harvest index.

There was a negative correlation between grain yield vs heading and maturity date. The higher the grain yield the lower would be the number of days taken to heading and maturity. The treatments with higher grain yield took less number of days to heading and mature earlier.

There was significant and positive relationship between grain yield and stand count, plant height, panicle length, panicle weight and thousand grain weight which contributed to higher grain yield. The highest positive and significant correlation was observed in thousand seed weight and straw weight (r=0.76** and r=0.77**) whereas the lowest significant correlation was obtained from stand count (r=0.359*). This finding is in agreement with that of [27,28] who indicated that there was positive and highly significant correlation between grain yield and thousand seed weight. The relationship of grain yield with leaf area and leaf area index was positive but not significant. Grain

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yield was positively and significantly correlated with biomass yield and harvest index.

There was a negative and significant correlation between harvest index vs heading and maturity date. The higher the harvest index the lower is the number of days taken to heading and maturity. The treatments with higher harvest index took less number of days to heading and mature earlier.

The relationship between HI and other parameters was also positive and significant. This means that an increase in the values of plant height, panicle length, panicle weight, straw weight, grain yield, biomass yield and thousand grain weight resulted in higher harvest index. The above results are similar with findings of [29] who mentioned a significant positive correlation between grain yield and harvest index. The relationship of harvest index with, stand count, leaf area and leaf area index was positive but not significant.

5. Conclusions

Among sowing dates, sowing with the onset of the first summer rains (July 7) was significantly superior in increasing grain yield by increasing leaf area, leaf area index, plant height and yield components. Sowing before the onset of the summer rains gave the highest grain yield (2569 kg/ha) with an increment of 694 kg/ha which is equal to 37% compared to sowing with the onset of the first summer rains (1875 kg/ha).

Among methods of sowing, transplanting (2277 kg/ha) being statistically at par with direct sowing with hydro seed priming (1914 kg/ha) produced significantly higher grain yield. However, direct sowing with hydro seed priming was superior in in producing higher leaf area and leaf area index and transplanting was superior in increasing plant height, panicle weight and thousand grain weight.

Direct sowing with hydro seed priming was more profitable than direct sowing without hydro seed priming and transplanting. Among the methods of sowing, since transplanting method require more labour for transplanting and difficult to apply in large hectares of land, direct sowing with the onset of first rain after hydro seed priming is more practicable and economical.

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References

[1] MoA. (2016), Annual report of sorghum production from 2013 to 2015. Ministry of Agriculture, Asmara, Eritrea.

[2] MoA. (2015), Sorghum and pearl millet: Hamelmalo Sub Zoba- unpublished report,Ministry of Agriculture, Zoba Anseba. Hamelmalo, Eritrea.

[3] Towned, J. Mtakwa, P. W. Mullins, C. E. and Simmonds, L. P. (1996), Soil Physical factors limiting establishment of sorghum and cowpea in two contrasting soil types in the semi-arid tropics. Soil Tillage Research 40: 89-106.

[4] Harris, D. Joshi, A. Khan, P.A. Gothakar, P. and Sodhi, P. S. (1999), On-farm seed priming in semi-arid agriculture: Development and evaluation in corn, rice and chickpea in India using participatory methods. Experimental Agriculture 35:15-29.

[5] Harris, D. (2006), Development and testing of "on-farm" seed priming. Advances in Agronomy 90: 129-178.

[6] Clark, L. E. (1997), Grain sorghum production in the Texas rolling plains. Texas A & M University Agricultural Research and Extension Center at Chillicothe-Vernon. Technical Report 97-1. In B. Diawara. 2012. Effect of sowing date on growth, development and yield of grain sorghum hybrids. A thesis submitted in partial fulfilment of the requirements for the Masters of Science Degree. College of Agriculture. Department of Agronomy. Kansas State University Manhattan, Kansas. Available at: http://krex.kstate.edu/dspace/bitstream [Accessed on August 12, 2015].

[7] Tabatabaei, S. A. (2013), Effect of salicylic acid and ascorbic acid on Germination indexes and enzyme activity of sorghum seeds under drought stress. Available at:www.jspb.ru/issues/2013/N4/JSPB_2013. [Accessed on December 28, 2015].

[8] Chivasa, W. Harris, D. and Nyamudeza, P. (2001), Determination of optimum on-farm seed priming time for maize (Zea mays L) and sorghum (Sorghum bicolor (L.) Moench) for use to improve stand establishment in semi-arid agriculture. Tanzanian Journal of Agricultural Sciences 3 (2): 103-112.

[9] Bahar, H.A. Adam, K.I. and Mohammed Ali, S.A. (2015b), Performance of Some Sorghum (Sorghum bicolor L. Moench) Varieties under Rain-Fed Condition at Zalingei Area, Sudan (Growth, Yield, Pests and Diseases). Available at:http://www.aiscience.org/journal/abs [Accessed on March 12, 2016].

[10] Bunck, J. H. (1977), Effect of sowing date on leaf number and total leaf area of hybrid grain sorghum. In B. Diawara. 2012. Effect of sowing dates on growth, development andyield of grain sorghum hybrids. A thesis submitted in partial fulfilment of the requirements for the Degree Master of Science. College of Agriculture. Department of Agronomy.

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Kansas State University Manhattan, Kansas. 2012. Available at: http://krex.kstate.edu/dspace/bitstream/handle/2097/1 [Accessed on July 24, 2015].

[11] Karhale, M. B. Jaybhaye, P. R. Asewar, B.V. Shinde, P.B. (2014), Effect of different sowing dates on Growth and Yield of Kharif Sorghum Hybrids. Available at:www.iosrjournals.org.[Accessed on November 10, 2015].

[12] Agbaje, G. O. and Olofintoye, J. A. (2002), Effect of Transplanting on yield and growth of grain sorghum (Sorghum bicolor (L.)Moench). Technical notes. Available at:https://www.unilorin.edu.n. [Accessed on August 22, 2015].

[13] Hassanpouraghdam, M. B. Pardaz, J. E and Akhtar, N. F. (2009), The effect of osmo-priming on germination and seedling growth of Brassica napus L. under salinity conditions. Journal of Food, Agriculture & Environment 7: 620-622.

[14] Khan, S., Anwar, K. Ullah, H. Gul, H. and Rehman, A. U. (2014), Phenology and tissue potassium concentration of sorghum as affected by various sources and levels of osmo priming. Science Park Research Journal 1 (25): 2321-8045.

[15] Conley, S.P. and Wiebold, W. J. (2003), Grain sorghum response to sowing date.Online. Crop Management doi: 10.1094/CM-2003-0204-01-RS. Available at:http://www.researchgate.net/publication/22871432 [Accessed on January 28, 2016].

[16] Murungu, F. S. Chiduza, C. Nyamugafata, P. Clark, L.J. and Whalley, W.R. (2004),Effects of "on-farm seed priming" on consecutive daily sowing occasions on the emergence and growth of maize in semi-arid Zimbabwe. Available at:www.sciencedirect.com/science/article/ [Accessed on July 22, 2015].

[17] Young, E. M. and Mottran, A. (2003), Transplanting sorghum and millet as a means of increasing food security in upper East Region of Ghana. A project summary – Ghana, February 2003. Available at:www.bangor.ac.uk/tran [Accessed on August 16, 2015].

[18] Abdalla, E. A. Osman, A. K. Maki, M. A. Nur, F. M. Ali, S. B. and Aune, J. B. (2015),The response of sorghum, groundnut, sesame, and cowpea to seed priming and fertilizer micro-dosing in South Kordofan State, Sudan. Available at: www.mdpi.com2073-4395/5/4/476 [Accessed on August 22, 2015].

[19] Mahmood, A. (2012), Performance of Sorghum (Sorghum bicolor L. Moench) as an Energy Crop for Biogas Production. A thesis submitted for the requirement of Doctoral Degree in Agriculture from Faculty of Agricultural and Nutritional Sciences, Home Economics and Environmental Management Justus Liebig University Giessen,Germany. Available at: www.geb.uni-giessen.de/M. [Accessed on January 11,2016].

[20] Reddy, S.R. (2008), Principles of crop production. 3 rd edn. Kalayani publishers, New Delhi, India.

[21] Diawara, B. (2012), Effect of sowing dates on growth, development and yield of grain sorghum hybrids. A thesis submitted in partial fulfilment of the requirements for the Degree Master of Science. College of Agriculture. Department of Agronomy. Kansas State University Manhattan, Kansas. 2012. Available at: http://krex.kstate.edu/dspace/[Accessed on June 14, 2015].

[22] Rao, S. S. Patil, J. V. Prasad, P. V. V. Reddy, D. C. S. Mishra, J. S. Umakanth, A. V.Reddy, B. V.S. and Kumar, A. A. (2013), Sweet Sorghum Sowing Effects on StalkYield and Sugar Quality in Semi-Arid Tropical Environment. Agronomy Journal 105(5):1458-1465 Available at: www.icrisat.org [Accessed on March 23, 2016].

[23] Assefa, D. Maru, B. Diress, T. and Mitiku, H. (2007), Transplanting Sorghum as a Means of Ensuring Food Security in Low Rainfall Sorghum Growing Areas of Northern Ethiopia. DCG Report No. 48 March 2007. Available at:https://www.agris.fao.org/agris-search/search.do [Accessed on August 12, 2015].

[24] Ramamurthy, V. Gajbhiyek, S. Venugopalan, M. V. and Parhad, V. N. (2005), On-farm evaluation of seed priming technology in sorghum (Sorghum bicolor L.). Available at:www.agriculturaits.czu.cz. [Accessed on December 23, 2015].

[25] Harris, D. Pathan, A. K. Gothkar, P. Joshi A. Chivasa, W. and Nyamudeza, P. (2007),On-farm seed priming using participatory methods to revive and refine a key technology. Agricultural Systems 69:151-164.

[26] Sankarpondian, R. Krishnadas, D. Muppidathi, N. and Chidambaram, S. (1993), Variability studies in grain sorghum for certain physiological characters under water stress condition. Crop Improvement 20:45-50.

[27] Ezeaku, I. E. and Mohammed, S.G. (2005), Character association and path analysis in grain sorghum. Available at:www.ajol.info. [Accessed on April 10, 2016].

[28] Arunah, U.L. Chiezey, U. F. Aliyu, L. and Ahmed, A. (2015), Correlation and Path Analysis between Sorghum Yield to Growth and Yield Characters. Available at:www.iiste.org [Accessed on Aprile 6, 2016].

[29] Sarvari, S. M. and Beheshti, S. A. (2012), Relationship between Grain Yield and Plant Characteristics in Grain Sorghum Genotypes under Drought Stress Conditions. Iranian Journal of Crop Sciences 14(2):183-201.Available at:www.en.journals.sid.ir/ViewPaper.aspx?ID=31. [Accessed on April 20, 2016].

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ARTICLE

Response of Stubble Shaving Times on Ratoon Yield of Different Sugarcane Genotypes

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ABSTRACT

Ratooning is common practice done in sugarcane with purpose of reducing the total cost of cultivation and early cane maturity. More than 35% of sugarcane productivity is lost due to improper attention of the farmers towards ratoons. Majority of farmers reported that the ratoonability wasn't good when harvested in December-January. This experiment was carried out to find the appropriate ratoon shaving time with response to different varieties in sugarcane ratoon crop in the year 2018/19 at national sugarcane research project, Jitpur, Bara. The experiment was conducted in split plot design with four levels of cane genotypes as Co – 0238, CoLk – 94184, Co – 0233 and CoS – 07250 as the main plot factor while four harvesting dates as sub plot factor with three replications. Observations of a number of millable canes, single cane weight, plant height and single cane diameter were recorded, tabulated and analyzed in R-studio. Ratoon stubble shaving in the month of November had the highest number of millable canes (88079/ha) which wasn't significantly different from the stubble shaving in the month of December, January. Likewise, highest cane yield (60.04 mt/ha), single cane weight (0.757 kg), cane diameter (2.11 cm), plant height (1.82 m) were found in early stubble shaving dates. Cane Yield and various yield parameter shows better performance in early ratoon shaving periods i.e. from November to January than late ratoon shaving dates.

1. Introduction

Sugarcane is a major commercial cash crop grown in Nepal with annual production of 1.95 million tons sharing 34th rank in total yield globally [4]. The national productivity of sugarcane is limited to only 45.12 t/ha which is less in comparison to global average 56.29 ton/ha [7]. Ratooning is common practice in sugarcane for cultivation cost reduction and early crop maturity. Moreover, ratoons have supplementary advantage of better juice quality and sugar recovery as compared to plant crop of same variety [14]. Low yield of ratoons compared to main crop is mainly due to differential potential of cultivars, poor sprouting of stubbles and higher mortality of tillers [12]. Moreover, more than 35% of its productivity is lost due to improper attention of the farmers towards ratoons [6]. Late maturing cultivars having good yield are suitable for growing ratoon but early maturing cultivars are poor ratooners.

Stubble shaving is an important operation by which the portion of cane sticking out of the collar region above the

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ground is removed to encourage proper germination and tillering [1]. Crops harvested in the spring give better ratoon than autumn harvested due to moderate temperature which is more conducive for ratoon sprouting [9]. Stubble shaving is usually recommended within a week of harvest of sugarcane because mortality of facultative tillers usually occurs from left over canes [2]. [10] noticed different response of different genotypes for sprouting, millable canes and commercial cane sugar for ratooning. [13] found superior response in late harvested canes in first week of November. Majority of farmers keep ratoon crops after harvesting crop without considering the environmental factors and basic agronomic practices like stubble shaving. Keeping all this in view, the present research was carried out to find the appropriate ratoon shaving time with response to different varieties.

2. Materials and Methods

Field experiments were conducted in sugarcane ratoon crop from November 2018 to February 2019 at National sugarcane research project, jitpur, Bara (27^0 6'48.31''N , 84^0 57'15.8''E and 85 masl). The experiment was conducted in split plot design with four level of cane genotypes as Co – 0238, CoLk – 94184, Co – 0233 and CoS – 07250 as main plot factor while four ratoon stubble shaving dates i.e. November, December, January and February were set in sub plot factor with three replications. Canes were planted in each plant size of 5m row length with 90 cm spaced 5 rows. NPK were applied in the field in the recommended dose of fertilizers 150:60:40 kg/ha NPK. Other crop management practices and plant protection measures were applied uniformly and when required. Observations of a number of millable canes, single cane weight, plant height and single cane diameter were recorded. Data were tabulated and analyzed in R-studio.

3. Results and Discussion

3.1 Number of Millable Canes

Different cane genotypes and stubble shaving dates had a significant difference in number of millable canes. The result revealed that ratoon stubble shaving in the month of November had the highest number of millable canes (88079/ha) which wasn't significantly different from the stubble shaving in the month of December, January. But there was less number of millable canes per hectare (53472 canes/ha) in the late stubble shaving date i.e. in the month of February. Sugarcane genotype CoLk- 94184 had the highest number of millable canes which wasn't significantly different from CoS 07250. There was no any significant different in interaction between ratoon shaving time and genotypes. The highest number of milllable canes in the early shaving date is due to the higher number of sprouts due to environmental factors such as high temperature in November than further coming months. Similar findings are also found by [9] and [5].

Table 1. Effect of ratoon shaving date in number of millable cane (NMC) of different sugarcane genotypes in 2019

Date	Genotypes				
	Co- 0238	CoLk 94184	Co - 0233	CoS 07250	NMC/ha
Nov	69907	109259	56481	116667	88079a
Dec.	68056	97222	44444	85648	73843a
Jan.	62500	76852	75463	78704	73380a
Feb.	46296	60185	46759	60648	53472b
NMC/ha	61690b	85880a	55787b	85417a	
Cv	23%				
Mean	72193				
LSD (d)	17674				
LSd(v)	12939				
LSD (dv)	Ns				

3.2 Plant Height

Plant height was found significantly different to different stubble shaving dates. Tallest canes (1.82 m) were found in early ratoon shaving date i.e. in the month of November followed by December (1.77 m), January (1.72 m) and February (1.68 m). However, there were no any significant differences in plant height among tested genotypes and their interaction effects. Smallest plant height among all shaving dates was found in late shaving date in February which might be due to shortest growing period and less absorption of nutrients for ratoon growth which is at par with the [3].

Table 2. Effect of ratoon shaving date in Plant height (PH) of different sugarcane genotypes

Date	Genotypes				
	Co- 0238	CoLk 94184	Co- 0233	CoS 07250	Mean
Nov	1.78	1.85	1.83	1.81	1.82a
Dec.	1.75	1.72	1.81	1.79	1.77ab
Jan.	1.73	1.70	1.75	1.68	1.72bc
Feb.	1.67	1.69	1.69	1.68	1.68c
Mean	1.73	1.74	1.77	1.74	
Cv	4.5				
Mean	1.75				
LSD (d)	0.06				
LSd(v)	Ns				
LSD (dv)	Ns				

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3.3 Cane Diameter

The result revealed that the thickest cane diameter (2.11 cm) was found in early ratoon shaving date i.e. in the month of November which wasn't significantly different from stubble shaving date December.

The cane diameter decreased in further stubble shaving date in January and February. Likewise, Genotypes Co 0238 had recorded thickest cane diameter of 2.2 cm followed by genotype Co 0233 and CoS 07250. But, there was no interaction effect between genotypes and ratoon shaving times.

Table 3. Effect of ratoon shaving date in cane diameter (CD) of different sugarcane genotypes at NSRP in 2019

Date	Genotypes				
	Co- 0238	CoLk- 94184	Co - 0233	CoS – 07250	CD (cm)
Nov	2.33	1.91	2.1	2.1	2.11a
Dec.	2.31	1.88	2.12	2.07	2.09a
Jan.	2.2	1.82	1.95	1.91	1.97b
Feb.	1.97	1.77	1.93	1.82	1.87c
CD (cm)	2.2a	1.85c	2.03b	1.98b	
Cv	4.5				
Mean	2.01				
LSD (d)	0.06				
LSd(v)	0.09				
LSD (dv)	Ns				

3.4 Single Cane Weight

The maximum single cane weight (0.757 kg) was recorded in early ratoon shaving date i.e. in the month of December which wasn't significantly different with the ratoon shaving date of 0.743 and 0.757 kg. Likewise, genotype Co 0238 had highest single cane weight among tested genotypes of 0.822 kg followed by Co 0233 of 0.769 kg. There were no interaction effects between tested two factors. High cane weight is attributed to high cane diameter and plant height due to long growing time which is at par with [11].

Table 4. Effect of ratoon shaving date in single cane weight (SCW) of different sugarcane genotypes

Date	Genotypes				
	Co- 0238	CoLk 94184	Co- 0233	CoS 07250	SCW (kg)
Nov	0.857	0.607	0.83	0.677	0.743a
Dec.	0.867	0.633	0.84	0.687	0.757a
Jan.	0.787	0.603	0.713	0.63	0.683b
Feb.	0.777	0.603	0.693	0.63	0.676b
SCW (kg)	0.822a	0.612d	0.769b	0.656c	
Cv	4.2				
Mean	0.715				
LSD (d)	0.02				
LSd(v)	0.04				
LSD (dv)	Ns				

3.5 Cane Yield

The result revealed that highest cane yield (60.04 mt/ha) was found in early stubble shaving date i.e. in the month of November which wasn't significantly different further two stubble shaving date i.e. in the month of December (54.71 mt/ha) and January (51.74 mt/ha) followed by late ratoon shaving date i.e. in the month of February (37.54 mt/ha).

As yield attributing parameter supports the yield performance, the highest cane yield was found after early stubble shaving in the ratoon. But cane yield was not significantly different among genotypes and their interaction with shaving dates. Higher cane yield is attributed to higher number of millable canes, cane height, weight and cane diameter which is at par with the findings by [8].

Table 5. Effect of ratoon shaving date in cane yield of different sugarcane genotypes

Date	Genotypes				
	Co 0238	CoLk 94184	Co 0233	CoS 07250	Mean
Nov	61.1	61.1	61.1	61.1	62.04a
Dec.	59.3	59.3	59.3	59.3	54.75a
Jan.	51.4	51.4	51.4	51.4	51.74a
Feb.	38.9	38.9	38.9	38.9	37.5b
Mean	52.66	52.2	44.21	56.94	
Cv	23				
Mean	51.5				
LSD (d)	12.07				
LSd(v)	Ns				
LSD (dv)	Ns				

4. Conclusions

From above discussion, yield parameter like of millable canes, plant height, cane diameter, single cane weight and cane yield shows better performance in early ratoon shaving periods i.e. from November to January than late ratoon shaving dates. Ratoon performance in high when stubble shaving is done in the start of spring season by considering environmental factors like temperature and soil.

References

[1] Bakker, H. (1999). Sugarcane cultivation and management, 207. New York: Springer.

[2] Chapman, L. S. Ferraris, R. and Ludlow, M. M. "Ratooning Ability of Cane Varieties, Variation in Yield and Yield Components," Proceedings of Australian Society Sugar Technology, Vol. 14, 1992, pp. 130-138.

[3] Chapman, L., Ferraris, R., & Ludlow, M. (1992).

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[4] FAOSTAT, (2014). FAO Statistical Database (FAOSTAT). Food and Agriculture Organization of the United Nations.

[5] Junej, SG. Kaloi, M. Panhwar, RN. Chohan, M. Junejo, AA. Soomro, AF. (2010)Performance of newly developed sugarcane genotypes for some qualitative and quantitative traits under Thatta conditions Journal of Plant Animal Science. 20(1): 40-43.

[6] Malik, K.B. (1997) Profitable cultivation of sugarcane. Directorate of Agriculture Information, Agriculture Department . Punjab, Lahore: 49.

[7] MoAD, 2016. Krishi diary, Agricultural information and communication center, Hariharbhawan, Lalitpur, Nepal.

[8] Ongin'jo, E., & Olweny, C. (2011). Determination of optimum harvesting age for sugarcane ratoon crop at the Kenyan Coast. Journal of Microbiology and Biotechnology Research, 1(2), 113-118.

[9] Rehman, A. and Ullah, E. (2008) Increasing yield of ratoon sugarcane. DAWN -Business; April 07, 2008.

[10] Saeed, M. (1993). Yield potential of second ratoon of promising varieties of sugarcane. Thesis. M.Sc. (Hons.) Agriculture, Department of Agronomy, University of Agriculture, Faisalabad.

[11] Shukla, S., & Lal, M. (2002). Competition functions and productivity in sugarcane-based associative and successive cropping systems in relation to nitrogen and sulphur nutrition. Indian journal of agricultural science, 72(6), 315-318.

[12] Singh, P., Rai, R.K. Suman, A. Srivastava, T.K. Singh, K.P. and Yadav, R.L. (2013). Ratooning induced rhizospheric changes impede nutrient acquisition and growth in sugarcane ratoon crop during grand growth stage in sub-tropics. Sugar Tech 15(1): 52-64.

[13] Stokes, I.E, and Ashley, (1956). Agronomic practices influence stubble deterioration of sugarcane. Proceeding in international society of sugarcane Technology congress 9: 255-271.

[14] Yadav, R.L. (1991). Sugarcane Production Technology; Constraints and Potentialities. Oxord & IBH Publishing Co. (Pvt.) Ltd. Bombay: 204.

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ARTICLE

Effect of Phenolic Components of Earth Apple (Helianthus Tuberosus) in the Inhibiting of Oxidation and Extension the Shelf-life of Vegetable Oils

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ABSTRACT

Earth Apple (Helianthus tuberosus) phenolic compounds were extracted using two methods ethanol extraction (98 percent ethanol for 24 hours at room temperature) and water extraction (distilled water for 24 hours at room temperature). To measure the sum of phenols in the extract, the Folin-Ciocateu method was used. The alcohol extract gave a higher phenol content of 58.29 mg/g (gallic acid), while the alcoholic extract had flavonoids 26.63 mg/g (gallic acid). Water extract was phenols content of 42.62 mg/g (gallic acid) while the alcoholic extract had flavonoids 11.23 mg/g (gallic acid). The alcoholic extract from Earth Apple gave the highest antioxidant effect at 88.32%, while the water extract was 77.43%. The inhibitory effect of the added Earth Apple extract oil to inhibit oxidation, remove concentrations (0.1, 0.15, 0.2 percent) of Palm Oil and Sunflower oil as it exceeded the reduction of peroxide values during the reservoir periods (15, 30, 45, 60 days).

1. Introduction

The Earth Apple is one of the spring vegetable crops belonging to the tent family (Helianthus tuberosus). Family asteraceae of perennial vegetable crops, but are re-grown annually as the total vegetative dies annually during Winter to give new growths during the spring. The part that is eaten is tubers that are made up at the end of the legs. The rhizomes are irregular and have protrusions which are the eyes that contain the buds and are eaten It is cooked or used in pickling and is rich in Inulin, which is used in the industry to obtain Sugar inulin also contain phenolic substances acting as antioxidants [35,2]. The Earth Apple is one of the most important vegetables in the world. Its biologically active ingredients may be beneficial to a large number of consumers. It is rich in healthy antioxidants such as carotenoids, hydrophilic substances such as phenolic compounds [3,4,5]. The Earth Apple was first used for medical purposes and was gradually used as food [6]. Researchers explained Earth Apple contains antioxidants, especially beta-carotene, It has beneficial health effects such as anti-cancer and antioxidants, and in enhancing immunity, as well as the activity of some carotenoids. Earth Apple is rich in antioxidants, whether carotenoids or hydrophilic phenols [8,9]. Although the content of carotenoids varies greatly between the structures of the Earth Apple [10]. The oils extracted from plants play an important role in the industry. Among the known

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species of these compounds, tannins, which were used in tanning, ink manufacturing, and phenolic compounds in the manufacture of colored materials. Phenolic compounds are known as low molecular weight compounds containing an aromatic ring with one or more hydroxyl groups [11]. Phenolic compounds are part of plant compounds with a long history in industries such as tanning skin, wine and inks, as well as their important role in human health [12]. Inedible and edible food crops contain multiple phenols with multiple applications in the food, pharmaceutical and cosmetic industries [13]. Phenolic compounds, they join oxidation processes by breaking down the chain of active reactions, called "primary oxidation," or by eliminating free radicals, or "secondary oxidation According to" [7,14]. Fatty oxidation occurs in food oils at various stages of processing, storage, purchase, and even use [15]. The primary source of palm oil is the oil palm (Elaeis guineensis). Phenolic compounds, terpenes, and sterols are the most common phytochemicals found in palms [16]. Sunflower (Helianthus annuus L.) cultivation has increased dramatically in recent years, owing to the high quality of its oil, which is suitable for human consumption [17]. Unsaturated fatty acids (linoleic 56 percent, oleic 30 percent, linolenic 0.7 percent). It also has a protein value of 37 percent clopulin, 51 percent clotillin, and 7 percent insoluble oils. Palm oil also contains a number of amino acids, Tocopherol (vitamin E), beta-sitosterol , and phytine, both of which are high in vitamin E (tocopherol) [18]. Palm's high content of unsaturated fatty acids, such as linoleic acid, helps to lower LDL, which decreases cholesterol in the blood and prevents atherosclerosis and blood vessel disease. It also induces a decrease in blood pressure. Cholesterol-linked diseases were once common [19]. Triglycerides, or esters of triglyceride fatty acid, are found naturally in oils and fats. Peroxidase is a measure of the oxidative oxidation of oils, and therefore of the nature of the products that contain these oils [20, 21].

2. Materials and Methods

2.1 Preparation of Plant Extracts

2.1.1 Alcoholic Extraction

I created alcoholic extracts utilizing method [22], weighing 100 g of each sample and adding 500 ml of 98 percent ethyl alcohol, mixing well, and leaving for 24 hours at room temperature 25-30°C. The extract was then filtered using Whatman No.1 filter paper. The concentrated filtrate was then filtered using a Vacuum Evaporator rotary evaporator at a temperature of 40°C, and the packaging was sealed and sealed in the refrigerator before use, and the concentrated filtrate was left at the laboratory temperature until a concentrated sticky material was collected.

2.1.2 Aqueous Extraction

Prepare the water extracts [23], weighing 100 g of each sample with 500 ml distilled boiling water and mixing for 24 hours and 30 minutes on a magnetic mixer. Then, with the Buchner funnel, sprinkle through the Whatman No.1 filter paper with discharge and concentrate the rotary vacuum evaporator at 40 °C, it is mounted at laboratory temperature 30-25 °C, put in dark containers, and held in refrigerator until use.

2.2 Estimate of Total Phenols

By dissolving 1 g of plant extracts in 46 mL of distilled water and 1 mL of the Folin-Ciocalteu reagent, the value of phenols in the water and alcohol extracts of the plants was calculated The ingredients had been thoroughly combined. 3 mL sodium carbonate (2 percent) Na_2CO_3, shake for 2 hours, then test absorption at 760 nm. The amount of phenols in the extracts was determined using a standard solution of Gallic acid at a concentration of 0-100 mg/ml and a correlation between acid concentration and absorption at a 760 nm wavelength. used the Folin-Ciocalteu method [24].

2.3 Estimate of Total Flavonoids

The method described above [25] Dissolving 1 g of plant extracts in 1.5 ml ethyl alcohol and adding an equivalent amount of $AlCl_3$. $6H_2O$ concentration was used to measure the total flavonoids content in plant extracts (2 percent in 100 ml methanol). The concentration of flavonoids in the extracts was determined by making a standard solution of the Rutin flavonide compound with concentrations ranging from (0-100 mg / ml) and measuring the absorption at 367 nm wavelength. By using the graphical relationship between acid concentration and absorption, the volume of flavonoids was assessed.

2.4 Antioxidant Activity

Antioxidant efficacy in alcoholic and aqueous extracts was estimated according to the method described in [26] using the proposed linoleic acid system [27]. Preparation of a mixture consisting of 4.1 mL linoleic acid (2.5 percent ethanol), 4 mL per extract, 8 mL phosphate-regulated solution 0.05 mM and pH = 7 and 3.9 mL distilled water, incubation at 40°C for 24 hours in dark-brown containers. Add 0.1 mL of mixture to 9.7 mL of ethanol (75 percent concentration) and 0.1 mL of ammonium thiocyanate to calculate the percentage of thiosanate oxidation (30 percent concentration). After three minutes, 0.1 mL chloride (20 mL molariate concentration) in 3.5 percent hydrochlo-

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ric acid, and then measuring absorbance with a 500 nm wavelength, the control sample was prepared in the same way as the above but with 4 mL ethanol instead of plant extract. Calculation rate of linoleic acid peroxides was calculated according to the following equation:

$$\text{Antioxidant effectiveness\%} = 100 - \frac{\text{Read the absorption of the model}}{\text{Read the absorption of the control sample}} \times 100$$

2.5 Antioxidants in the Oil

I followed the method described by Scott (1965) and then dissolving 0.02% of the industrial antioxidant BHT and phenolic extracts 0.1,0.15, 0.2% in the ethyl alcohol and added to the sunflower oil and palm oil samples at 45 °C to equal the final concentration of antioxidant in the oil as stated [28], then mix the mixture well and incubated the degree Heat 45°C and put another model of oil free of the antioxidant promised a comparison model. The antioxidant efficiency of the oil was followed for 60 days by estimating the peroxide value according to the method mentioned in [29].

3. Results and Discussion

3.1 Total Content of Phenols

Figure 1 appears the contrasts between water and alcoholic extracts in phenolic compounds of the Earth Apple with 58.27 mg/g for the extracts and 42.62 mg/g for the water extricate. The contrast within the sum of phenolic compounds between water and alcoholic extracts is due to the nature of the partitioned compounds and the dissolvability of total solvents utilized for extracts. [30] The control of water extracts contains little amounts of phenolic compounds compared with tall levels of alcoholic extracts due to ethanol effectiveness within the extracts of polyphenols and tannins from the plant [31].

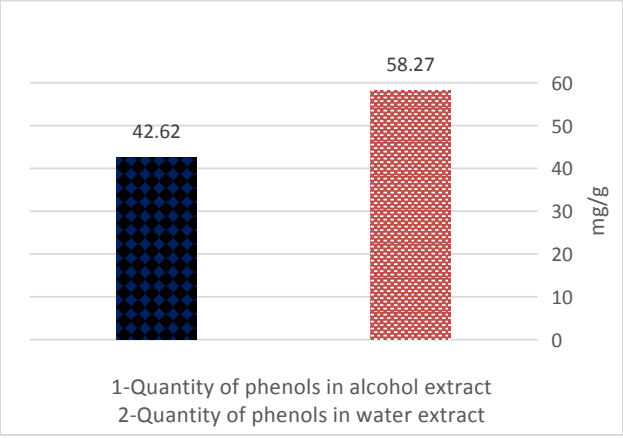

Figure 1. Total substance of phenolic compounds in Earth Apple extricate

3.2 Total Flavonoids Content

Figure 2 appears the sum of flavonoids in water and liquor extricate from Earth Apple extricate. The most noteworthy concentration of flavonoids within the Earth Apple extricate was 26.61 mg/g, taken after by Earth Apple (11.25 mg/g). The total flavonoids in water alcohol extricate are due to the high ethanol resistance of phenolic compounds for diverse sorts of natural products compared to other solvents [32].

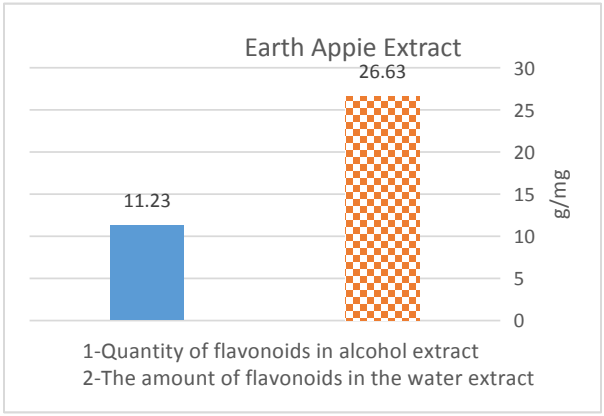

Figure 2. Total flavonoids content of Earth Apple extract

3.3 Antioxidant Activity

Figure 3 shows the effectiveness of antioxidants between prepared extracts, industrial antioxidants, and alcohol and water extracts. Oil extracts from the Earth Apple gave the highest antioxidant effect of 88.32% and was lower than BHT 96.21%. The water extract of the Earth Apple gave an antioxidant effect of 77.41%. The contrasts between water and alcohol extracts in antioxidant viability values may be due to the nature and concentration of phenolic compounds found in plants as well as to the sort and nature of the dissolvable [33,34].

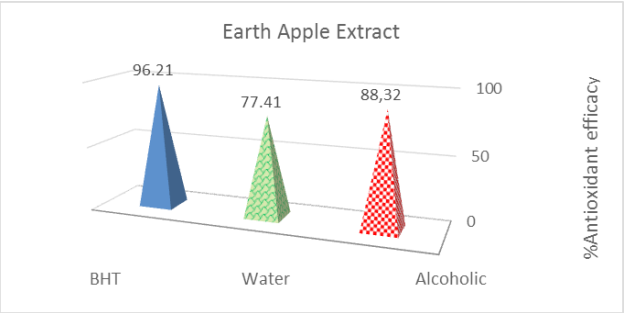

Figure 3. Antioxidant efficacy in the extract of water and alcohol.

3.4 Obstruction of Oil Oxidation

3.4.1 Palm Oil

Table 1 shows the effect of alkaline extract of pheno-

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lic substances (T1, T2, T3) in concentrations (0.1, 0.15, 0.2) as well as the T4 water extract at a concentration of 0.2% and compared with the control sample T5 (without addition) and another sample T6 added (BHT) to the values of peroxide of Palm oil stored for periods (15, 30, 45, 60) day and temperature of 45 °C the results showed that the T3 concentration was higher than 0.2% for the 60 day storage period of 2.81 Meq/kg oil compared to the T6 treatment using industrial antioxidants (BHT) of 3.02 Meq/kg oil if there were no significant differences at 0.1, Compared to the control sample of 11.0 Meq/kg of olive oil for 60 days, with significant differences between the results this means that natural substances can be used instead of industrial materials to preserve oils and get better results without side effects on public health because the antioxidant mechanism inhibits oil oxidation during storage periods due to its interaction with free radicals or decomposition of peroxides or formation of complexes with metal ions [35]. Research showed that the value of peroxide in olive oil and canola oil was about 10.62.5.73 Meq/kg oil respectively [36].

Table 1. Effect of the Earth Apple extract Peroxide values (Meq/kg) for Palm Oil for different storage periods and storage grade 45°C

Storage Duration (Day)	Treatment						**Oil*-Fruit**
	T1	T2	T3	T4	T5	T6	
0	6.04	6.04	6.04	6.04	6.04	6.04	--
15	5.42	5.11	4.83	4.42	8.04	3.02	5.14
30	4.11	3.41	2.83	3.03	8.04	3.02	4.07
45	3.42	3.41	3.04	4.02	8.42	3.02	4.22
60	4.42	3.02	2.81	3.01	11.00	3.02	4.54

(T1) %0.1 Alcoholic (T2) 0.15 %Alcoholic (T3) 0.2 % Alcoholic (T4) 0.2 % water (T5) Control (T6) 0.2% BHT

3.4.2 Sun Flower Oil

Table 2 appears the impact of Earth Apple extricate on the peroxide values of sunflower Oil for distinctive capacity periods and at 45°C all medications appeared an viable anti-oxidant impact of sunflower oil and essentially compared to the control test T5 and the mechanical antioxidant T6, comes about appear that all concentrations appeared inhibitory viability to repress oil oxidation but to shifting degrees based on concentrations antioxidant action expanded with expanded concentration. there was no noteworthy contrast between the peroxide values of the most elevated concentration and its esteem with the mechanical antioxidant, whereas there was a quick increment within the peroxide esteem of the T5 control test 18.0 Meq/kg and medications (T1, T2, T3, T4) appeared the next impact of mechanical cancer prevention agents amid the 60 day capacity period (3.43, 3.22, 3.22, 4.03) Meq/kg, whereas T6 (4.80 Meq/kg) in this respect, plant extracts have appeared tall antioxidant movement due to their capacity to restrain oxidation of fat and oils for their capacity to tie press, which is among the compounds that are characterized by compelling phenolic compounds in these plant extracts [37].

Table 2. Effect of Earth Apple extract on peroxide values (Meq / kg) for Corn Oil for different storage periods and storage grade 45 °C

Storage Duration (Day)	Treatment						Oil*Fruit
	T1	T2	T3	T4	T5	T6	
0	8.10	8.10	8.10	8.10	8.10	8.10	
15	5.41	4.62	4.21	5.00	11.03	3.00	5.54
30	6.02	4.43	3.60	3.02	16.04	3.00	6.01
45	5.02	4.62	4.40	3.02	16.05	3.00	601
60	3.43	3.22	3.22	4.03	18.00	4.80	6.11

(T1)%0.1 Alcoholic (T2) 0.15 %Alcoholic (T3) 0.2 % Alcoholic (T4) 0.15 % water (T5) Control (T6) 0.2% BHT

4. Statistical Analysis

Complete Randomized Design (C.R.D) was used to analyze all the studied factors as statistically analyzed. These factors were tested using a least significant difference (L.S.D.) at a probability level of 0.05 [38].

5. Conclusions

The results showed that the quantities of phenols extracted alcoholic higher than the extraction of water from the Earth Apple, and added to different concentrations helped to an increase in stability for vegetable oils more than 60 days at a temperature of 45 °C.

References

[1] Young, A. J.; D. M. Phillip, and G. M. Lowe. (2004). Carotenoid Antioxidant Activity. Pp. 105-126. In: Krinsky, N. I.; S. T. Mayne, and H. Sies. (eds.) Carotenoids in Health and Disease. Marcel Dekker Inc., NY., USA. PP: 551.

[2] Linting, J.V., (2004). Conversion of Carotenoids to Vitamin A:New Insights on the Molecular Level. PP. 337-356. In: Krinsky, N. I.; S. T Mayne, and H. Sies. (eds.). Carotenoids in Health and Disease. Marcel Dekker Inc., NY., USA. PP: 551.

 DOI: https://doi.org/10.30564/jrb.v3i2.3030

[3] Hager T.J., Howard L.R. (2006). Processing Effects on Earth Apple Phytonutriens. Horticultural Science, 41: 74-79.

[4] Sharma K.D., Karki S., Thakur N.S., Attri S. (2012). Chemical composition, functional properties and processing of. Earth Apple J. of Food Science and Technology, 49: 22-32.
DOI: 10.1007/s13197-01103107.

[5] Leja M., Kaminská I., Kramer M., Maksylewicz-Kaul A., Kammerer D., Carle R., Baranski R. (2013). The Content of Phenolic Compounds and Radical Scavenging Activity Varies with Carrot Origin and Root Color. Plant Foods Human Nutrition, 68: 163-170.
DOI: 10.1007/s11130-013-0351-3.

[6] Da Silva Dias, J. C. (2014). Nutritional and health benefits of Earth Apple and their seed extracts. Food and Nutrition Sciences, 5(22), 2147.

[7] Augspole, I., Rackejeva, T., Kruma, Z., & Dimins, F. (2014). Shredded carrots quality providing by treatment with Hydrogen peroxide. In 9th Baltic Conference on" Food for Consumer Well-Being" FOODBALT (pp. 150-154).

[8] Tanaka T., Shnimizu M., Moriwaki H. (2012). Cancer Chemoprevention by Carotenoids. Molecules, 17: 3202-3242.
DOI: 10.3390/molecules17033202.

[9] Fiedor J., Burda K. (2014). Potential Role of Carotenoids as Antioxidants in Human Health and Disease. Nutriens, 6:466-488.
DOI: 10.3390/nu6020466.

[10] Baranski, R., Allender, C., & Klimek-Chodacka, M. (2012). Towards better tasting and more nutritious carrots: Carotenoid and sugar content variation in carrot genetic resources. Food research international, 47(2), 182-187.

[11] Halfi, Sawsan Ali Hamid (2009). Extraction, separation and diagnosis of phenolic compounds and their derivatives from vegetable sources and their use in microbes and microbial inhibitors and their application in food systems.

[12] Ramli, S. (2006). Total phenolic content and antioxidant activity of flavonoids isolated from leaves of selected citrus species. Msc. Thesis. , University Putra, Malaysia.

[13] Kähkönen, M.P.; Hopia, A.I.; Vuorela, H.J.; Rauha, J.P.; Pihlaja, K.;Kujala, T.S and Heinonen, M. (1999). Antioxidant activity of plant extracts containing phenolic compounds . J. Agric. Food Chem. 1999 , Vol.47, No.10,pp. 3954-3962.

[14] Ndhlala, A. R., Moyo, M., & Van Staden, J. (2010). Natural antioxidants: fascinating or mythical biomolecules?. Molecules, 15(10), 6905-6930.

[15] Bouaziz, M., Feki, I., Ayadi, M., Jemai, H., & Sayadi, S. (2010). Stability of refined olive oil and olive-pomace oil added by phenolic compounds from olive leaves. European Journal of Lipid Science and Technology, 112(8), 894-905.

[16] Neo Y,P, Ariffin A, Tan C..P,, and Tan, Y.A. (2010). Phenolic acid analysis and antioxidant activity assessment of oil palm (E. guineensis) fruit extracts. Food Chem.Vol. 122(1):353-9.

[17] De Souza A., L.A., M.L.M. Carvalho, C.A.G. Crislaine Aparecida Gomes Pinto, V.Y. Kataoka and T.T.A. Silva, (2013). Deterioration of sunflower seeds during storage. Journal of Seed Science, 35(2): 240-247.

[18] Moreal,R.A., Singh.v., Eckhoff.S.R., Powell.M.J., Hicks. K.B and Norton.R.A (1990). A comparison of yield and composition of oil exctracted from corn fiber and corn fiber bran.Cereal chemistry, 76: 449-451.

[19] Lowell, B.K. (2006). The change in the peroxide values of corn and cottonseed oils under various storage conditions. J. Am. Oil. Chem. Soc. 10(4): 66-68.

[20] Nwobi BE, Ofoegbu O, Adesina OB (2006). Extraction and Qualitative Assessment of African Sweet Orange Seed Oil. Afr. J. Food Agric. Nutr. Dev. 6(2).

[21] Orthoefer.F.T, Sinram.R.D. eds Waston S,A. and Ramstad P.E.,(1987). corn oil: composition, processing and ultilization, in corn, chemistry and technology American Association of cereals chemists, St Paul, MU, 535-552.

[22] Elmastas, M.; Cinkilic, S. and Aboul – Enein, H. Y.(2015). Antioxidant Capacity and Determination of Total Phenolic Compounds in Daisy (Matricaria Chamomilla, Fam. Asteraceae). World J. of Analytical Chemistry, 3: 9-14.

[23] Moussawi, Umm al-Humad Humaid Jaber and Al-Halafi, Sawsan Ali Hamid (2012). The use of some plant extracts as microbial inhibitors and natural oxidants. Basrah Agricultural Sciences .25 (Special No. 3) .826-835.

[24] Slinkard, K. and Singleton, V. L. (1997). Total phenol analyses: Automation and caparison with manual methods. American. J. Enology and viticulture, (28):49-55.

[25] Huang,D.;Lin,C.;Chen,H.and Lin,Y.H.(2004).Antioxidant and antiproliferative activities ofsweet potato (Ipomoea batata L.) Lam(Tainong 57) constituents. Bot .Bull.Acad.Sin. 45: 179-186.

[26] Moussawi, Umm al-Humad Humaid Jaber and Al-Halafi, Sawsan Ali Hamid (2012). The use of some plant extracts as microbial inhibitors and natural oxidants. Basrah Agricultural Sciences .25 (Spe-

DOI: https://doi.org/10.30564/jrb.v3i2.3030

cial No. 3) .826-835.

[27] Osawa, T. and Namiki, M. (1981). Anovel type of antioxidants isolated from leaf wax of Eucalyptus leaves. Agri. Biol. Chem, 45: 735-739.

[28] Scott, G. (1965). Atmospheric oxidation and antioxidant. Elsevier Publishing. New York.

[29] Assocaition of Official Analaytical Chemists A.O.A.C. (2008). Official Methods of Analysis 16thed. Assocaition of Official Analaytical Chemists International Arligton, Virginia, U.S.A.

[30] Cai, Y., Z.; Luo, Q.; Sun, M. and Corke, H. (2004). Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer. Life Sci., 74: 2157-2184.

[31] Tawaha, K., Alali, F.Q., Gharaibeh, M., Mohammad, M.and El-Elimat, T. (2007). Antioxidant activity and total phenolic content of selected Jordanian plant species. Food Chemistry 104: 1372-1378.

[32] Nickavar, B. and Abolhsani, F. A. (2009). Screening of Antioxidant properties of seven umbellferae fruits from Iran. Pak. J. pharm. Sci., 22: 30-35.

[33] Al-Mudhafr ,A.W.H, ; Shaymaa M. AL-Selawi, and Hameed. A. H. Al-Hjar (2019) Study the Effect of Phenolic Compounds Extracted From Carrot Plant and Assess Their Effectiveness as Antioxidant Plant Archives , 19 (2), 864 - 868.

[34] Kähkönen, M.P.; Hopia, A.I.; Vuorela, H.J.; Rauha, J.P.; Pihlaja, K.;Kujala, T.S and Heinonen, M. (1999). Antioxidant activity of plant extracts containing phenolic compounds . J. Agric. Food Chem. , Vol.47, No.10,pp. 3954-3962.

[35] Erminda T., Maria A., Keysson V.F., Denise M. G. Freire, A. M. and Apostolis A. K. (2019) Extraction of Phenolic Compounds from Palm Oil Processing Residues and Their Application as Antioxidants, Food Technology and Biotechnology Vol. 57(1) pp:1-21.

[36] Roiaini, M., Ardiannie, T., & Norhayati, H. (2015). Physicochemical properties of canola oil, olive oil and palm oil blends. International Food Research Journal, 22(3).

[37] Al-Mudhafr, A.W.H. (2019) Studying the properties of the active compounds extracted from the seeds of some root plants and the effect of preserving sun flower oil, Journal of Food and Nutrition Research 7 (8), 573-578.

[38] Genstat,(2009) General Statistical Genstat Guides Vol. 12 Copyright 2009, VSV ,international Ltd.UK .

 DOI: https://doi.org/10.30564/jrb.v3i2.3030

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ARTICLE

Folk Medicinal Plants Used by Local Herbalists in and around Rajshahi Metropolitan City, Bangladesh

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ABSTRACT

Folk medicinal plants used by local herbalists in and around Rajshahi metropolitan city were recorded. The study include 111 medicinal plants used to cure various diseases such as diarrhea, diabetes, toothache, fever, worm, snake-bite, blood disease, cough, menstrual disease, wound, itches, chicken pox, constipation, dysentery, eczema, piles, sex problems, skin diseases, headache, anemia, burning sensation, bronchitis, paralysis, jaundice, asthma,etc. Finally, this study shows that traditional medicine really contributes to the health care of the population and deserves to be accompanied. The identified medicinal plants will guide future research into natural substances for the development of improved traditional medicines.

1. Introduction

Traditional medicine as identified by the World Health Organization (WHO) "Total of knowledge, skills, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement of treatment of physical and mental illness" [16].

The fact has proved that the ethnic communities around the world owning their own culture based on that they developed their system of medical practices, which are being addressed as folk and ethno-medicines. There are numerous medicinal plants available in their surroundings and those herbs are being used by the tribal community as medicine for curing their diseases. The local people lived in a forest environment for many generations and developed their knowledge of the flora and fauna of the forest that is known as folk or indigenous knowledge. At the same time, they have developed folk beliefs based on traditional practices that helped them in curing various forms of diseases. The beliefs and practices related to curing disease which are based on unwritten knowledge are carried from generation to generation through the practitioners [7]. Various research work on traditional medicinal plants was carried out in Bangladesh by [2,4,5,11,12,15,17-31]. The present document was undertaken to record the traditional medicinal plants used by local herbalists in and around Rajshahi metropolitan city, Bangladesh.

2. Materials and Methods

2.1 Study Area

Rajshahi is a metropolitan city, and a major urban,

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commercial and educational centre of Bangladesh. It is also the administrative seat of eponymous division and district. Located on the north bank of the Padma River, near the Bangladesh-India border, the city has a population of over 763,952 residents. The city is surrounded by the satellite towns of Nowhata and Katakhali, which together build an urban agglomeration of about 1 million populations. Arguably Rajshahi is the most clean and green among the cities in Bangladesh [3].

2.2 Methodology

The present investigation focused on traditional medicinal plants in and around Rajshahi metropolitan city, Bangladesh during July 2017 to December 2018 to collect information on the medicinal uses of different plant species. A total of 111 species belonging to 102 genera under 55 families were recorded. Medicinal information was obtained through semi-structured interviews with knowledgeable traditional healers. A total of 19 local herbalists having an age range 32-78 years were interviewed using semi-structured interviewed method [32] Plant parts with either flower of fruits collected using traditional herbarium techniques to make voucher specimens for documentation and voucher specimens have been preserved at Herbarium of Rajshahi University.

2.3 Identification

Collected specimens have been critically examined, studied and identified. Identifications have been confirmed by consulting standard literatures [8,14,1]. Nomenclature has been updated following recent literature [1,9,13].

3. Results and Discussion

Folk medicinal plants used by local herbalists in and around Rajshahi metropolitan city, Bangladesh was carried out from July 2017 to December 2018. A total of 111 plant species under 102 genera and 55 families were recorded. Distribution of angiosperm species in the families shows variation. The family Fabaceae and Euphorbiaceae represented by 6 species each. Each of Moraceae and Apocynaceae is represented by 5 species. Each of Asteraceae and Amaranthaceae is represented by 4 species. Each of Lamiaceae, Acanthaceae Zingiberaceae, Liliaceae, Piperaceae Malvaceae, Caesalpiniaceae, Combretaceae, Rutaceae, Solanaceae and Verbenaceae is represented by 3 species. Each of Lauraceae, Cucurbitaceae, Mimosaceae, Myrtaceae, Anacardiaceae, Oxalidaceae, Apiaceae, Convolvulaceae, Araceae and Poaceae is represented by 2 species. A single species in each was recorded by 30 families (Table 1). Out of 111 species, 41.73% species were used in herbs, followed by 17.92% shrubs, 7.79% climbers and 31.27% trees (Figure 1). For each species local name, scientific name, family, habit, ailments, treatment process and part (s) used are provided.

Use of plant parts as medicine shows variation. Leaves (49.89%) are the leading part used in a majority of medicinal plans followed by Bark (15.92%), fruits (19.70%), root (17.32%), seed (12.88%), stem (8.68%), whole plants (16.82%), flowers (3.53%), leaf stalk (0.99%), rhizome (2.53%), gum (3.53%), petiole (2.53%), tuber (1.65%), bulb (1.65%), latex (1.65%), bud (0.99%) (Figure 2). The survey has also recorded 66 categories of uses of 111 medicinal plants. Out of 66 diseases, fever (20.82%), dysentery (18.11%), cough (11.83%), diarrhea (9.99%), asthma (8.32%), diabetes (7.89%), skin disease (7.50%) and jaundice (6.53%) (Figure 3).

The result of this information showed that these local people of study area still depend on medicinal uses of plants for the treatment of burning sensation, diabetes, bronchitis, weakness, insects and snake bite, high blood pressure, asthma, passing of semen, gonorrhea, skin diseases, jaundice, headache, glandular swelling, diarrhea, acidity, dry cough, cancer, dysentery, scabies, menstrual disorder, tumors, leucoderma, catarrhal fever, chronic fever, malarial fever, toothache, burning wounds, stomachic, stomachache, piles, fever, epilepsy, gout, rheumatism, traumatic injury, abortion, vomiting, bleeding gums, ulcer, anemia, ring worm, hiccup, pneumonia, gastritis, tuberculosis, arthritis, heart disease, abdominal pain, hypertension, paralysis, constipation, baldness, sore, dyspepsia, chicken pox, pain, pyorrhea, eczema, cholera, flatulence, scurvy, intoxication, indigestion, whooping cough, digestive system disorders, liver disorders, intestinal worms, worms, gastrointestinal disorders, edemas, alterative and attendant, wound and injury, menstruation, cold, lung infection, dysuria, edema, bleeding, heavy bleeding, kidney, eye inflammation, boils, mouth freshener, bruises, high cholesterol, dry skin, hepatitis, hair fall, cough and many types of diseases.

Most of the species were used for the treatment of different diseases are *Polyalthia longifolia, Cinnamomum tamala, Litsea glutinosa, Peperomia pellucida, Piper betel, Piper longum, Kalanchoe pinnata, Nigella sativa, Nymphaea nouchali, Tinospora cordifolia, Argemone mexicana, Ficus religiosa, Ficus benghalensis, Ficus hispida, Ficus racemosa, Artocarpus heterophyllus, Boerhaavia diffusa, Amaranthus spinosus, Amaranthus viridis, Achyranthes aspera, Enhydra fluctuans, Basella alba, Glinus oppositifolius, Polygonum hydropiper, Aborma augusta, Bombax ceiba, Hibiscus rosa-sinensis, Abelmoschus esculentus, Sida cordifolia, Coccinia grandis, Momordica*

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charantia, Brassica napus, Moringa oleifera, Mimusops elengi, Diospyros malabarica, Acacia nilotica, Mimosa pudica, Cassia fistula, Tamarindus indica, Saraca indica, Cajanus cajan, Lablab purpureus, Erythrina variegata, Dalbergia sissoo, Butea monosperma, Clitoria ternetea, Lowsonia inermis, Punica granatum, Psidium guajava, Syzygium cumini, Terminalia arjuna, Terminalia chebula, Terminalia belerica, Acalypha indica, Euphorbia hirta, Jatropha gossypifolia, Phyllanthus emblica, Phyllanthus reticulatus, Ricinus communis, Cissus quadrangularis, Litchi chinensis, Mangifera indica, Spondias pinnata, Azadirachta indica, Citrus aurantifolia, Aegle marmelos, Feronia limonia, Averrhoa carambola, Oxalis corniculata, Centella asiatica, Coriandrum sativum, Swertia chirata, Catharanthus roseus, Rauvolfia serpentina, Alostonia scolaris, Nerium indicum, Carissa carandus, Calotropis procera, Datura metel, Solanum nigrum, Capsicum frutescens, Ipomoea aquatica, Ipomoea batatas, Heliotropium indicum, Clerodendrum viscosum, Vitex negundo, Lantana camara, Ocimum sanctum, Leucas aspera, Leonurus sibiricus, Nyctanthes arbortristis, Andrographis paniculata, Justicia gendarussa, Adhatoda vasica, Tridax procumbens, Wedelia chinensis, Tagetes erecta, Eclipta alba, Areca catechu, Colocasia esculenta, Alocasia indica, Cyperus rotundus, Cynodon dactylon, Saccharum officinarum, Ananas comosus, Musa sapientum, Curcuma longa, Zingiber officinale, Amomum subulantum, Allium cepa, Allium sativum, Aloe barbadensis (Table 1). The collected information is comparable with the result of other studies in Bangladesh like [2,4,5,10,11,12,15,6,17-31].

Table 1. Investigated medicinal plants used by the local herbalists in the study area

Bangla name	Botanical name and Family name	Habit	Parts Used	Ailments & Treatment Process
Ada	*Zingiber officinale* Roscoe (Zingiberaceae)	Herb	Rhizome	**Indigestion:** Rhizome powder is taken internally [2]. **Cold and Cough:** Corm juice is taken [5]. **Cattarhal fever:** Ginger juice mixed with leaf juice of *Ocimum sanctum* and honey is taken orally [29]. **Gout:** Warm paste of rhizome with cotton seed is applied externally [28].
Akando	*Calotropis procera* (Aiton) W.T. Aiton (Asclepiadaceae)	Shrub	Leaf	**Arthiritis:** Warm mustard oil with salt and leaves are taken externally [26]. **Paralysis:** Warm leaf paste is taken externally [28]. **Rheumatism:** Gums mixed with *Brassica napus* oil used internally [22].
Alach	*Amomum subulatum* Roxb. (Zingiberaceae)	Herb	Seed, Fruit, pod	**Mouth freshener, Nausea, motion sickness & Cough:** Powder of seeds is taken orally [10, 11].
Anarosh	*Ananas comosus* (L.) Merr. (Bromeliaceae)	Herb	Flower, Leaf, Fruit	**Fever:** Fruits are taken internally [17]. **Abortion:** Young flower extract is taken internally [21].
Apang	*Achyranthes aspera* L. (Amaranthaceae)	Herb	Stem, Leaf, Root	**Jaundice:** Juice of leaves is taken internally [24]. **Tonsillitis:** The crushed leaf mixed with water and filtrate is taken [19]. **Traumatic injury:** Root decoction is taken internally [5].
Arhar	*Cajanus cajan* (L.) Millsp. (Fabaceae)	Shrub	Leaf, Seed	**Piles:** Leaf paste is taken [17]. **Jaundice and pneumonia:** Leaf juice is taken orally [20]. **Bowels:** Seed paste is taken externally [25]. **Mother milk secretion:** Decoction leaves and seeds are taken orally [31].
Amra	*Spondias pinnata* (L.f.) Kurz. (Anacardiaceae)	Tree	Bark, Root	**Diarrhea, Dysentery and Vomiting:** Infusion of the bark is taken [30]. **Gonorrhea:** Decoction of the bark is taken orally [23]. **Menstruation:** Roots are use in regulating menstruation [24].
Aakh	*Saccharum officinarum* L. (Poaceae)	Shrub	Stem	**Jaundice:** Stem juice is taken internally [25].
Arjun	*Terminalia arjuna* (Roxb.) Wight & Arn. (Combretaceae)	Tree	Bark	**Blood pressure & Heart disease:** Extract of stem bark is taken orally [17].
Amm	*Mangifera indica* L. (Anacardiaceae)	Tree	Gum, Leaf	**Fever, Diarrhea and Toothache:** Decoction of the leaves is taken internally [18]. **Skin disease:** Gum paste is used externally [22].
Amrul	*Oxalis corniculata* L. (Oxalidaceae)	Herb	Leaf	**Stomach pain:** Decoction of leaves mixed with water is orally taken for the treatment of stomach pain [27]. **Scurvy:** Leaves juice is taken orally to cure scurvy [29].
Amloki	*Phyllanthus emblica* L. (Euphorbiaceae)	Tree	Fruit, Bark, Leaf	**Diabetes:** Green fruits and cumbered dry fruits can be used for treatment of diabetes [23]. **Stomach problem:** Fruit powder and bark juice is taken orally [21]. **Toothache problem:** Young fruits are taken orally. **Scurvy:** Green fruit is taken internally [10].

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Bangla name	Botanical name and Family name	Habit	Parts Used	Ailments & Treatment Process
Ashok	*Saraca indica* L. (Caesalpiniaceae)	Tree	Bark, Root	**Abortion:** Powder of dried bark is taken internally [2]. **Anemia:** Bark extracts mixed with 1 teaspoon sugar and 1 glass of milk is taken orally [27]. **Dysentery:** Root extracts mixed with water is taken [31].
Babla	*Acacia nilotica* (L.) Willd ex Delile (Mimosaceae)	Tree	Bark, Leaf, Bark	**Bronchitis:** Bark extracts is taken orally [21]. **Dysentery:** Pods are taken internally [11]. **Leucoderma:** Leaf decoction is taken [25].
Badarlathi	*Cassia fistula* L. (Caesalpiniaceae)	Tree	Young Leaf, Fruit, Bark	**Ringworms:** Juice of young leaves is taken orally [24]. **Gout:** Fruits pulp is taken [5]. **Constipation:** Leaf decoction is taken orally [12]. **Diabetes:** Decoction of bark mixed with water is taken [17].
Bhat	*Clerodendrum viscosum* Vent. (Verbenaceae)	Shrub	Leaf, Root	**Asthma, tumors and skin diseases**: Leaf and root paste is taken externally [20]. **Hair disease:** Leaf paste is applied [23].
Basak	*Justicia adhatoda* L. (Acanthaceae)	Shrub	Whole plant specially leaf	**Cough and Fever:** Leaf juice is taken internally [18]. **Piles:** The extract or juice of plant is used in bleeding piles [30].
Bel	*Aegle marmelos* (L.) Correa (Rutaceae)	Tree	Fruit, Root	**Stomachache:** Unripe wood apple is made pieces and used in stomachache [4]. **Constipation:** Ripe wood apple is made juice and taken to cure constipation [10]. **Diarrhea:** Extract of root is taken. **Heart disease:** Root juice is taken internally [23].
Bot	*Ficus benghalensis* L. (Moraceae)	Tree	Latex, Root, Bud	**Rheumatic pain:** Latex is applied externally [12]. **Vomiting:** A tip of the hanging roots crushed and mixed with water is used for obstinate vomiting [19]. **Malaria:** Grinding, decoction of young buds; taken orally for malaria [25].
Bohera	*Terminalia bellirica* (Gaertn) Roxb. (Combretaceae)	Tree	Green fruit	**Cough: Green fruit decoction is** taken orally [26].
Berela	*Sida cordifolia* L. (Malvaceae)	Herb	Whole plant	**Asthma:** 10 g root juice smeared and boiled in 4-5 cup of water till it comes to 2 cup, filtered and the decoction is taken twice daily for 1 month [27]. **Bleeding Piles:** 5-6 young leaves are crushed and applied on the affected area at least 15-20 days [29]. **Gonorrhea:** 2-3 seedlings are boiled in a 1 liter of water till it comes to 250 ml then the solution taken orally in early morning [19]. **Rheumatism:** 2-3 saplings are finely crushed mixed with little amount of mustered oil, boiled it and then the solution is taken orally for 4-5 days [22].
Bherenda	*Ricinus communis* L. (Euphorbiaceae)	Shrub	Leaf, seed	**Jaundice:** Leaf juice is taken orally [30]. **Dysentery:** Juice of tender leaves mixed with sugar is orally taken to cure Dysentery [31]. **Constipation:** Seed oil is used internally for the treatment of constipation [23].
Bokul	*Mimusops elengi* L. (Sapotaceae)	Tree	Stem-bark	**Swelling:** Stem bark decoction is taken [12]. **Asthma:** Flowers smell is used to cure asthma by smoking [19].
Chotra	*Lantana camara* L. (Verbenaceae)	Shrub	Leaf	**Wound:** Grind the leaves with turmeric and salt and apply it twice a week to the wounds [24].
Chirata	*Swertia chirata* L. (Gentianaceae)	Herb	Whole plant	**Fever:** Whole plant juice is taken internally [20]. **Vomiting: R**oot juice mixed with honey is taken orally [21].
Chitki	*Phyllanthus reticulatus* Poir. (Euphorbiaceae)	Shrub	Leaf, Root	**Diarrhea:** 100 g leaves are soaked into 3 cups of water for overnight and then administered internally [12]. **Malaria:** 20 gm root is boiled with 4-5 cups of water till it comes to 1 cup and half of the liquid is administered orally in early morning and other half in the evening for 4-5 days [22]. **Epilepsy:** 10 gm roots are crushed and soaked in a 1 liter of water for 10-12 hours and then the solution taken 4-5 days [27].
Chatim	*Alstonia scholaris* (L.) R. Br. (Apocynaceae)	Tree	Bark, Gum, Root	**Ulcers:** The milky juice of gum is taken orally to cure ulcers [26]. **Cancer:** Root extracts is taken orally to cure cancer [28]. **Rheumatism:** Dry bark, salt, and *Piper nigrum* crushed them with water and made a paste used for rheumatism [23]. **Gastric problem:** Bark (50 mg) is mixed with sufficient salt and administered once daily for 5 days [19].
Dherosh	*Abelmoschus esculentus* (L.) Moench (Malvaceae)	Herb	Fruit	**Stomachic:** Water, sugar mixed with fruit juice is taken [25]. **Female weakness:** Young fruits use as a vegetable at lunch regularly for a month [26]. **Hair fall:** Paste of young fruits used on head regularly [28]. **Constipation:** Young fruits use as a vegetable regularly [12].

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Bangla name	Botanical name and Family name	Habit	Parts Used	Ailments & Treatment Process
Dhone	*Coriandrum sativum* L. (Apiaceae)	Herb	Seed, Whole Plant	**Asthma:** Whole plant extract is taken [2]. **Sneezing:** Coriander seeds mixed with ginger, jeera, pepper and milk make juice, it taken internally [25]. **Cold & Fever:** Whole plant juice mixed with salt is taken [27].
Durba ghas	*Cynodon dactylon* (L.) Pers. (Poaceae)	Herb	Whole plant	**Stop bleeding:** Whole plant paste is taken externally [11].
Dalim	*Punica granatum* L. (Punicaceae)	Tree	Fruit, stem, Leaf, Seed	**Dysentery:** Dried fruit decoction is taken [4]. **Dry cough:** Dry leaf powder is taken orally [18]. **Stomach pain:** Three to four young twigs are eaten with little salt twice a day for a week [20]. **Heart and throat pain**: The seeds juice is considered a tonic for the heart and throat [12].
Debdaru	*Polyalthia longifolia* (Sonn.) Thw. (Annonaceae)	Tree	Bark	**Fever:** The bark is used as a febrifuge in the treatment of fever [26].
Dudhia	*Euphorbia hirta* L. (Euphorbiaceae)	Herb	Whole plant	**Dysentery:** Whole plant is used to make paste and taken 3 times a day to cure dysentery [28]. **Bronchitis:** Grinding decoction of whole plant is taken to cure bronchitis once daily for a week [31].
Dhutra	*Datura metel* L. (Solanaceae)	Shrub	Leaf	**Rheumatic pain:** Paste of leaves is taken externally [4]. **Asthma:** Leaf smoked is taken [10]. **Skin disease:** Datura and Neem Leaf paste is applied externally [23].
Gaikhura	*Amaranthus viridis* L. (Amaranthaceae)	Herb	Whole plant	**Acidity:** Leaves are boiled with roots and smashed then taken [17]. **Leprosy:** Whole plant juice taken internally [29].
Genda	*Tagetes erecta* L. (Asteraceae)	Herb	Whole plant	**Bleeding:** Leaf paste is taken externally [12]. **Pain:** Leaves are smashed and the paste is applied on the blotch after slight warming to make it lighter to burst out and reduces the pain [31]. **Tuberculosis:** About 250 mg leaves powder mixed with little amount of goat-milk and have to be taken [23]. **Dysentery:** 2 teaspoonful's leaves juice mixed with 2 teaspoonfuls's of sugar is taken [25].
Ghrito kumari	*Aloe vera* (L.) Burm. f. (Liliaceae)	Herb	Leaf	**Paralysis:** Leaf extract is taken orally [18]. **Jaundice:** Juice of leaf is taken internally [24]. **Weakness:** Juice of leaf mixed with sugar is taken [22]. **Skin care:** Leaf paste is taken externally [5]. **Hair fall:** Juice of leaves is used for hair fall solution and mode silky and shines [26].
Gaab	*Diospyros malabarica* (Desr.) Kostel. (Ebenaceae)	Tree	Fruit, Leaf, Stem	**Dyspepsia:** About 15 mg fruit powder macerated with little amount of water to make a paste and then taken orally twice daily for 3-4 days [30]. **Cough:** Approx. 2 gm of leaves powder is boiled in 5 cup of water till it come to the 2 cup than half of the liquid is administered orally in early morning and other in the evening for 7 days [31].
Gima shak	*Glinus oppositifolius* (L.) Aug. DC. (Molluginaceae)	Herb	Leaf	**Fever:** Fried leaves are eaten to cure several fevers [21]. **Body pain:** Juice of leaves is orally taken to relief from body pain [17]. **Earache:** Castor oil and whole plant warm juice is taken [11].
Guloncho	*Tinospora cordifolia* (Thunb.) Miers (Menispermaceae)	Climber	Stem, Leaf Stalk	**Passing of semen:** Stem juice mixed with milk is taken orally. **Diabetes:** Powder obtained from feaf stalk r mixed with neem paste is taken [31,23]. **Jaundice:** Leaf juice is taken orally [26]. **Pain and Edema:** The plant oil is effective in reducing pain and edema [28].
Hatisur	*Heliotropium indicum* L. (Boraginaceae)	Herb	Leaf	**Dog bite:** Leaf juice is taken externally [25]. **Insects bite:** Leaf juice mixed with 5 gm *Ricinus communis* oil is taken externally [24,11].
Haritaki	*Terminalia chebula* Retz. (Combretaceae)	Tree	Seed, Fruit	**Vomiting:** Seed powder mixed with honey is applied orally [22]. **Dysentery:** Fruit powder mixed with hot water is taken [27].
Harjora	*Cissus quadrangularis* L. (Vitaceae)	Climber	Whole plant	**Irregular menstruation:** Juice obtained from stem is taken internally [20]. **Stomachic:** Stem paste is taken internally [12]. **Indigestion:** Juice of leaves are mixed with water and orally used for indigestion [18]. **Piles:** Juice of leaves are orally used for recovery of piles [17].
Helencha	*Enhydra fluctuans* (Lour.) Spreng. Asteraceae	Herb	Whole plant	**Fever:** Curry made from whole plant is taken [10].

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Bangla name	Botanical name and Family name	Habit	Parts Used	Ailments & Treatment Process
Holud	*Curcuma longa* L. (Zingiberaceae)	Herb	Rhizome, Flower	**Eczema:** Rhizome paste is taken externally [19]. **Dysentery:** Powder made from rhizome mixed with hot rice, mustard oil and table salt is taken [23]. **Gonorrhea:** Paste of flower is taken [18]. **Gastric problem:** Fresh rhizome chewing with table salt [21].
Jagath madan	*Justicia gendarussa* Burm. f. (Acanthaceae)	Shrub	Leaf	**Headache:** Leaf is covered with mustard oil then that leaf is put on the forehead [5,18,31].
Jagdumur	*Ficus racemosa* L. (Moraceae)	Tree	Fruit	**Dry cough:** Curry made from young fruit is taken internally [24]. **Asthma:** Fresh fruit mixed with honey is taken [21]. **Diabetes:** Young dry fruit powder is taken orally [12].
Joba	*Hibiscus rosa-sinensis* L. (Malvaceae)	Shrub	Flower	**Burning wound:** Paste of flower is used for burning wound [11]. **Irregular menstruations:** Paste of flower mixed with water orally treated twice daily for two weeks [23]. **Cooling and astringent:** Powder obtained from flower buds mixed with water is taken internally [26]. **Hair treatment:** Paste of flower used orally for hair treatment [27].
Jamalkota	*Jatropha curcas* L. (Euphorbiaceae)	Shrub	Leaf, Seeds, Gums, Stems,	**Fever:** Juice made from Jamalgota leaf, lemon leaf and ata leaf mixed with hot water is taken [25]. **Worms:** Paste made from seeds is taken internally [28]. **Cancer:** Decoctions of leaves are used for anti-cancer [29]. **Constipation:** Gum mixed with liquid food and orally treated [22].
Jam	*Syzygium cumini* (L.) Skeels. (Myrtaceae)	Tree	Bark, Seed, Fruit	**Asthma:** Bark decoction is taken internally [24]. **Diabetes:** Seed paste is taken with sugar or a pinch of salt, fruits extracts taken daily against diabetes [31,23].
Kalomegh	*Andrographis paniculata* (Burm.f.) Nees. (Acanthaceae)	Herb	Leaf	**Fever, headache, diarrhea, and cholera:** Juice obtained from leaves is taken internally [24]. **Lung infections:** Decoction of leaf is taken orally [21]. **Leprosy:** Paste of leaf is taken externally [25].
Kamranga	*Averrhoa carambola* L. (Oxalidaceae)	Tree	Fruit, Leaf	**Piles:** After slicing the star fruit it has to be boiled in open sunlight for 1 week and to make dry powder out of it. Then 1.5 gm of that powder of star fruit has to be taken with one glass of water twice every day [17]. **Fever:** 2gm dry powder of star fruit leaves has to be taken with 1.2 cup of water every day morning and evening for ¾ days [20]. **Dysentery:** In an intense stage of these ailments 1 teaspoonful of extract or juice of ripens star fruit has to be taken to improve the situation [31]. **Liver pain:** 3-4 teaspoonful of ripen star fruit juice to be taken with water to improve this condition [21].
Karamcha	*Carissa carandas* L. (Apocynaceae)	Shrub	Fruit, Root, bark	**Diabetes:** Root bark decoction is taken orally [22]. **Wound:** Decoction of root bark is orally taken internally [12].
Katanotey	*Amaranthus spinosus* L. (Amaranthaceae)	Herb	Whole plant	**Toothache:** Whole plant decoction is taken [23]. **Dysentery:** Leaf juice is taken internally [10]. **Wounds:** Leaf paste is taken externally [31].
Kathal	*Artocarpus heterophyllus* Lam. (Moraceae)	Tree	Root, Leaf	**Diarrhea:** Decoction of roots is used internally in diarrhea [2]. **Skin disease:** Yong leaves paste used regularly on infected skin [5].
Kalokeshi	*Eclipta alba* (L.) Hassk. (Asteraceae)	Herb	Whole plant	**Diarrhea:** Leaf juice mixed with sugar or honey is taken [10]. **Constipation:** Pounded leaf mixed with cold water is taken [11]. **Hair treatment:** Leaf paste is applied externally [5].
Kochu	*Colocasia esculenta* (L.) Schott. (Araceae)	Herb	Leaf, Petiole	**Stop bleeding:** Leaf juice taken externally [17]. **Tumors & Cancer:** Leaf juice is taken internally [30].
Korobi	*Nerium oleander* L. (Apocynaceae)	Tree	Leaf, Root bark	**Ulcer & Joints pain:** Root bark paste is taken externally [25]. **Insect bite & Swellings:** Young leaf decoction is taken externally [18].
Kola	*Musa sapientum* L. (Musaceae)		Stem, Bark	**Stop bleeding:** Stem juice is taken [11]. **Snake bite:** Bark juice is taken externally [18].
Kalijeeri	*Nigella sativa* L. (Ranunculaceae)	Herb	Seed	**Blood pressure:** Seed oil is taken orally [20]. **Asthma:** Black seed is taken internally [31].
Korolla	*Momordica charantia* L. (Cucurbitaceae)	Climber	Whole plant	**Colic and fever:** Whole plant juice is taken [2]. **Diabetes:** Juice of the whole plant orally taken to treated diabetes. The leaves juice is taken orally daily for diabetes [12]. **Headache:** Root paste is used in headache [21]. **Stomachic:** Cooked fruits used as stomachic [30].

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Kolmi shak	*Ipomoea aquatica* Forssk. (Convolvulaceae)	Climber	Whole plant	**Jaundice and Bronchitis:** Dry leaf powder mixed with cold water is taken orally [24]. F**ever, Anthelmintic, Carminative, Leprosy, and Liver complaints**: Cooked vegetables are taken orally [31].
Kotbel	*Feronia acidissima* L. (Rutaceae)	Tree	Stem, Leaf, Fruit	**Piles:** Paste prepared from stem bark is applied externally [26]. **Vomiting:** Leaves juice is orally taken to control vomiting [28]. **Heart disease:** Fruits juice is orally taken to help heart disease and digestion [18].
Khoksha dumur	*Ficus hispida* L.f. (Moraceae)	Tree	Fruit	**Diabetes:** Juice of fruit mixed with water is taken orally [22]. **Jaundice:** Fruit decoction is applied [26].
Lajjaboti	*Mimosa pudica* L. (Mimosaceae)	Herb	Root, Leaf	**Diarrhea:** Root paste is taken [4]. **Piles:** Root juice is taken externally [18]. **Snake bites:** Root juice mixed with raw cow milk is taken internally [20]. **Muscular pain:** Decoction of leaf mixed with water is taken [21].
Lebu	*Citrus aurantifolia* (Christm.) Swingle (Rutaceae)	Shrub	Fruit	**Catarrhal fever:** Fruit juice mixed with honey is taken orally [24]. **Apetite:** Has to eat by making lemonade or may be taken with rice [21]. **Nausea:** Juice of fruits is taken internally [25]. **Stomachache:** Fruit juice mixed with water and taken it every morning in empty stomachache [23].
Luchipata	*Peperomia pellucida* Kunth. (Piperaceae)	Herb	Leaf	**Headache:** Crushed leaf is applied externally [12]. **Abdominal pains and Fever:** Leaf juice is taken [26].
Litchu	*Litchi chinensis* Sonn. (Sapindaceae)	Tree	Fruit	**Heart, brain and liver:** Fruits are tonic to the heart, brain and liver [28].
Mehedi	*Lawsonia inermis* L. (Lythraceae)	Shrub	Leaf	**Skin disease:** Leaf paste is taken externally [20]. **Hair treatment:** Leaves pastes are valuable external used in hair fall solution and make hair silky and shine [23].
Madar	*Erythrina orientalis* Murr. (Fabaceae)	Tree	Leaf, Root	**Joints pain:** Paste of leaves is applied externally to relief pain of the joints [12]. **Earache:** Leaves juice is poured into the ear to relief earache [21]. **Toothache:** Leaves juice is used to relief toothache [18]. **Nematode:** Extract of roots is taken once daily as much as patient can to control [29].
Mankochu	*Alocasia macrorrhizos* (L.) G. Don. (Araceae)	Herb	Fruit, Petiole	**Snakebite:** Paste of petiole used in affected area treated for snake bite [5]. **Fever:** Fried of fruit is taken to cure several fevers [17].
Mistialo	*Ipomoea batatas* (L.) Lam. (Convolvulaceae)	Climber	Tuber, Leaf	**Edema:** At least10-12 leaves are paste and used in the affected area for at least 1 month [25]. **Dysentery:** Sweet potato grained with appropriate amount of water and 1 teaspoonful filtered extract of it has to be taken 15-20 minutes alternately to treat the disease [28]. **Skin disease:** Tuber paste is taken externally [29].
Mohavringaraj	*Wedelia chinensis* (Osbeck) Merr. (Asteraceae)	Herb	Leaf	**Alopecia:** Leaf paste is taken externally [5]. **Stop vomiting:** Leaf juice mixed with salt is taken orally [29].
Morich	*Capsicum frutescens* L. (Solanaceae)	Herb	Leaf, Fruit	**Night blindness:** Juice of leaves is used to cure night blindness [17]. **Headache:** Leaves are used in headache on forehead [28]. **Blood dysentery:** Chili powder mixed with water and fried with hot rice is taken internally [26]. **Mouth disease:** Young fruit paste is taken [25].
Muktajhuri	*Acalypha indica* L. (Euphorbiaceae)	Herb	Leaf	**Ringworm:** Leaf juice is taken orally [24]. **Snake bite:** Leaf paste is applied externally [20].
Mutha	*Cyperus rotundus* L. (Cyperaceae)	Herb	Tuber, Root	**Fever:** Fresh root are crushed and boiled in 5 cup of water reduced to 3 cup then filtered it and the decoction has to be taken twice per day [31]. **Diarrhea:** About 5 gm of crushed root are soaked overnight in 3 cup of water and taken twice daily for 3-5 days [26]. **Wounds & Sores:** Macerated root paste is taken externally [22].
Nayantara	*Catharanthus roseus* (L.) G. Don. (Apocynaceae)	Herb	Whole plant	**Leukemia:** Whole plant is plucked and made juice which helps in leukemia [2,5,26].
Neem	*Azadirachta indica* A. Juss. (Meliaceae)	Tree	Leaf	**Chicken pox:** Leaf paste mixed warm water is taken externally [17]. **Jaundice:** Juice of leaf is taken [28]. **Pyorrhea:** Leaf decoction is taken [11]. **Skin disease:** Paste of leaf is taken externally [29].
Nishinda	*Vitex negundo* L. (Verbenaceae)	Shrub	Leaf	**Headache:** Tonic obtained from leaf is taken [18]. **Catarrhal fever:** Leaf decoction mixed with long pepper is taken [12].

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Oporajita	*Clitoria ternetea* L. (Fabaceae)	Climber	Root, Leaf	**Throat pain & Swelling:** Leaf paste is taken externally [23]. **Tuberculosis:** Root decoction is taken orally [27]. **Headache:** Leaf paste is taken externally [31].
Piaj	*Allium cepa* L. (Liliaceae)	Herb	Bulb	**Cold & Cough:** Warm bulb juice along with *Brassica napus* oil is taken by massage of the whole body to cure common cold, cough [28]. **Headache:** Warm blub juice along with *Briassica napus* oil is applied on head to cure headache [30]. **Snake bite:** Macerated bulb juice is applied on the affected area for snake bite [10].
Palash	*Butea monosperma* (Lam.) Taub. (Fabaceae)	Tree	Flower, Leaf, Seed	**Diarrhea:** Flower infusion is given [12]. **Urinary disease:** Flower juice mined with milk is orally taken to cure urinary complaints [25]. **Body toxin:** Flower is used to remove body toxins [23].
Pakur	*Ficus religiosa* L. (Moraceae)	Tree	Fruit	**Asthma:** The dried fruit, pulverized and taken in water for fortnight removes asthma [2]. **Dry cough:** Fruits extracts or cooked vegetable are taken orally for dry cough [11].
Pathorkuchi	*Kalanchoe pinnata* (Lam.) Pers. (Crassulaceae)	Herb	Whole plant	**Wounds, boils and insect bite:** Leaf paste is taken externally [23].
Pepulte	*Litsea glutinosa* (Lour.) C.B. Rob. (Lauraceae)	Tree	Leaf, Bark	**Diarrhea and dysentery:** Bark juice is taken internally [31].
Punarnava	*Boerhaavia diffusa* L. (Nyctaginaceae)	Herb	Root, leaf	**Diuretic:** The root paste mixed with water is orally applied as a diuretic twice daily [24]. **Asthma:** Decoctions of the roots and leaves are taken in moderate doses to cure asthma [27].
Puishak	*Basella alba* L. (Basellaceae)	Climber	Leaf, Root	**Constipation:** Leaf juice is taken orally [29]. **Toothache:** Root is applied internally [24]. **Burning sensation:** Leaves paste is used for burning sensation [12].
Pan	*Piper betel* L. (Piperaceae)	Climber	Leaf	**Phlegm:** Leaves serves as a natural expectorant and aids in easy removal of phlegm [30]. **Killing lice and cough:** Leaf juice helps in killing lice and in reducing cough [31].
Pipul	*Piper longum* L. (Piperaceae)	Climber	Leaf, Bark	**Weakness:** Bark extract mixed with water is used in the marinade for body weakness [24]. **Dyspepsia:** 250 mg (leaf) dust of this plant has to be taken with one glass of water for 1 week [23]. **Asthma:** 250 mg leaves dust of this plant mixed with water is taken internally [25]. **Rheumatism:** 250 mg leaves powder of this plant mixed with 1 teaspoonful of ginger extract has to be taken 2 times daily [28].
Piyara	*Psidium guajava* L. (Myrtaceae)	Tree	Leaf, Bark	**Diarrhea:** Leaf and stem bark decoction is taken internally [30]. **Mouth wash:** Young leaf is taken [27]. **Dysentery:** Paste of root mixed with water is taken orally [17].
Rasun	*Allium sativum* L. (Liliaceae)	Herb	Bulb	**Cough and fever:** Bulb extract is taken orally [29]. **Eczema and scabies:** Bulb paste is taken externally [31]. **High blood pressure:** Garlic bulb mixed with hot rice is taken internally [19].
Roktodron	*Leonurus sibiricus* L. (Lamiaceae)	Herb	Whole plant	**Menstrual disease and Uterus contraction:** Dried whole plant is taken internally [18]. **Febrifuge:** Decoction of root and leaves are taken orally [12].
Setodron	*Leucas aspera* L. (Lamiaceae)	Herb	Leaf, Root	**Snake-bite:** Macerated leaf is administered orally [18]. **Rheumatism:** Leaf juice is taken internally [12]. **Stomach pain:** Leaf extract is taken [26]. **Psoriasis and skin disease:** Leaves pastes are orally used to care psoriasis and other skin disease [29].
Shim	*Lablab purpureus* (L.) Sweet. (Fabaceae)	Climber	Leaf	**Skin disease:** Leaf paste is taken externally [21]. **Burning sensation:** Leaf paste is used internally [27].
Sisso	*Dalbergia sissoo* Roxb. (Fabaceae)	Tree	Leaf, Bark	**Hemorrhage:** Dried bank is used as a local astringent and haemostatic in various forms of hemorrhage [23]. **Gonorrhea:** Decoction of leaves is taken orally to acute stage of gonorrhea [19]. **Dysentery:** Leaf decoction is taken internally [17].
Shialkata	*Argemone mexicana* L. (Papaveraceae)	Herb	Root, Latex	**Skin cracks:** Latex and root paste is taken externally [21]. **Jaundice:** Latex is taken internally [11]. **Tumors and cancer:** Latex is used for tumors, cancer [2]. **Malarial fever:** Shiailkata root mixed with betel leaf juice is taken orally [20].
Shimul	*Bombax ceiba* L. (Bombacaceae)	Tree	Gum	**Burning sensation:** Paste of gum is taken externally [18]. **Sexual weakness:** Young root extracts mixed with boiled water is taken [5]. **Rheumatism:** Root bark decoction is taken internally [10].

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Bangla name	Botanical name and Family name	Habit	Parts Used	Ailments & Treatment Process
Sorisha	*Brassica napus* L. (Brassicaceae)	Herb	Seed	**Hair treatment:** Seed oil is boiled slightly and externally used in hair. It makes hair strong and shines [27]. **Sleep:** Seed oil used on head to for good sleep [23]. **Skin cracks:** To avoid skin cracks seed oil applied on skin [19]. **Gout:** Plaster of mustard is used in gout [12]. **Cough and Neuralgic:** Warm seed oil is taken externally [29].
Supari	*Areca catechu* L. *(*Arecaceae)	Tree	Seed, Root	**Teaniasis:** Crushed of fresh seeds is taken orally [25,29]. **Blood Dysentery:** 4 gm fresh seed are crushed and has to be boiled in 3 cup of water until it comes to 1 cup then filtered it and the decoction taken twice a day as a remedy against blood dysentery [31,12]. **Toothache:** Equal amount of root powder and dry nut powder are to fry in the pots and make ash out of it. Then the ash may be used for brushing the teeth as a remedy against toothache [29]. **Sore:** Fruit has to be dried in open sunlight and to make dry powder out of it. Then the powder applied on the affected area [23].
Sarpogandha	*Rauvolfia serpentina* (L.) Benth ex Kurz.(Apocynaceae)	Herb	Root	**Blood pressure and Dysentery:** Extract obtained from root is taken internally [28].
Shapla	*Nymphaea nouchali* Burm. f. (Nymphaeaceae)	Herb	Rhizom, Leaf	**Dysentery:** Dried rhizome powder mixed with water as used for dysentery [17]. **Burning spot:** Paste of leaves is used to remove burning spot [25].
Sajna	*Moringa oliefera* Lam. (Moringaceae)	Tree	Leaf, Root, Fruits, Seed.	**Blood pressure:** Whole leaves cooked and eaten in high blood pressure [23]. **Abortion:** Paste obtained from root bark is taken orally [11]. **Fever and abdomen pain:** Extract obtained from root is taken orally [20]. **Rheumatism:** Oil obtained from seed is taken [28]. **Diabetes:** Leaves are dried on heat and if taken with rice regularly, help in controlling diabetes [12]. **Cold & Cough:** Leaf extract is taken internally [26].
Sheuli	*Nyctanthes arbor-tristis* L. (Oleaceae)	Tree	Bark, Leaf, Roots	**Chronic fever:** Leaves juice mixed with honey is orally in chronic fever [11]. **Round and thread-worms:** Root juice is taken orally [5]. **Rheumatic fever:** Juice obtaine from bark is taken orally [17]. **Bronchitis:** Leaf decoction is taken internally [23].
Tulsi	*Ocimum sanctum* L. (Lamiaceae)	Herb	Leaf	**Coughs, colds, fever and bronchitis:** The leaves juice is taken internally [23].
Thankuni	*Centella asiatica* (L.) Urban. (Apiaceae)	Herb	Whole plant	**Loose motion, Dysentery and Stomach pain:** Whole plant paste is taken internally [17]. **Tuberculosis:** Whole plant juice is taken internally [20].
Tejpata	*Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm. (Lauraceae)	Tree	Leaf, Bark	**Diabetes:** Leaf juice is taken internally [19]. **Bronchitis:** Oil obtained from leaf mixed with honey is taken internally [10]. **Cold & Cough:** Dry leafs beady is use to smocking for few times to cure cough caused cold [17].
Telakucha	*Coccinia grandis* (L.) Voigt (Cucurbitaceae)	Climber	Leaf	**Hypertension:** Juice obtained from leaf is taken internally [12]. **Fever and Vomiting:** Juice obtained from crushed leaf juice mixed with water is taken orally [26].
Tetul	*Tamarindus indica* L. (Fabaceae)	Tree	Fruit, Seed, Leaf	**Fever:** Ripe fruit pulp is taken internally [4]. **Gastritis:** 200 gm dry seed powder is boiled with 3 cups of water till to reduce 2 cups and then taken orally twice daily for 7-9 days [25]. **Blood Dysentery:** Leaf juice is taken orally [21]. **Mouth disease:** Boiled decoction of stem and bark is administered thrice for 5 days to prevent mouth disease [28].
Titbegun	*Solanum nigrum* L. (Solanaceae)	Herb	Leaf, Fruit	**Dropsy:** Leaf decoction is taken internally [12]. **Ringworm:** Green fruit paste is taken orally [19].
Tridhara	*Tridax procumbens* L. (Asteraceae)	Herb	Leaf	**Dysentery and Diarrhea:** Juice obtained from leaf is taken [21]. **Bronchitis:** Juice obtained from crushed leaf mixed with water is applied internally [24]. **Bleeding:** Paste of crushed leaf is taken externally [29].
Ulot kambal	*Abroma augusta* L.f. (Sterculiaceae)	Shrub	Petiol, Seed	**Weakness:** Juice obtained from petiole mixed with sugar is taken orally [26]. **Stomach pain:** Paste of seed mixed with water is applied internally [31].

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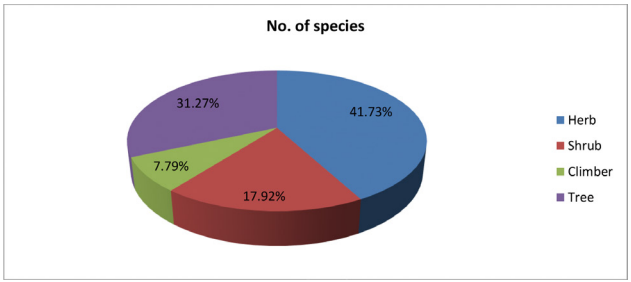

Figure 1. Investigated plant habit in the study area

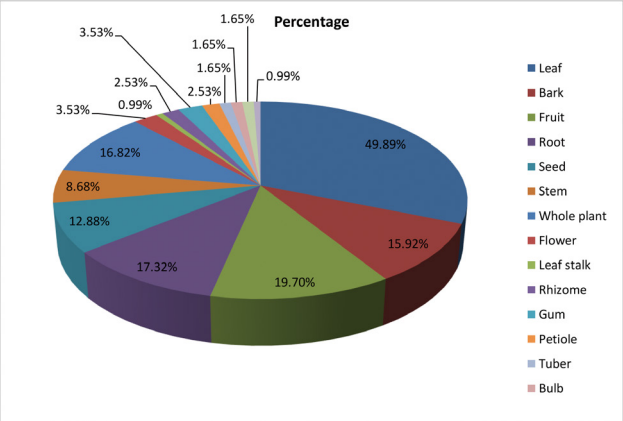

Figure 2. Recorded plant parts used as medicine

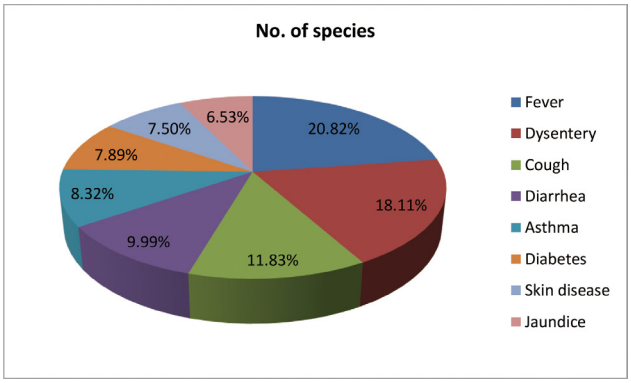

Figure 3. Investigated dominant diseases in the study area

4. Conclusions

The survey has recorded 66 categories of ailments of 111 medicinal species belonging to 55 families were recorded in the study area. Rural community's practitioners and older people of Rajshahi utilize a number of plant species grown around their homes for several medicinal uses. However, the younger generation by ignoring their ancestral traditional medicine is inclining towards the allopathic medicine. Since, several bioactive compounds are being extracted from traditional medicinal plants; they are in great demand in pharmaceutical industries. The photochemical an analysis and pharmacological investigations of traditional medicinally important plants by taking in view their proper conservation too, would help in developing novel drugs to treat ailments. The investigation also recorded important medicinal plants and how to use them to care for and treat various diseases.

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References

[1] Ahmed ZU, Begum ZNT, Hassan MA, Khondker M, Kabir SMH, Ahmad M, Ahmed ATA, Rahman AKA and Haque EU(Eds). Encyclopedia of Flora and Fauna of Bangladesh. 6-10. Angiosperms; Dicotyledons. Asiat. Soc. Bangladesh, Dhaka, 2008-2009.

[2] Anisuzzaman M, Rahman AHMM, Rashid MH, Naderuzzaman ATM and Islam AKMR. An Ethnobotanical Study of Madhupur, Tangail. Journal of Applied Sciences Research, 2007, 3(7): 519-530.

[3] Bangladesh Population Census (BPC) 2001, Bangladesh Bureau of Statistics; Rajshahi City Corporation 2007.

[4] Choudhury, AR and Rahmatullah M. Ethnobotanical study of wound healing plants among the folk medicinal practioners several district in Bangladesh. American- Eurasian Journal of Sustainable Development, 2012, 6(4): 371-377.

[5] Faruque MO and Uddin SB. Ethnomedicinal study of the Marma community of Bandarban district of Bangladesh. Academia Journal of Medicinal Plants, 2014, 2(2): 014- 025.

[6] Ghani A. Medicinal Plants of Bangladesh. Asiatic Society of Bangladesh, Dhaka, 2003.

[7] Guruprasad SL, Ningaiah N, Gangadhar MR. Indigenous Knowledge of Medicinal Plants among the Iruliga tribal population of Western Ghats areas, Karnataka, India.Journal of Anthropology, 2013, 9: 195-203.

[8] Hooker JD. (rep. ed. 1961). Flora of British India. Vols.1-7. L. Reeve and Co. Ltd. London, U.K, 1877.

[9] Huq AM. Plant Names of Bangladesh. Bangladesh National Herbarium, BARC, Dhaka, Bangladesh, 1986.

[10] Jamila M and Rahman AHMM. Traditional Medicine Practices for the treatment of Blood pressure, Body pain, Gastritis, Gonorrhea, Stomachic, Snake bite and Urinary problems of Santal Tribal Practitioners at the Village Jamtala of Chapai Nawabganj District, Bangladesh. Journal of Pregressive Research in Biol-

 DOI: https://doi.org/10.30564/jrb.v3i2.3038

ogy, 2016, 2(2): 99-107.

[11] Khan MS. Prospects of Ethnobotany and Ethnobotanical Research in Bangladesh. In: RL Banik, MK Alam, SJ Pei and A Rastogi (eds.), Applied Ethnobotany, BFRI, Chittagong, Bangladesh, 1998, Pp. 24-27.

[12] Nahar J, Kona S, Rani R, Rahman AHMM and Islam AKMR. Indigenous Medicinal Plants Used by the Local People at Sadar Upazila at Naogaon District, Bangladesh International Journal of Advanced Research., 2016, 4(6): 1100-1113.

[13] Pasha MK and Uddin SB. Dictionary of Plant Names of Bangladesh (Vascular Plants). Janokalyan Prokashani. Chittagong, Dhaka, Bangladesh, 2013.

[14] Prain D (rep. ed. 1963). Bengal Plants. Vols.1-2. Botanical Survey of India. Calcutta, India, 1903.

[15] Rahman AHMM, Ferdous Z and Islam AKMR. A Preliminary Assessment of Angiosperm Flora of Bangladesh Police Academy. Research in Plant Sciences., 2014, 2(1): 9-15.

[16] Srinivas BM. Ethno Medical Practices among the Jenu Kuruba of Karnataka. Man and Life 2010, 36(3-4):107-112.

[17] Yusuf M, Wahab MA, Choudhury JU and Begum J. Ethno-medico-botanical knowledge from Kaukhali proper and Betunia of Rangamati district.Bangladesh J.Plant Taxon., 2006, 13(1): 55-61.

[18] Rahman AHMM and Khatun MA. Leafy Vegetables in Chapai Nawabganj District of Bangladesh Focusing on Medicinal Value. Bangladesh Journal of Plant Taxonomy, 2020, 27(2): 359-375.

[19] Khatun MR and Rahman AHMM Ethnomedicinal Uses of Plants by Santal Tribal Peoples at Nawabganj Upazila of Dinajpur District, Bangladesh. Bangladesh Journal of Plant Taxonomy, 2019, 26(1): 117-126.

[20] Khatun MM and Rahman AHMM. Medicinal Plants Used by the Local People at the Village Pania under Baghmara Upazila of Rajshahi District, Bangladesh. Discovery, 2018, 54(266): 60-71.

[21] Islam MT and Rahman AHMM. Folk medicinal plants used by the Santal tribal practitioners against diarrhea and dysentery in Tanore Upazila of Rajshahi District, Bangladesh. International Journal of Pharmacognosy, 2018, 5(6): 360-363.

[22] Kona S and Rahman AHMM. Inventory of Medicinal Plants at Mahadebpur Upazila of Naogaon District, Bangladesh. Applied Ecology and Environmental Sciences, 2016, 4(3): 75-83.

[23] Jesmin Nahar J, Kona S, Rani R, Rahman AHMM and Islam AKMR. Indigenous Medicinal Plants Used by the Local People at Sadar Upazila of Naogaon District, Bangladesh. International Journal of Advanced Research, 2016, 4(6): 1100-1113.

[24] Rahman AHMM and Akter M. Taxonomy and Traditional Medicinal Uses of Apocynaceae (Dogbane) Family of Rajshahi District, Bangladesh. Research & Reviews: Journal of Botanical Sciences, 2015, 4(4): 1-12.

[25] Rahman AHMM and Keya MA. Traditional Medicinal Plants Used by local people at the village Sabgram under Sadar Upazila of Bogra district, Bangladesh. Research in Plant Sciences, 2015, 3(2): 31-37.

[26] Rahman AHMM and Gulshana MIA. Taxonomy and Medicinal Uses on Amaranthaceae Family of Rajshahi, Bangladesh. Applied Ecology and Environmental Sciences, 2014, 2(2): 54-59.

[27] Rahman AHMM, Nitu SK, Ferdows Z and Islam AKMR. Medico-botany on herbaceous plants of Rajshahi, Bangladesh. American Journal of Life Sciences, 2013, 1(3): 136-144.

[28] Rahman AHMM, Sultana N, Islam AKMR and Zaman ATMN. Study of Medical Ethno-botany of traditional medicinal plants used by local people at the village Genda under Savar Upazilla of district Dhaka, Bangladesh. Journal of Medicinal Plants Studies, 2013, 1(5): 72-86.

[29] Rahman AHMM. Graveyards angiosperm diversity of Rajshahi city, Bangladesh with emphasis on medicinal plants. American Journal of Life Sciences, 2013, 1 (3): 98-104.

[30] Rahman AHMM, Kabir EZMF, Sima SN, Sultana RS, Nasiruddin M and Naderuzzaman ATM. Study of an Ethnobotany at the Village Dohanagar, Naogaon. Journal of Applied Sciences Research. Pakistan, 2010, 6(9): 1466-1473.

[31] Rahman AHMM, Anisuzzaman M, Haider SA, Ahmed F, Islam AKMR and Naderuzzaman ATM. Study of Medicinal Plants in the Graveyards of Rajshahi City. Research Journal of Agriculture and Biological Sciences, 2008, 4(1): 70-74.

[32] Alexiades MN (Ed). Selected Guidelines for Ethno Botanical Research: A Field Manual. The New York Botanical Garden, New York., 1996, 305pp.

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ARTICLE

Evaluating Rice Biodiversity and Yields of Upland Rice Landraces Grown in Shifting Cultivation in Bandarban, Bangladesh

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ABSTRACT

Shifting cultivation, popularly known as *jhum*, is a dominant form of agriculture in the Chattogram Hill Tracts (CHT) of Bangladesh with upland rice being the major component of the system. The region is known for its rice biodiversity, which is under threat. This study was an attempt to explore the extent of rice biodiversity and variation in rice yields observing 81 randomly selected shifting cultivation plots from 26 dispersedly located mountainous villages in four sub-districts of Bandarban, one of three districts of the CHT. A total of 28 landraces of upland rice was grown in shifting cultivation. Highest number of landraces (16) was found in sub-district Thanchi. Three landraces most frequently observed were Gunda, Maemonsing and Sadabinni. Rice grain yield varied between 1.421 t ha-1 and 3.442 t ha-1 across landraces with the highest being recorded for Patobi. Landrace Dilon the lowest yield. Relative performance of landraces Kobrokbinni, Maemonsing, Monthon, Patobi and PD were superior to standard BRRI dhan83 and Gunda in relation to grain yield. Some of these landraces having wider adaptability may be released as varieties.

1. Introduction

Shifting cultivation, swidden culture, or popularly known as *jhum* cultivation in South and Southeast Asian countries is waning. In the wake of economic and social transformation, government regulations came down heavily transforming shifting cultivation into market oriented settled agriculture [1,2]. In Bangladesh, however, shifting cultivation still remains a dominant form of crop production in the sloping highlands of mountainous CHT [3,4]. The region, located in the south-east corner of Bangladesh, comprises three hill districts – Bandarban, Khagrachari and Rangamati. Geographically a part of Hindu Kush-Himalaya, the CHT is home to 12 ethnic communities. Unlike in the floodplains constituting a major segment of the country, the rugged, undulating mountainous lands of the CHT cover about 10% of the country's total landmass. However, only

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3.1% of the CHT land area is suitable for crop growing year-round while 74% represents hills and mountains with 2.72% sloping uplands[5]. High elevation hills and mountains are more and the proportion of arable land is less in Bandarban compared with other two hill districts of the CHT.

Two types of agricultural practices are prevalent in the CHT: plough agriculture or crop production in the valley lands using plowing as is being followed in plain lands, and traditional shifting cultivation in the sloping uplands in the hilly and mountainous areas. Shifting cultivation or *jhum* system is dominant and widely practiced for crop production in Bandarban [4,6]. In the shifting cultivation, farmers grow several crops together with rice being dominant under rainfed condition. Reliable statistics on area and production under *jhum* in the CHT are hard to get; but it is generally assumed that about 70,000 farmers practice *jhum* covering a minimum of 40,000 ha annually. The region is known for genetic diversity in rice [7].

Mountainous region comprising northern Myanmar, the CHT and northeasters Himalayan states of India might be center of diversity of Asian rice [8]. In uplands of the CHT farmers generally grow upland rice landraces in shifting cultivation that thrives depending on rainfall since irrigation cannot be provided in the sloping hilly lands. Many of the farmers prefer growing sticky and specialty rice cultivars. These upland rice landraces are traditionally grown in low-input, subsistence systems as is being practiced in similar environments in north-eastern India [9] and south-east Asian countries [10-12]. Invariably no farmer cultivates high yielding rice varieties in the shifting cultivation system.

Upland rice yield in the mountainous areas of the CHT is generally low [13,14] which may be attributed to culture type, land topography, rainfall characteristics and the varieties that farmers use [15]. Spatial differences in upland rice yields and varieties used have been reported [16]. Choudhury et al. [17] studied genetic structure and diversity of indigenous rice varieties grown in the Eastern Himalayan region of Northeast India. Atlin et al. [18] evaluated *indica* upland genotypes against traditional and improved tropical *japonica* upland varieties and elite *indica* high-yielding varieties (HYV) under high-fertility favorable upland conditions for characterizing the features of tested entries. Recently, Van Andel et al. [19] studied the diversity of rice genotypes used by the Guianas farmers in their traditional farming systems. Food insecurity is a major concern in such situations. Our earlier study conducted in Bandarban [14] also suggests that low yields of upland rice crop in shifting cultivation led to food insecurity of a greater segment of ethnic farmers. Mahmud et al. [20] suggested that improved management practices in rice replacing indigenous landraces with drought tolerant varieties might improve yield.

Yields of crops including upland rice are directly influenced by biophysical characteristics (www.ohchr.org/Documents/Issues/EPoverty/Lao/MilesKenneyLazarAnnex5.pdf) along with varietal differences [21]. Ran et al. [22] also showed that of all the factors associated with rice yield variation in mountainous terrain of southwest China, variety had more influence. In contrast, Sadimantara et al. [23](2018) reported fairly stable yields of local varieties of upland rice in Sulawesi of Indonesia. Roy et al. [24] evaluated 68 hill rice landraces of Northeast Indian states and categorized them in early and late maturing groups based on plant height, kernel length, kernel length-to-width ration, grain length, and grain length-to-width ratio. Similar information on genotypic variation in upland rice in Bangladesh is either scanty or unavailable, although Siddique et al. [25] studied the varietal differences of upland rice under lowland conditions and reported large variation in grain morphology. Some other authors reported low yields of indigenous rice in shifting cultivation or *jhum* in the CHT [14,26]; but work on yield variability and diversity of *jhum* rice has not been reported. This study was an attempt to evaluate the extent of rice biodiversity and yield potentials of upland rice genotypes grown in shifting cultivation in the uplands of Bandarban district in Bangladesh.

2. Materials and Methods

This on-farm study was conducted sampling shifting cultivators' plots, enumerating the rice landraces grown in shifting crops, and determining grain yields harvesting rice from the selected plots. Farmers established their shifting cultivation plots slashing forest, burning and clearing debris, and dibbling seeds following rains (April – May, 2019) without resorting to tillage on the mountainous uplands [27]. Once the shifting cultivation plots were established in the rugged terrains of hills and mountains, a team of Agrarian Research Foundation (AR) travelled through four upazila (sub-districts) of Bandarban district in June-July, 2019 to select farmers and their plots. Invariably all farmers in the selected locations planted upland rice in shifting cultivation plots, albeit the rice varieties and associated crops varied across locations. Visiting cropped areas and discussing with farmers, shifting cultivation plots were selected at random from 26 dispersedly located para (villages) of four upazila (sub-districts). A total of 81plots, each measuring

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one *kani* (0.16 ha) or more and the owner farmers thereof were selected for the study. Rice landraces planted in each plot were identified interviewing the owner farmers.

Rice crop attained maturity at different times beginning late-August through early October depending on planting time and landraces used by the farmers. Rice peduncle (panicle base) turning to yellow was taken as physiological maturity [28]. From each selected plot, three quadrants of rice, each quadrant measuring 1.0 m x 5.0 m, were sampled and harvested at maturity. Harvested rice of three quadrants of each plot was threshed and brought to ARF Office, Reicha (Bandarban) and sundried to a constant weight. Moisture content of dried rice samples was recorded, adjudged to 12% moisture content and converted to grain yield per ha. In view of unequal sample size in respect of number of farmers planted to each variety, variation in agronomic practices for growing rice across locations, and heterogeneity of experimental plots, analysis of variance could not be performed. However, rice grain yield data of each variety and location were subjected to descriptive statistical analysis wherever feasible.

Yield performance of landraces grown in shifting cultivation was compared with modern variety BRRI dhan83 and cultivar Gunda using Relative Performance (RP) as follows:

RP = (Grain yield of landraces)/grain yield of BRRI dhan83 or Gunda

Average yield data of BRRI dhan83 were taken from a trial recently conducted in nine upazila of the CHT [29] while the average grain yield of Gunda was taken from the present study. The performance of a genotype was considered satisfactory when RP was ≥1.

3. Results and Discussion

Selected farmers in 26 different locations (para) of four upazila in Bandarban district had planted 28 landraces of upland rice (Table 1). The cultivar most frequently observed was Gunda planted in eight locations followed by landraces Maemonsing and Sadabinni. The landrace Gunda was mostly concentrated in a few villages (para) in Rowangchari and Bandarban sadar upazila, while Sadabinni was dispersedly planted across four upazila of Bandarban district. Landrace Maemonsing was grown in mountains covering a cluster of three villages of three adjoining upazila- Rowangchari, Bandarban sadar and Ruma. Likewise, the production of cultivar Monthon was concentrated in high hills of Ruma and Thanchi upazila. Although few farmers planted landraces Batia, Chama, Chilikma, Dilon, Kanbui, Monbui, and Rongkui (Table 1), because of low yield potentials and growing food demand these landraces are progressively being extinct. Tribal people in the CHT prefer glutinous aromatic and specialty rice like Binni, Patobi, Rigui, Chilikma, a few farmers planted such genotypes because of their low yields.

Table 1 indicates that Thanchi upazila was the area for wider diversity of upland rice genotypes which was followed by Rowangchari. As many as 28 different landraces of upland rice were grown in association with other crops in *jhum* culture. Apart from commonly grown upland rice landraces, Thanchi farmers planted 12 more landraces compared with other three upazilas. In contrast, lesser numbers but more frequently observed landraces were grown in Bandarban sadar upazila. Sampled farmers in Thanchi upazila planted eight indigenous rice landraces which were mutually exclusive of the cultivars grown in other upazilas. Our findings indicate that Bandarban, located in the Indo-Burma border, still remains a biodiversity hotspot of a large number of indigenous rice landraces in the region. Valalsanga et al. [30] also recently indicated high genetic diversity of rice genetic resources in neighboring states of northeast India.

The number of farmers' plots we sampled in Ruma upazila was less compared with other three upazilas. The reason of fewer samplings in Ruma upazila was primarily due to distance from the district town (Bandarban) and *jhum* plots being located in relatively inaccessible areas. Such unequal sample size thus presented problem in running statistical analysis.

In the present study, a total of 81 plots of shifting cultivators were evaluated (Table 2). Eight farmers of five villages planted a fairly recently introduced cultivar Gunda in mid-range hills in Bandarban sadar and Rowanghchari upazila. The second most frequently used cultivars were Maemonsing and Sadabinni. Maemonsing was planted in high-range mountainous areas in three villages of Bandarban sadar, Rowangchari and Ruma upazila. Regardless of ranges of hills and mountains, Sadabinni genotype was widely grown throughout the four upazila in Bandarban district. Monthon genotype was also concentrated in the high range hills and mountains of Rowangchari and Thanchi upazila. Each of the two aromatic, glutinous rice varieties Kalobinni and Lal binni were planted by five farmers. Kalobinni was grown in high-range hills in southern part of Bandarban sadar while Lal binni occurred in low hills in Bandarban sadar, Rowangchari and Ruma upazila.

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Table 1. Spatial distribution of rice varieties in four upazila of Bandarban district

Upazila (sub-dist)	Village (Para)	Genotypes planted
Rowangchari	Grokkhanpara	Reshamdhan
	Bijoypara	Lal binni
	Paglachara	Ranga dhan, Ranga binni, Sona dhan, Sadabinni
	Lulain para	Lendachikon
	Hanshama para	Gunda, Sadabinni
	Raja khamar	Gunda, Sadabinni
	Ramjadipara	Gunda
	Jaminipara	Cockrow, Maemonsing
	Lulai Headman para	Naisadhan
	Tungkhongpara	Gunda, PD, Rong Kui
Bandarban sadar	Parjatanpara	Kobrokbinni
	Tigerpara	Patobi
	Mrolongpara	Chilikma,Cockrow, Gunda,Kalobinni
	Ramripara	Chilikma,Kalobinni, Maemonsing, Sadabinni
	Thwingyapara	Lal binni
Ruma	Battolipara	Lal binni, Maemonsing, Monthon
	Royalpara	Sadabinni
Thanchi	Amtalipara	Dilongdhan, Monthon, Rongkui
	Bidyamoni Tripura para	Dilongdhan, DMP (Pahari), Monthon (Lomba Pahari)
	Boli bazaar Rai Mohan para	Batia
	Commanderpara	Chama
	Dakshinpara	Kopro
	ElmaraMarma para, Bolibazar	Rigui (s), Mongbui
	Komola bazaar Marma para	PD
	Kolaypara Jiban Nagar Hills	Sheshedhan, Sadabinni
	NiadariNicher para	Cockrow, Lal Binni, PD
	Sandakpara	Kanbui,Rongkui, Sona dhan

Scarcely occurring landraces like Batia, Chama, Chilikma, Dilon, DMP, Kanbui, Kopro, Mongpui, Rigui, Rongkui and Sheshe were planted in the mountains mostly in Thanchi. In Bandarban district, paddy is not traded in the market and rice is grown primarily for meeting household food requirements. It might be reasonably assumed that apart from ecological considerations, farmers' taste could be an important factor in selecting rice genotypes for cultivation in the study sites.

Table 2. Provenance of upland rice varieties planted in *jhum* in four upazila of Bandarban district

Variety/ landrace	Provenance	Farmers involved (No)
Batia	Boli bazaar Rai Mohan para, Thanchi	1
Chama	Commanderpara, Thanchi	2
Chilikma	Mrolongpara, Ramripara, Bandarban sadar	3
Cockrow	Hanshamapara, Rajakhamar, Ramjadipara (Rowangchari); Tungkhonpara, Mrolongpara (Bandarban sadar)	5
Dilon	Amtalipara, Bidyamoni Tripura para, Thanch	2
DMP (Pahari)	Bidyamoni Tripura para, Thanchi	1
Gunda	Hanshamapara, Rajakhamar, Ramjadipara (Rowangchari); Tungkhonpara, Mrolongpara (Bandarban sadar)	8
Kalobinni	Mrolongara, Ramripara (Bandarban sadar)	5
Kanbui	Sandakpara, Thanchi	2
Kobrokbinni	Parjatanpara, Bandarban	1
Kopro	Dakshinpara (Thanchi)	1
Lal binni	Bijoypara (Rowangchari); Thwingyapara(Bandarban); Bottolipara(Ruma)	5
Lendachikon	Lulain para, Rowangchari	1
Maemonsing	Jaminipara (Rowaqngchari); Ramripara (Bandarban sadar); Bottolipara(Ruma)	7
Mongbui	ElmaraMarma para, Bolibazar (Thanchi)	2
Monthon	Battolipara (Ruma), Amtolipara and Bidyamoni Tripura para (Thanchi)	6
Monthon (Lomba Pahari)	Bidyamoni Tripura para (Thanchi)	1
Naisadhan	Lulai Headman para (Bandarban sadar)	1
Patobi	Tigerpara (Bandarban sadar)	1
PD	Tungkhongpara (Bandarban sadar), Komola bazaar Marma para, Niadari Nich para (Thanchi)	5
Ranga binni	Paglachara (Rowangchari)	2
Ranga dhan	Paglachara (Rowangchari)	1
Resham-dhan	Gorokkhonpara (Rowangchari)	1
Rigui (scented)	Elmara Marma para, Bolibazar (Thanchi)	2
Rong Kui	Amtalipara, Sandakparaq (Thanchi)	4
Sadabinni	Paglachara, Hanshamapara, Raja Khamar (Rowangchari); Ramripara (Bandarban sadar); Royalpara(Ruma); Kolaypara Jiban Nagar Hills (Thanchi)	7
Sheshe	Kolaypara Jiban Nagar Hills, Thanchi	1
Sona dhan	Paglachara, Rowangchari; Sandakpara, Thanchi	3

Crops in shifting cultivation are grown in sloping uplands without land tillage and depending on natural rainfall. Onset and termination of rainy season determine the length of crop growing season. Seeds of upland rice are

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dibbled on dry land surface without tillage and the stand establishment relies heavily on rainfall. Rainfall records of Bandarban (Figure 1) suggest that rainfall received in April and May 2019 was favorable for a good stand establishment of rice and other component crops in the hills. Rainfall peaked in July-August when upland rice was in reproductive and grain-filling stages. It is reasonable to assume that rice experienced a good rainfall sufficient for supporting its growth. Our observations are in agreement with Saito et al. [31] who observed a close association between growing season rainfall and upland rice yield in Laos. Using 40 years' rainfall data Akinbile et al. [32] demonstrated that rice yield was positively related with rainfall in Nigeria. In a classification and regression tree analysis of a dataset, Bruelle et al. [33] showed rice yield was more affected by agro-environmental factors than management factors in Madagascar.

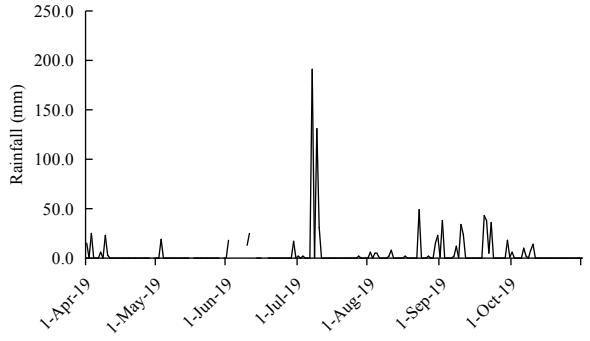

Figure 1. Rainfall pattern during experimental period, Bandarban, Bangladesh

Out of 28 landraces, each of 11 landraces had a single plot sample, and thus single plot sample yield data were used for these landraces. In other cases, the number of sample plots was unequal ranging from 2 to 8. Rice grain yields differed remarkably across landraces. Intra-genotypic difference in grain yield was also enormous (Table 3). Rice grain yield ranged between 1.421 t ha^{-1} and 3.442 t ha^{-1} showing a variation of over 142%. The highest yield was recorded for a long-grain, aromatic, glutinous rice genotype Patobi. A bold grain, non-aromatic glutinous cultivar Dilon produced the lowest grain yield (Figure 2). Fairly high and stable yield was obtained for genotypes Gunda (3.058 t ha^{-1}), Maemongsing (3.442 t ha^{-1}) and PD (3.106 t ha^{-1}). In view of relatively higher price and greater demand, yield of Sadabinni (2.880 t ha^{-1}) looks also reasonably good. The highest yield was obtained for the genotype Patobi; but because of sample size direct comparison of Patobi and other scarcely occurring landraces with those of frequently occurring landraces could not be made. Our results are in agreement with Zewdu et al. [34] who observed a wide variability in grain yield of upland rice which they attributed to differences in the test locations in Ethiopia and genotypic variations. Earlier, Van Keer et al. [35] also reported extensive variability in productivity of tropical japonica type glutinous upland rice varieties in an extensive research area in northern Thailand. Haryanto et al. [36] also reported wide variability in upland genotypes with significant genotype x environment interaction.

Table 3. Variations in grain yield of upland rice genotypes in Bandarban, Bangladesh

Variety/Landrace	Grain yield range (t ha^{-1})	Relative performance against	
		BRRI dhan83	Gunda
Batia	-	0.8152	0.6825
Chama	1.804 – 2.066	0.7047	0.5899
Chilikma	1.154 – 2.760	0.5805	0.4859
Cockrow	1.701 -2.812	0.8875	0.7430
Dilon	1.340 – 1.502	0.5551	0.4647
DMP (Pahari)	-	0.8156	0.6828
Gunda	2.190 -4.012	1.1945	1.0000
Kalobinni	0.752 – 2.047	0.6203	0.5193
Kanbui	1.765 – 2.120	0.7605	0.6367
Kobrokbinni	-	1.2363	1.0350
Kopro	-	0.8703	0.7286
Lal binni	1.340 -3.096	0.8563	0.7168
Lendachikon	-	0.8047	0.6736
Maemonsing	2.056 – 4.126	1.3324	1.1154
Mongbui	1.744 -2.910	0.8141	0.6815
Monthon	1.654 -3.763	1.2602	1.0549
Monthon (Lomba Paharri)	-	1.0000	0.8371
Naisadhan	-	0.6039	0.5056
Patobi	-	1.3445	1.1256
PD	2.098 – 3.888	1.2133	1.0157
Ranga binni		0.8387	0.7021
Ranga dhan	-	0.7578	0.6344
Reshamdhan	-	0.8156	0.6828
Rigui (scented)	1.405 -1.906	0.6465	0.5412
Rong Kui	1.614 – 3.487	0.9563	0.8005
Sadabinni	1.554 – 3.561	1.1250	0.9418
Sheshe	-	1.0000	0.8371
Sona dhan	1.326 – 2.066	0.6168	0.5164

- Data not available

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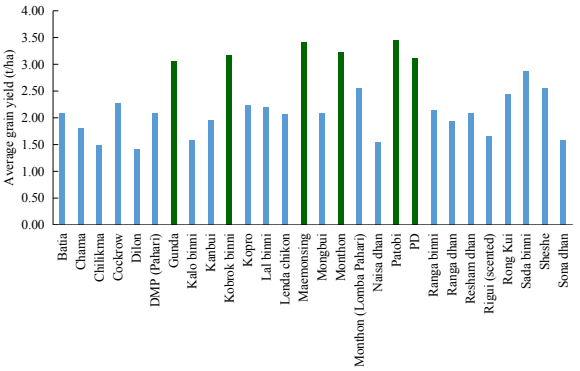

Figure 2. Average grain yield of upland rice genotypes in Bandarban, Bangladesh

Relative performances of local landraces in terms of grain yields were better or similar for Kobrokbinni, Maemonsing, Monthon, Patobi, and PD compared to BRRI dhan83 and Gunda (Table 3). These clearly indicate that some of the landraces are having potentiality of giving relatively higher grain yields at least in certain specific locations. Yield enhancement of these potential landraces could be tried providing improved agronomic management conditions. These may also be used as parent materials for developing drought tolerant high yielding varieties for adaptation in hilly areas.

All the upland rice landraces sampled in the study were grown in shifting cultivation. Frequency of occurrence of the landraces also differed a great deal across locations, except the genotype Sadabinni. However, all the landraces did not occur evenly throughout the study locations. Hence, analysis of spatial differences in rice grain yields or variety x location effect on yield variation was not attempted.

4. Conclusions

In the Chattogram Hill Tracts (CHT) in general, and Bandarban in particular, shifting cultivation has been the dominant upland rice ecosystems primarily due to land topography and socio-economic characteristics of the ethnic communities. Production of upland rice in shifting cultivation has been a key of food security for the resource-poor farmers in Bandarban. Most hill farmers prefer glutinous upland rice (like Binni, Patobi, Rigui etc.), but moderate yielding landraces are now gaining ground due to yield stability across locations and seasons. Farmers in Bandarban sadar, in the high range hills in southern Rowangchari and in Ruma prefer landraces Gunda, Maemonsingh and Monthon because of drought tolerance. In contrast, provenance of landraces like Cham, Chilikma, Kopro, Lenda chikon, Patobi, Resham dhan, Rigui and Sona dhan are in specific locations and probably have no wider adaptability or farmers' acceptability. For a long time, these location specific landraces endured harsh environment and adapted to local agro-climatic conditions with names that farmers selected and maintained to meet their social, economic, cultural and ecological needs [37]. Landraces are not considered in the public seed production and distribution system. In this study, the landraces showing potentiality of high yields across locations (for example, Gunda, Monthon) may be released as varieties for wider dissemination in the hilly areas.

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References

[1] Xu JC. The political, social, and ecological transformation of a landscape – the case of rubber in Xishuangbanna, China. Mountain Research and Development, 2006, 26: 254-262.

[2] Fox J, Fujita Y, Ngidang D, Peluso N, Potter L, Sakuntaladewi N, Sturgeon J, Thomas D. Policies, Political-Economy, and Swidden in Southeast Asia. Human Ecology, 2009, 37: 305-322.

[3] Nath TK, Inoue M, Chakma S. Shifting Cultivation (*jhum*) in the Chittagong Hill Tracts, Bangladesh: Examining its Sustainability, Rural Livelihood and Policy Implications. Int. J. Agric. Sust., 2005, 3(2): 130-142.

[4] Hossain MI, Riyadh ZA, Ferdausi J, Rahman MA, Saha SR. Crop agriculture of Chittagong Hill Tracts: Reviewing its management, performance, vulnerability and development model. Intl. J. Agric. & Env. Res., 2020, 6(5): 707-727.

[5] Forestal Forestry and Engineering International Limited (Forestal). Chittagong Hill Tracts: soil and land use survey (1964–1966), vol 2, 1996, Vancouver, Canada.

[6] Quais MK, Rashid MM, Shahidullah SM, Nasim M. Crops and Cropping Sequences in Chittagong Hill Tracts. Bangladesh Rice J, 2017, 21 (2) : 173-184.

[7] Huang X, Kurata N, Wei X, Wang ZX, Wang A, Zhao Q, Zhao Y, Liu K, Li W, Guo Y et al. A map of rice genome variation reveals the origin of cultivated rice. Nature, 2012, 490: 497-501.

[8] Nakagahara M. The differentiation, classification and center of genetic diversity of cultivated rice (Oryza sativa L.) by isozyme analysis. Trop. Agric. Res. Sci., 1978, 11: 77-82.

[9] Das B, Sengupta S, Parida SK, Roy B, Ghosh M, Prasad M, Ghose TK. Genetic diversity and popu-

DOI: https://doi.org/10.30564/jrb.v3i2.3033

lation structure of rice landraces from Eastern and North Eastern States of India. BMC Genetics, 2013, 14.71.

[10] Warner K. Shifting cultivators: Local technical knowledge and natural resource management in the humid tropics. Food and Agriculture Organization of The United Nations, Rome. 1991.

[11] Li P, Feng Z, Jiang L, Liao C, Zhang J. A Review of Swidden Agriculture in Southeast Asia. Remote Sens., 2014, 6: 1654-1683. DOI: 10.3390/rs6021654.

[12] Siahaya M, Hutauruk TR, Aponno HSES, Hatulesila JW, Mardhanie AB. Traditional ecological knowledge on shifting cultivation and forest management in East Borneo, Indonesia. Intl. J. Biodiversity Sci. Ecosystem Services & Management, 2016, 12(1-2):14-23. DOI: 10.1080/21513732.2016.1169559.

[13] Rasul G, Thapa GB. Shifting cultivation in the mountains of South and Southeast Asia: Regional patterns and factors influencing the changes. Land Degradation and Development, 2003, 14:495-508. doi: 10.1002/ldr.570.

[14] Nahar A, Akbar MA, Biswas JC, Gafur A, Uddin MF, Rasid S, Mollah MAM, Marma MS, Marma TM, Marma SSM, Islam MK, Neogi MG, Hamid A. Household Demography and Food Security of Jhum Farmers in Bandarban District, Bangladesh. Journal of Applied Agricultural Economics and Policy Analysis, 2020, 3(1): 8-14. DOI:10.12691/jaaepa-3-1-2.

[15] Saito K, Asai H, Zhao D, Laborte AG, Grenier C. Progress in varietal improvement for increasing upland rice productivity in the tropics. Plant Production Sci, 2018, 21(3): 145-158. DOI: 10.1080/1343943X.2018.1459751.

[16] Ghimire R, Wen-chi H, Shrestha RB. Factors Affecting Adoption of Improved Rice Varieties among Rural Farm Households in Central Nepal. Rice Science, 2015, 22(1): 35-43.

[17] Choudhury B, Khan ML, Dayanandan S. Genetic structure and diversity of indigenous rice (Oryza sativa) varieties in the Eastern Himalayan region of Northeast India. SpringerPlus, 2013, 2:228.

[18] Atlin GN, Lafitte HR, Tao D, Laza M, Amante M, Courtois B. Developing rice cultivars for high-fertility upland systems in the Asian tropics. Field Crops Research, 2006, 97: 43-52.

[19] Van Andel T, Veltman MA, Bertin A, Maat H, Polime T, Hille Ris Lambers D, Tjoe Awie J, De Boer H, Manzanilla V. Hidden Rice Diversity in the Guianas. Front. Plant Sci., 2019, 10:1161. DOI: 10.3389/fpls.2019.01161.

[20] Mahmud S, Alam MR, Amin M, Hassan MM. Performances of improved and traditional rice based *jhum* cultivation in a hill district of Bangladesh. J Bangladesh Agril Univ, 2018, 16(2): 193-197. DOI: 10.3329/jbau.v16i2.37960.

[21] Barah BC, Pandey S. Rainfed Rice Production Systems in Eastern India: An On-Farm Diagnosis and Policy Alternatives. Ind. Jn. of Agri. Econ., 2005, 60: 110-136.

[22] Ran Y, Chen H, Ruan D, Liu H, Wang S, Tang X, et al. Identification of factors affecting rice yield gap in southwest China: An experimental study. PLoS ONE, 2018, 13(11): e0206479. https://doi.org/10.1371/journal.pone.0206479.

[23] Sadimantara GR, Kadidaa B, Suaib, Safuan LO, Muhidin. Growth performance and yield stability of selected local upland rice genotypes in Buton Utara of Southeast Sulawesi. IOP Conf. Series: Earth and Environmental Science, 2018, 122: 012094. DOI :10.1088/1755-1315/122/1/012094.

[24] Roy S, Marndi BC, Mawkhlieng A, Banerjee RM, Yadav AK, Misra AK, Bansal, KC. Genetic diversity and structure in hill rice (Oryza sativa L.) landraces from the North Eastern Himalayas of India. BMC Genetics, 2016, 17:107. DOI: 10.1186/s12863-016-0414-1.

[25] Siddique MA, Islam MZ, Khalequzzaman M and Ahmed MS, MS. Genetic diversity in rice (Oryza sativa L.) landraces of hilly areas in Bangladesh. Bangladesh J. Pl. Breed. Genet., 2011, 24(2): 25-30.

[26] Mantel S, Mohiuddin M, Alam MK, Olarieta JR, Alam M, Khan FMA. Improving the *jhum* system in Bangladesh. LEISA Mag., 2006, 22(4):20-21.

[27] Gafur A, Jensen JR, Borggaard OK, Petersen L. Runoff and losses of soil and nutrients from small watersheds under shifting cultivation (Jhum) in the Chittagong Hill Tracts of Bangladesh. Journal of Hydrology, 2003, 279: 293-309.

[28] Tian W, Li L, Liu F, Zhang Z, Yu G, Shen Q, Shen B. Assessment of the maturity and biological parameters of compost produced from dairy manure and rice chaff by excitation-emission matrix fluorescence spectroscopy. Bioresour Technol, 2012, 110:330-7.

[29] Bangladesh Rice Research Institute (BRRI). Annual Research Review Workshop, 2019-2020. XVI: Adaptive Research Division, BRRI, Gazipur, 53p, 2021.

[30] Vanlalsanga S, Singh P, Singh YT. Rice of Northeast India harbor rich genetic diversity as measured by SSR markers and Zn/Fe content. BMC Genetics, 2019, 20:79 doi.org/10.1186/s12863-019-0780-6.

[31] Saito K, Linquist B, Keobualapha B, Phanthaboon K,

Shiraiwa T, Horie T. Cropping intensity and rainfall effects on upland rice yields in northern Laos. Plant and Soil, 2006, 284: 175-185.

[32] Akinbile CO, Ogunmola OO, Abolude AT, Akande SO. Trends and spatial analysis of temperature and rainfall patterns on rice yields in Nigeria. Atmospheric Sci. Letters, 2019, 21(3): e944. doi.org/10.1002/asl.944.

[33] Bruelle G, Naudin K, Scopel E, Domas R, Rabeharison L, Tittonell P. 2014. Short- to mid-erm impact of conservation agriculture on yield variability of upland rice: Evidence from farmer's fields in Madagascar. Experimental Agriculture, 1996, 51:66-84. doi.org/10.1017/S0014479714000155.

[34] Zewdu Z, Abebe T, Mitiku T, Worede F, Dessie A, Berie A, Atnaf M. Performance evaluation and yield stability of upland rice (Oryzasativa L.) varieties in Ethiopia, Cogent Food & Agriculture, 2020, 6:1, 1842679.
DOI: 10.1080/23311932.2020.1842679.

[35] Van Keer K, Trebuil G, Courtois B, Vejpas C. On-farm characterization of upland rice varieties in North Thailand. International Rice Research Notes, 1998, 23 (3): 21-22.

[36] Haryanto TAD, Suwarto S, Yoshida T. Yield Stability of Aromatic Upland Rice with High Yielding Ability in Indonesia. Plant Prod. Sci., 2008, 11(1): 96-103.

[37] Teshome A, Baum BR, Fahrig L, Torrance JK, Arnason TJ, Lambert JD. Sorghum (Sorghum bicolor L.) Moench) landrace variation and classification in North Shewa and South Welo, Ethiopia. Euphytica, 1997, 97: 255-263.

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