IJOEAR

International Journal of Environmental & Agriculture Research

www.ijoear.com

ISSN
2454-1850

Volume-9, Issue-10, October 2023

Preface

We would like to present, with great pleasure, the inaugural volume-9, Issue-10, October 2023, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas.

Environmental Research:

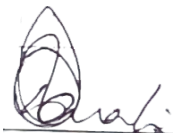
Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

Mukesh Arora
(Managing Editor)



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Dairy Sheep	Water Buffalo
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Maple syrup	Forestry Growth
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Dr.Chiti Agarwal

Dr. Chiti Agarwal works as a postdoctoral associate at the University of Maryland in College Park, Maryland, USA. Her research focuses on fungicide resistance to fungal diseases that affect small fruits such as strawberries. She graduated from North Dakota State University in Fargo, North Dakota, with a B.S. in biotechnology and an M.S. in plant sciences. Dr. Agarwal completed her doctorate in Plant Pathology while working as a research and teaching assistant. During her time as a graduate research assistant, she learned about plant breeding, molecular genetics, quantitative trait locus mapping, genome-wide association analysis, and marker-assisted selection. She wants to engage with researchers from many fields and have a beneficial impact on a larger audience.

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Mr. Isaac Newton ATIVOR

MPhil. in Entomology, from University of Ghana.

He has extensive knowledge in tree fruit orchard pest management to evaluate insecticides and other control strategies such as use of pheromone traps and biological control to manage insect pests of horticultural crops. He has knowledge in agronomy, plant pathology and other areas in Agriculture which I can use to support any research from production to marketing.

Mr. Bimal Bahadur Kunwar

He received his Master Degree in Botany from Central Department of Botany, T.U., Kirtipur, Nepal. Currently working as consultant to prepare CCA-DRR Plan for Hariyo Ban Program/CARE in Nepal/GONESA.

Table of Contents

Volume-9, Issue-10, October 2023

Physiological and Yield Contributing Characters Depicting A High Yield Potential Triticale Line (x *Triticosecale* Wittm.)

Mohammad Nur Alam[1*], Md. Abdul Hakim[2], Md. Zaherul Islam[3], Md. Abdullah Al Mamun[4], Md. Siddikun Nabi Mandal[5], Md. Monwar Hossain[6], Md. Forhad Amin[7], Rabiul Islam[8], Md. Ilias Hossain[9], Md. Sariful Bin Ekram[10], Shaila Sharmin[11], Md. Zakir Hossain[12], Samima Akter[13], Md. Tanvir Abedin[14], Most. Nilufar Yeasmin[15], Md. Mostofa Kamal Sohel[16]

[1-6]Wheat Breeding Division, Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur, 5200, Bangladesh
[7]Regional Station, Bangladesh Wheat and Maize Research Institute, Joydebpur, Gazipur-1701, Bangladesh
[8,16]Regional Station, Bangladesh Wheat and Maize Research Institute, Jashore, 7400, Bangladesh
[9,15]Regional Station, Bangladesh Wheat and Maize Research Institute, Shyampur, Rajshahi-6212, Bangladesh
[10,12]Agricultural Engineering Division, Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur, 5200, Bangladesh
[11]College of Agricultural Sciences, International University of Business Agriculture and Technology, Dhaka, 1230, Bangladesh
[13]Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur, 5200, Bangladesh
[14]Department of Biochemistry and Molecular Biology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, 5200, Bangladesh
*Corresponding Author

Received:- 02 October 2023/ Revised:- 11 October 2023/ Accepted:- 18 October 2023/ Published: 31-10-2023

Abstract— *Triticale is used as a dual-purposes. In Bangladesh, dairy and poultry farms are being extended faster day by day. Therefore, the demand of fodder and feed increases swiftly. Moreover, triticale tolerates biotic and abiotic stressors better than wheat and durum. The trials were conducted in two consecutive years to search out a high yielding triticale line whereas two varieties were used as check viz. BARI Triticale 1 (E1) and BARI Triticale 2 (E2) and four lines (expressed as E3, E4, E5, and E6). In the research areas, temperature, rainfall and relative humidity were higher in 2018-19 than in 2019-20, but rainfall was lower. As a result, days to heading (DH), days to maturity (DM), fertile spikes per meter square (FSPMS), and grain yield (GY) were more in 2019-20 than in 2018-19. In 2018-19, thousand grain weight (TGW) correlated negatively with DH, DM, and FSPMS. In 2019-20, a positive association was established between FSPMS and GY. Furthermore, E5 and E6 lines had lower plant height (PH), but higher FSPMS and TGW than the control in both seasons. In addition, E5 and E6 yielded more GY than check and other lines. These findings suggested that E5 and E6 lines may be released as high yielding triticale variety (ies) to boost triticale production in Bangladesh.*

Keywords— Days to maturity, fertile spike, grain yield, thousand grain weight, triticale.

I. INTRODUCTION

Triticale demand is increasing globally as a dual-purpose uses like food, fodder and main composition of cattle and poultry feeds [1]. It is also a well-known economic crop [2]. Triticale is a superior ruminant feed than other cereals because of its high starch digestibility, and it is used to make forage, hay, and silage, among other things [2, 3]. Triticale has 71.2% digestible organic matter in dry matter, but lathyrus, blackgram, and cowpea have lesser digestibility, with 66.6%, 66.0%, and 73.8%, respectively [2]. Triticale can be used to make bread mixing with wheat and maize flour, and various food products, such as whole berries, flakes, cakes, biscuits, pasta, and morning cereals. It is the best animal feed consisted of superior amino acid balance (more lysine and protein) [4]. It contains more protein (15.9%) than wheat (11.8%), maize (11.1%), and barley (12.1%), despite having a lower gluten in proportion [2, 3].

The current global production of triticale is around 17 million tons, with Europe producing 90% [1, 5]. The United States and the rest of the Americas contributed 2.1% of overall production, while Asia produced 7.4% (FAO 2020) [5]. Furthermore, food production should be boosted by 50% over the current level, as the world's population is predicted to rise from 600 million to 1100 million by 2050 [6].

Triticale (x *Triticosecale* Wittm.) is a hybrid developed by crossing between durum wheat (*Triticum durum*) and rye (*Secale cereale*). It was initially bred by Stephen Wilson in 1873 [7]. The first triticale varieties were octoploids (AABBCCDD), but only hexaploid types (AABBCC) have great yield potential and are widely planted globally [8]. As a result, triticale inherited the traits of wheat (high yield potential and high quality yield) and rye (biotic and abiotic stress tolerance) [9, 10].

Triticale is grown in Bangladesh throughout the winter months (November to March) [11]. In 2009, the Wheat Research Centre (WRC) of Bangladesh Agricultural Research Institute (BARI) released two triticale varieties, viz. BARI Triticale 1 and BARI Triticale 2 (N.B.: In 2017, WRC-BARI was renamed Bangladesh Wheat and Maize Research Institute). Each variety produced between 4300 and 4600 kg ha^{-1} of grain yield and 10 to 12 t ha^{-1} of forage with a single cutting [12]. In Bangladesh, triticale grain can be utilized as a substitute to wheat and maize, particularly for animal feed and in the flour sector. Some high yielding triticale lines were created by CIMMYT, and their yield at optimal sowing time exceeded 10 t ha^{-1} [13]. Different research institutes have published spring and winter triticale types, which are outlined in Table 1 along with their primary characteristics.

TABLE 1
SPRING AND WINTER TRITICALE VARIETIES RELEASED BY DIFFERENT ORGANIZATIONS AND COUNTRIES

SN	Genotype	Important traits	Cultivation location	Growth habit	Ref.
1	BARI Triticale 1	✓ High yielding dual variety having superior grains as well as green forage yielding ability and agronomic performance ✓ Leaf rust resistant and leaf spot disease tolerant	Bangladesh	Spring	[12]
2	BARI Triticale 2	✓ Semi-dwarf triticale variety ✓ High yielding dual variety ✓ Tolerant to leaf rust and leaf spot disease	Bangladesh	Spring	
3	Karma 2000	✓ Lowest drought susceptibility	Turkey	Spring	
4	Tacettinbey	✓ Resistant to abiotic stress	Turkey	Spring	
5	Presto	✓ Resistant to abiotic stress	AARI	Spring	
6	AC Ultima, Bunker, Pronghorn, Taza (T198) and Tyndal	✓ T124 Spring type with FHB resistance ✓ Reduction in awn expression, and superior in GPC ✓ Resistant to leaf rust and stem rust, etc.	Agriculture and Agri-Food Canada, Oipc	Spring	[14, 15]
7	Gnu's, Juanillo, Civet, Beagle's, and Wombat's	✓ Yield, diseases resistant	Mexico/CIMMYT/Morocco	Spring	[16]
8	Lasko	✓ High protein content	Poland	Spring	
9	GT2-88/89	✓ High yield potentiality	Bulgaria	Winter	
10	MT1	✓ High yield potentiality	Poland	Winter	
11	Siskiyou	✓ Resistant to bacterial leaf streak (BLS) disease	Northern California	Spring	[17]
12	Pi 428,736	✓ Resistant to BLS	Manitoba, Canada	Spring	
13	Sorento	✓ Resistant to leaf rust and powdery mildew	Beijing, China	Spring	
14	Pi 428,854	✓ Resistant to BLS	Russia	Spring	
15	CAMELOT	✓ Early maturing, awnless, and short stature, and	Resource Seeds, Inc. California, USA	Spring	

		✓ Resistant to stripe rust, leaf rust, powdery mildew, and BYD, etc.			
16	MERLIN	✓ Late maturing, leaves have a waxy bloom, and ✓ Resistant to powdery mildew, moderately resistant to leaf rust, stripe rust, and BYD, etc.	Resource Seeds, Inc., California, USA	Spring	
17	TRICAL BRAND 102	✓ Awnletted, late maturing, ✓ Resistant to stripe rust, leaf rust and *Septoria tritici* leaf blotch	Resource Seeds, Inc., California, USA	Winter	
18	TRICAL BRAND 105, TRICAL BRAND 118 and TRICAL BRAND 2700	✓ Good lodging resistance, ✓ Resistant to stripe rust, leaf rust and *Septoria tritici* leaf blotch, and moderately susceptible to BYD	Resource Seeds, Inc., California, USA	Spring	[17]
19	ALZO	✓ Tall with good straw strength	Resource Seeds, Inc., California, USA	Winter	[17]
20	BEAGLE	✓ Resistant to *Septoria tritici* leaf blotch, stripe rust, leaf rust and ✓ Moderately susceptible to BYD	CIMMYT in cooperation with INIA		
21	BEAGUELITA 'S'	✓ Resistant to *Septoria tritici* leaf blotch, stripe rust, and leaf rust, and moderately susceptible to BYD	CIMMYT in cooperation with INIA	Spring	
22	CELIA	✓ Stiff straw and good lodging resistance, ✓ Resistant to stripe rust, leaf rust, and *Septoria tritici* leaf blotch, moderately resistant to *Pseudocercosporella* foot rot and snow mold, and	Oregon Agricultural Experiment Station, USA	Winter	
23	LANCE	✓ Awnless, medium late maturing	Resource Seeds, Inc., California, USA	Spring	
24	MAH 3600	✓ Tall with good straw strength	Developed in Poland and received for evaluation from Resource Seeds, Inc., California, USA	Winter	
25	MAH 3800	✓ Mid-tall with good straw strength, and ✓ Resistant to leaf rust and BYD	Developed in Poland and received for evaluation from Resource Seeds, Inc., California, USA	Winter	
26	Siskiyou	✓ Awns are short and purple to black in color, ✓ Resistant to *Septoria tritici* leaf blotch, moderately susceptible to stripe rust and leaf rust, and susceptible to BYD	CIMMYT and the California AES	Spring	
27	YUMA	✓ Medium maturing and is tall with fair straw strength, ✓ Resistant to stripe rust and moderately susceptible to BYD	Nutriseed, Inc. (AZ)., UK	Spring	

Triticale grows taller than wheat and durum. As a result, lodging is a major issue for triticale cultivation. A triticale variety with a short stature/plant height (PH) is preferable for cultivation. Winter in Bangladesh is short, and temperature increases chronologically around mid-February, when triticale crop stands on flowering stage. Again, when the crop reached at the grain filling stage in March, high temperature and relative humidity exist resulting in the reduction of the stage. In consequence,

small sized, shriveled and unfilled/unfertile grains are formed. Therefore, the development of short duration triticale variety in the country has a crucial demand. According to numerous experts, FSPMS and TGW contributed more to GY production [18, 19, 20]. In Bangladesh, the discovery of a short duration and high producing triticale line has become a major concern. Therefore, the trials were performed to identify a high yielding triticale line that may be introduced as a variety to meet up triticale demand for multipurpose usage.

II. MATERIAL AND METHODS

2.1 Location and soil characteristics:

Experiments were carried out throughout the seasons 2018-19 and 2019-20 (4th week of November to 1st week of April) at the research station of Bangladesh Wheat and Maize Research Institute located in 23° 11' 14.52" N, 89° 11' 11.99" E; 10.4 masl) [21]. The experiment field is located in Agro-Ecological Zone #1 (AEZ #1), which is known as the "Old Himalayan Piedmont Plain" [22]. AEZ # 1 is classified as high land, flood-free, fine texture soil made mostly of silt and loam soils. Soils on the research farm have medium organic matter (2.38-2.45%) and pH ranging from 4.96 to 5.29, and additional nutrients are present in the soils shown in Table 2 (Test report).

TABLE 2

THE CHARACTERISTICS OF SOIL COMPOSITIONS OF THE RESEARCH FARM OF BANGLADESH WHEAT AND MAIZE RESEARCH INSTITUTE

Lab	Sample No.	Test results of soil samples									
		pH	OM	N	P	K	S	Zn	B	Ca	Mg
			%	%	µg/g	meq/100g	µg/g	µg/g	µg/g	meq/100g	meq/100g
36041	BWMRI 1	4.96	2.45	0.14	33.18	0.32	34.08	1.96	0.11	2.18	0.75
36042	BWMRI 2	5.24	2.38	0.13	31.26	0.19	18.81	1.25	0.05	0.99	0.39
36043	BWMRI 3	5.29	2.44	0.12	34.69	0.22	22.38	1.19	0.04	2.23	0.78

Laboratory: Regional Laboratory, Soil Resources Development Institute, Nashipur, and Dinajpur, Ministry of Agriculture, The Government of the People's Republic of Bangladesh; OM: Organic matter

2.2 Plant materials and experimental design:

Experiments were conducted with four lines of triticale (x *Triticosecale* Wittm.) and two varieties viz. BARI Triticale 1 and BARI Triticale 2 used as check. The trials were accommodated in randomized complete block design with three biological replicates.

2.3 Land Preparation, fertilization, seeding, and agronomic management:

The land was plowed, cross-tilled, and leveled four times with a tractor and harrow. During the final ploughing, cowdung at 5000 kg ha^{-1} was applied to the entire ground. Fertilizers were applied at a rate of 100-27-50-20-4.5-1 kg ha^{-1} cowdung-N-P-K-S-Zn-B. N-P-K-S-Zn-B was obtained from urea, triple super phosphate, potash muriate, gypsum, zinc sulphate monohydrate, and boric acid, in that order. In the sub-plot, two-thirds of the urea and all fertilizers were applied right before seed sowing. Provax 200 WP (Carboxin 17.5% and Thirum 17.5% FF) was used as seed treatment @3g kg^{-1} to improve germination and protect seedlings from soil-borne fungi. Row spade was used to prepare rows. Using the continuous line sowing method, seeds were sown with hands into 1.0-1.5 inches of soil depth in lines with row spacing of 20 cm between two lines. Each sub-plot was made up of 10 rows having 5m row length. After the first watering at 20 days after sowing (DAS), the remaining one-third urea was top-dressed. The first and second years of seeding were completed on December 1, 2018 and November 30, 2019, respectively. Intercultural operations and other activities were carried out in accordance with the crop management recommendations set by BWMRI (2018) [23].

2.4 Data recording, crop harvesting and processing:

DH, DM and PH were recorded timely as described by Alam et al. (2013a, 2013b) [24, 25]. In the Zadoks stage 9.2, when grains were loosed in spikelet, crop was harvested [26]. All processes were furnished as the recommended guides of BWMRI [27, 28].

2.5 Statistical analysis:

The statistical analyses were performed with SPSS (version 23). Treatment means (±SD) for biological replications were compared to control for significance with least significant difference at $P \leq 0.05$ level. The correlation analyses among the parameters were performed using bivariate correlation. The relationships among variables were also analyzed following linear regression.

III. RESULTS

3.1 Days to heading:

The DH of various lines and varieties of triticale was observed insignificant in the season of 2018-19, but significant in the 2019-20 (Fig. 1A). In the 2018-19, E2 had the highest DH, but E5 had the lowest, followed by E3. Again, in the 2019-20 season, E1 and E5 represented the lowest DH, while E3 demonstrated the greatest than them. As a result, the E1 and E5 lines had the lowest DH both seasons. Furthermore, the DH was found to be higher in the 2019-20 season than in the 2018-19 (Figure 1A).

3.2 Days to maturity:

In both seasons, the DM of triticale genotypes was found insignificant. The line E6 had the lowest DM in the 2018-19, followed by E5. In the same time span, E3 displayed the highest DM, followed by E1. Furthermore, in the 2019-20, E4 had the greatest DM, followed by E1, but E2 had the lowest, followed by E5 and E6. The 2019-20 season displayed significantly higher DM than the 2018-19 (Figure 1B).

3.3 Plant height

Lodging for triticale is the great problem to the farmers since its height is more than wheat and durum. The PH of triticale lines was exhibited significantly difference shown in the Figure 1C. The lowest PH was depicted by E4 followed by E6 in the 2018-19 while the highest PH was portrayed by E2 followed by E5 same season. Moreover, in the 2019-20, the lowest PH was demonstrated by E1 followed by E5, but the maximum PH was showed by E3 and E6. The PH scaled in the 2019-20 was depicted comparatively shorter than the 2018-19 (Figure 1C).

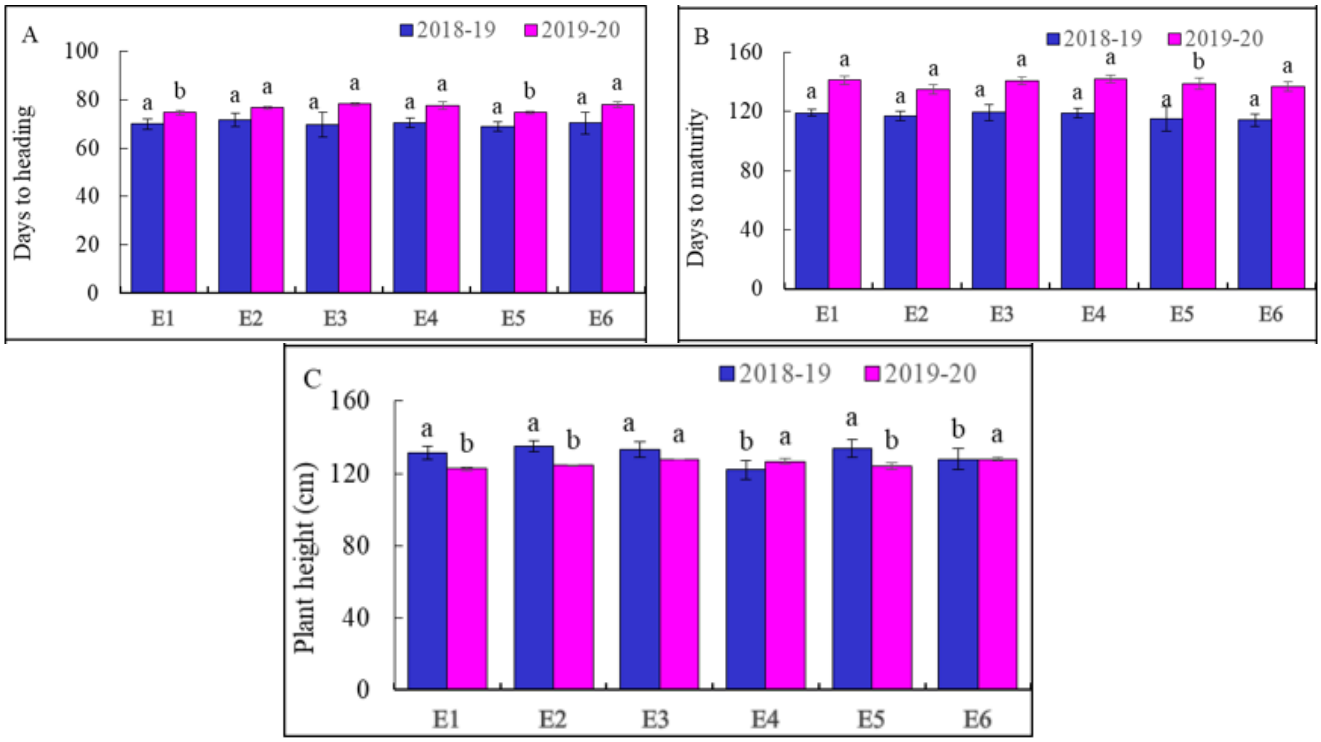

FIGURE 1: Days to heading (A), days to maturity (B) and plant height (cm) (C) of triticale varieties and lines grown in the seasons of 2018-19 and 2019-20. E1 = BARI Triticale 1; E2 = BARI Triticale 2; E3 = Triticale line 1; E4 = Triticale line 2; E5 = Triticale line 3; E6 = Triticale line 4. Data were means (±SD) of four biological replications. Bars with different letters indicate significant difference at $P \leq 0.05$ (Duncan test). BARI = Bangladesh Agricultural Research Institute.

3.4 Fertile spikes m^{-2}

In the investigation, the number of FSPMS of six genotypes of triticale was found highly significant both seasons (Figure 2A). In the 2018-19, the highest FSPMS was counted by E6 followed by E5, and the lowest one by E4. Moreover, the minimum FSPMS was showed by E4, but the highest one by E6 in the 2019-20. In addition, comparatively more FSPMS was exhibited in the 2019-20 than the 2018-19 (Figure 2A).

3.5 1000-grain weight

The TGW is one of the most vibrant factors of all yield contributing characters. The TGW of various genotypes of triticale grown both seasons was exhibited highly significance (Figure 2B). Comparatively lower TGW was exhibited by genotypes grown in the 2018-19 than the 2019-20. In year-wise in the trial, the highest TGW was demonstrated by E6, and the lowest one by E4 in the 2018-19. On the other hand, the minimum TGW was showed by E2, but the maximum one by E5 in the 2019-20 (Figure 2B).

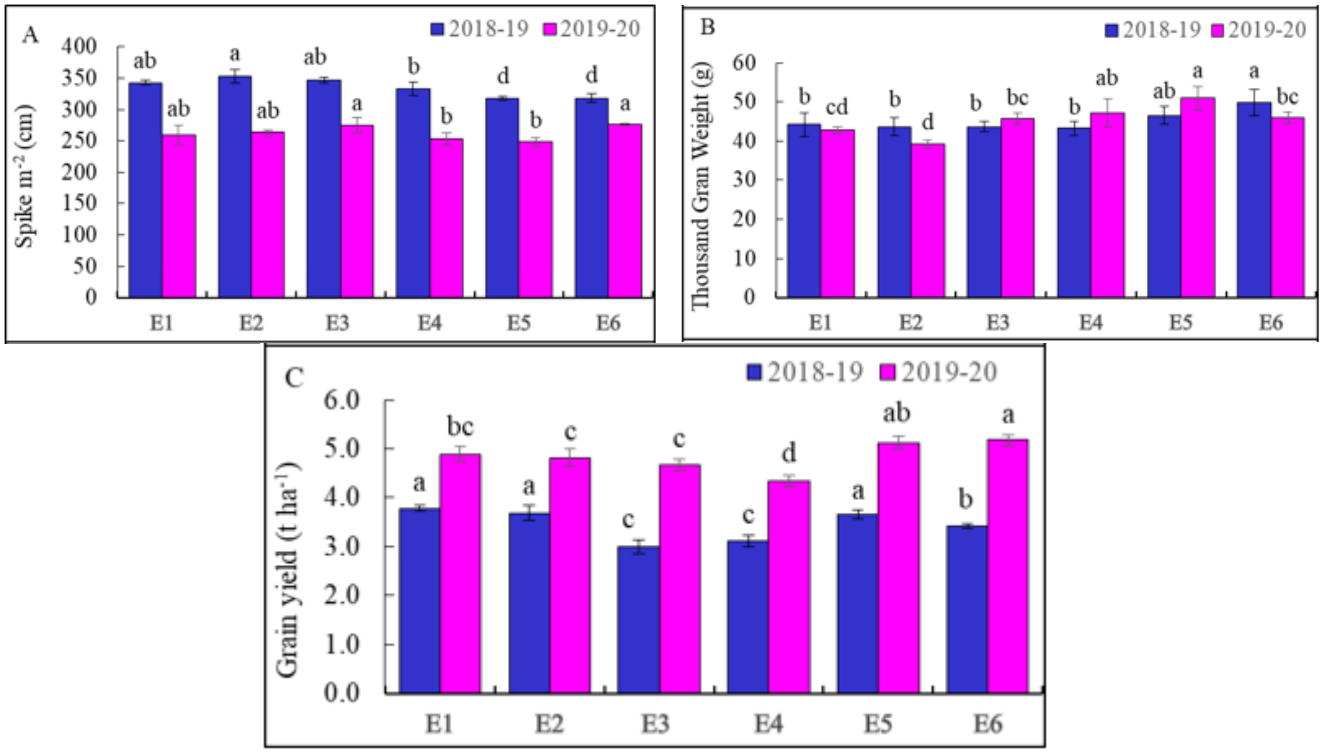

FIGURE 1: Number of fertile spike^{-2} (A), thousand grain weight (g) (B) and grain yield (t ha^{-1}) (C) of triticale varieties and lines grown in the seasons of 2018-19 and 2019-20. E1 = BARI Triticale 1; E2 = BARI Triticale 2; E3 = Triticale line 1; E4 = Triticale line 2; E5 = Triticale line 3; E6 = Triticale line 4. Data were means (±SD) of four biological replications. Bars with different letters indicate significant difference at $P \leq 0.05$ (Duncan test). BARI = Bangladesh Agricultural Research Institute.

3.6 Grain Yield

In the observation, GY produced by lines/varieties of triticale both seasons was found highly significant difference (Figure 2C). The highest GY was exhibited by E6 followed by E5, but the lowest one by E3 in the 2018-19. Oppositely, in the 2019-20 the lowest GY was portrayed by E4, but the maximum was demonstrated by E6 followed by E5 (Fig. 2C). The released varieties E1 and E2 were depicted comparatively lower GY than the lines E5 and E6 except E3 and E4 both seasons. In the season of 2019-20, relatively higher GY was demonstrated by lines/varieties of triticale than in the 2018-19 (Figure 2C).

3.7 Correlation among the parameters of triticale genotypes

In the 2018-19, the very low correlation was depicted between DH and DM (r^2 = 0.112) (Table 3). The relationship among FSPMS with DH and DM were exhibited negative (r^2 = - 0.103 and r^2 = - 0.876, P< 0.05, respectively), but positively correlated with PH (r^2 = 0.610). Again, TGW was showed positively correlated with FSPMS (r^2 = 0.747, P< 0.05), oppositely had

negatively correlation with DH, DM and PH (r^2 = -0.245, r^2 = - 0.894 and r^2 = - 0.029, P< 0.05, respectively) (Table 3). Moreover, GY was positively correlated with PH, FSPMS and TGW (r^2 = 0.341, r^2 = 0.698, r^2 = 0.651, P< 0.05, respectively) while was negatively found with DH and DM (r^2 = - 0.010, r^2 = - 0.733, respectively) (Table 3).

TABLE 3

CORRELATION COEFFICIENT AMONG THE PARAMETERS OF TRITICALE GENOTYPES GROWN IN THE SEASON OF 2018-19

	DH	DM	PH	FSPMS	TGW	GY
DH	1					
DM	0.112	1				
PH	-0.034	-0.194	1			
FSPMS	-0.103	-0.876	0.61	1		
TGW	-0.245	-0.894	-0.029	0.747	1	
GY	-0.01	-0.733	0.341	0.698	0.651	1

****. Correlation is significant at the 0.05 level (2-tailed)***

DH = Days to heading, DM = Days to maturity, PH = Plant height, FSPMS = Fertile spike per meter square, and TGW = Thousand grain weight, GY = Grain yield.

TABLE 4

CORRELATION COEFFICIENT AMONG THE PARAMETERS OF TRITICALE GENOTYPES GROWN IN THE SEASON OF 2019-20

	DH	DM	PH	FSPMS	TGW	GY
DH	1					
DM	0.171	1				
PH	0.915	0.263	1			
FSPMS	0.041	-0.703	0.164	1		
TGW	-0.091	0.149	0.274	0.137	1	
GY	-0.395	-0.653	-0.234	0.883	0.152	1

****. Correlation is significant at the 0.05 level (2-tailed). DH = Days to heading, DM = Days to maturity, PH = Plant height, FSPMS = Fertile spike per meter square, and TGW = Thousand grain weight, GY = Grain yield.***

On the other hand, the positive relationship between DH and DM was observed in the season of 2019-20 (r^2 = 0.171, P< 0.05). PH had also highly positive correlation with DH (r^2 = 0.915, P< 0.05), but low correlation with DM (r^2 = 0.263, P< 0.05) (Table 4). FSPMS had very low positive relationship with PH (r^2 = 0.164), but had highly negative correlation with DM (r^2 = -0.703). In addition, TGW exhibited positively correlation with DM, PH and FSPMS (r^2 = 0.149, r^2 = 0.274, r^2 = 0.137, respectively), (Table 4). Moreover, GY demonstrated highly positive correlation with FSPMS (r^2 =0.883), and very low correlation with TGW (r^2 =0.152), but negative correlation with DH, DM and PH (r^2 = -0.395, -0.653 and -0.234, respectively) (Table 4).

IV. DISCUSSION

The growth and development, physiological characteristics, yield and yield contributing attributes of triticale were mostly influenced by meteorological conditions and edaphic factors [19, 20]. Triticale could be grown in yearly rainfall from 265 to 440 mm [29]. Other findings provoked that triticale could be grown from -1 to 19 º C and from 175 to 800 mm rainfall [30]. Therefore, temperature, rainfall and humidity have the harsh effects on the growth and development of flower initiation, anthesis, grain formation, DM, yield and yield contributing characters of triticale [6]. In our study, minimum, mean, and maximum temperature and %RH were higher in the season of 2019-20 than those of the season of 2018-19, and rainfall was lower in the period of 2019-20 than the 2018-19 (Figure 3, Figure 4, Figure 5). Abiotic stress has the detrimental effects on plant growth and development [30, 31, 32]. DH is an important physiological factor for cool loving triticale. Heading under high temperature (<25 ºC temperature) bars the anthesis process of wheat resulting in negative effect of grain formation, described by many researchers [25, 34]. Again, long span of DH under low temperature enhanced tillering, physiology, grain weight and yield of wheat [35].

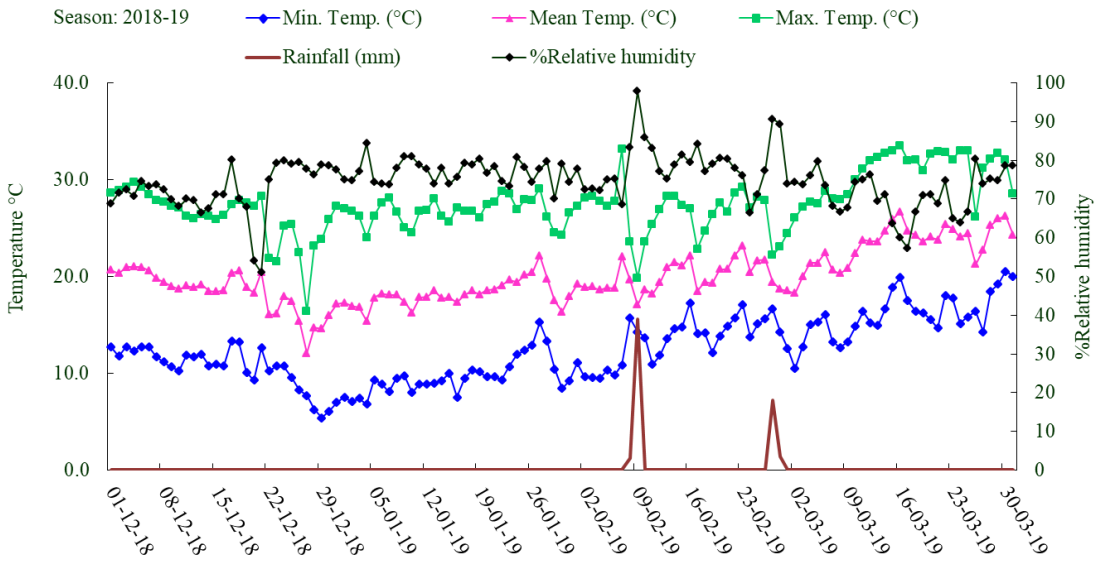

FIGURE 3: Minimum, maximum, and mean temperature, rainfall (mm) and %relative humidity during triticale growing period (from o1 December, 2018 to 31 March, 2019) at the headquarter research farm of BWMRI, Dinajpur, Bangladesh.

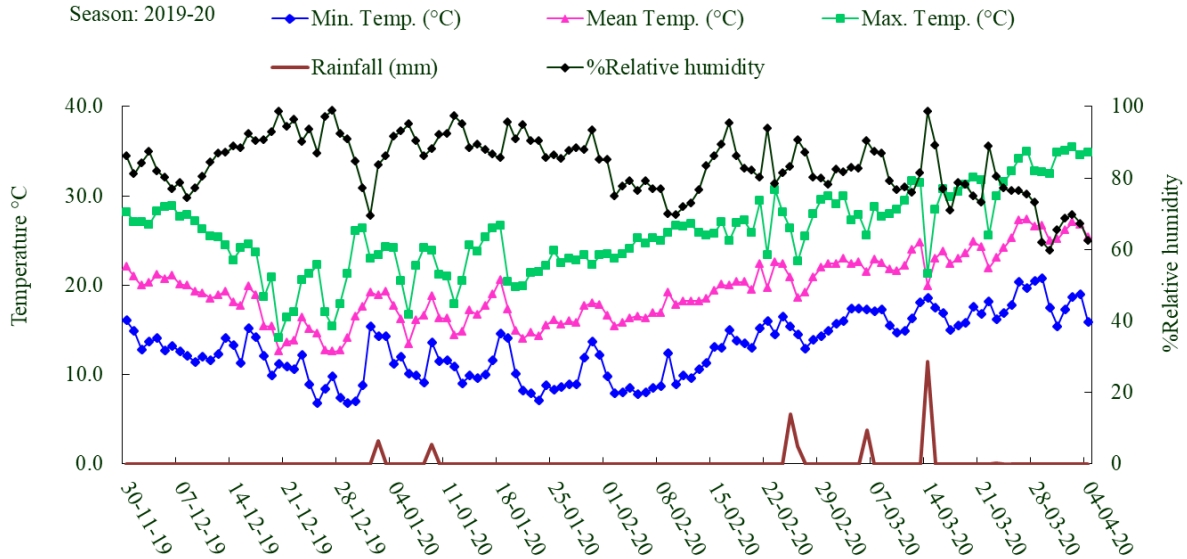

FIGURE 4: Minimum, maximum, and mean temperature, rainfall (mm) and %relative humidity during triticale growing period (from 30 November, 2019 to 04 April, 2020) at the headquarter research farm of BWMRI, Dinajpur, Bangladesh.

In the trials, long length of DH under comparatively lower temperature in the period of 2019-20 might enhance GY of triticale (Figure 1A, Figure 2C, Figure 3, Figure 4, Figure 5). The related findings were summarized by Sarker et al. (2006) [18] and Bezabih et al. (2019) [36]. In Bangladesh, under timely sowing of triticale, its grain formation was sophisticatedly occurred in mid-February to mid-March [37]. But comparatively lower temperature might enhance the length of DM which was desired for high yield of triticale (Figure 1B, Figure 2C, Figure 3, Figure 4, Figure 5, Table 3, Table 4). Since triticale grows in tall, there is more chance to decline to lodging; PH is considered as a vital point to protect its lodging. Lodging of triticale due to light storm or wind flow might cause more yield reduction of triticale [38]. To release a variety of triticale, tallness is considered greatly as a better protection of lodging [39].

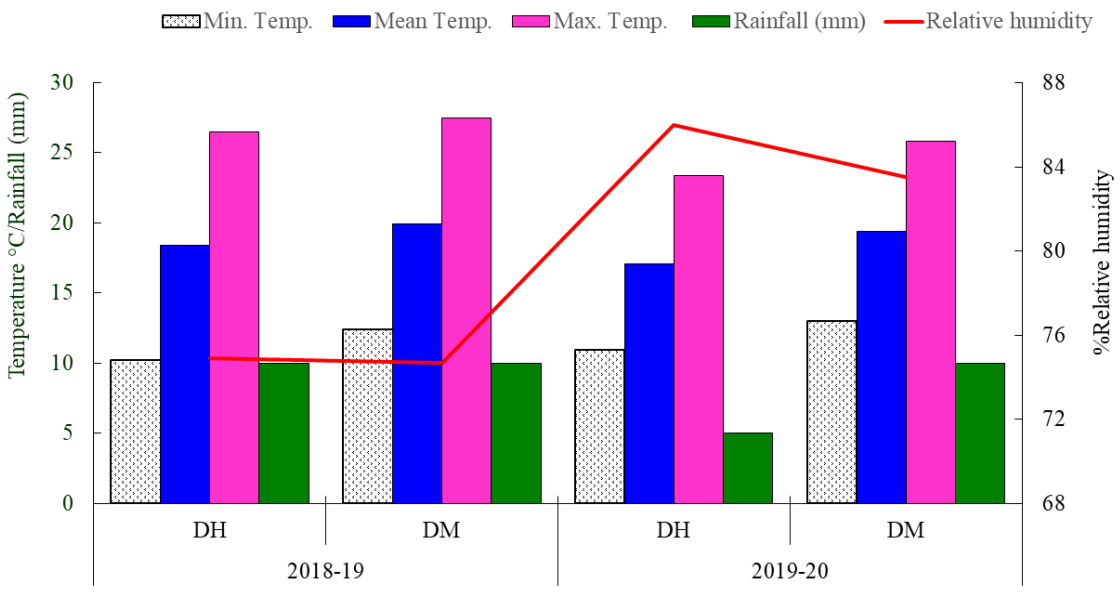

FIGURE 5: Minimum, maximum, and mean temperature, rainfall (mm) and %relative humidity in the period of days to heading and days to maturity during triticale growing period in the seasons of 20018-19 and 2019-20 at the headquarter research farm of BWMRI, Dinajpur, Bangladesh

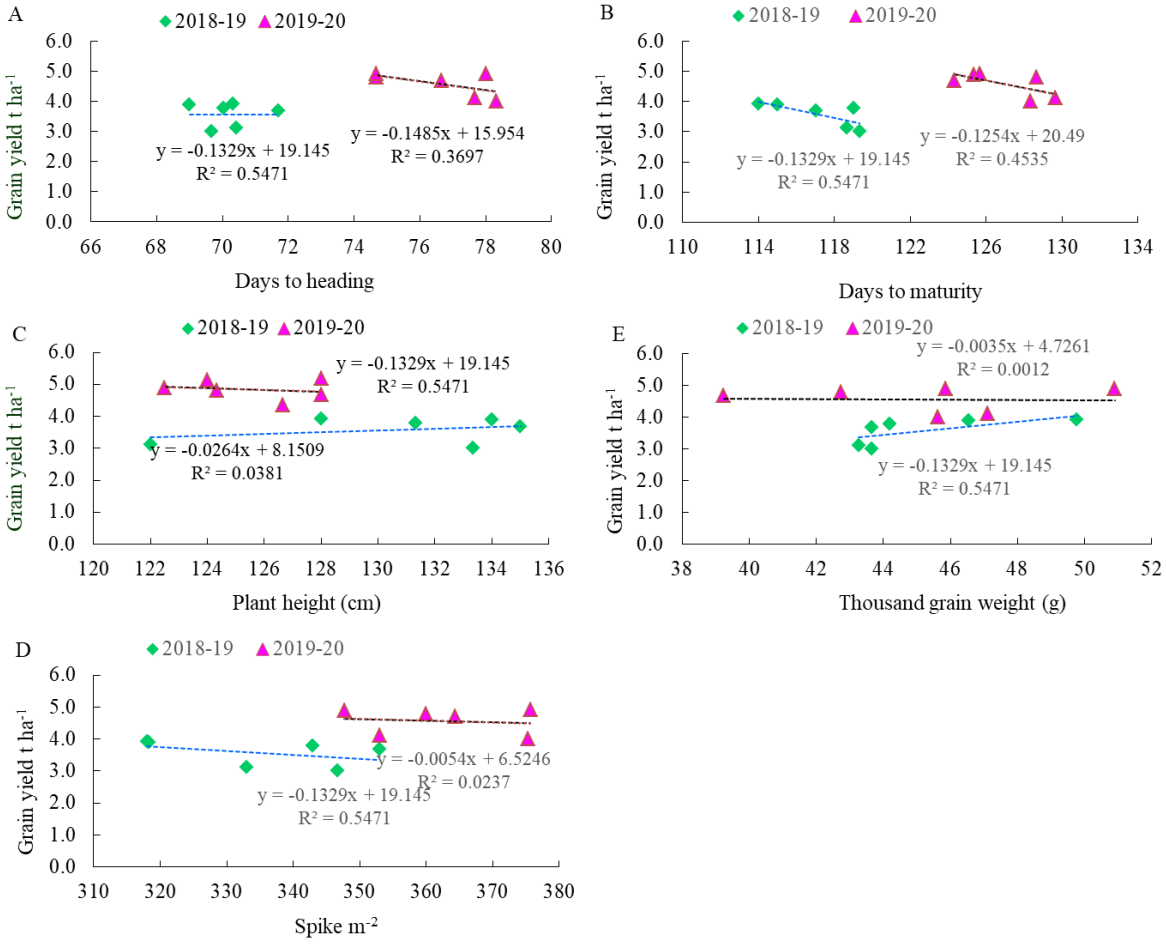

FIGURE 6: The relationship of grain yield with days to heading (A), days to maturity (B), plant height (C), fertile spike m^{-2} (D) and thousand grains weight (E) of triticale, each in two growing seasons (2018-19 and 2019-20)

In the season of 2018-19, the low relationship between PH and GY was observed (r^2 = 0.337) (Table 3; Figure 6C), but negatively very low relationship found between PH and GY (r^2 = -0.234) in the season of 2019-20 (Table 4; Figure 6C). GY of wheat was the combined results of phenotypic, physiological and yield contributing characters [40]. FSPMS is one of the characters. Optimum number of FSPMS generally contributes to produce higher grain yield in triticale. FSPMS produced in the season of 2019-20 was higher than that of the season of 2018-19 might be influenced by lower temperature and more rainfall existed in the season of 2019-20 (Figure 2A, Figure 3, Figure 4, Figure 5), similar findings evidenced by Alam et al. (2013b) [25], Mazurenko et al. (2020) [41] and Hossain et al. (2019, 2021) [42, 43]. Positive correlation observed between FSPMS and GY in the study was also other evidence of higher yield in the season of 2019-20 (r^2 = 0.169) (Table 3 and Figure 6D). After physiological maturity, number of FSPMS lasted with fertile grain in plants; GY production also depended on, described by Feledyn-Szewczyk et al. (2020) [44]. TGW had a great influence on the yield of triticale (Figure 2B). It had also crucial influences on yield of wheat crop increment or reduction, evidenced by Al-Tabbal (2016) [45] and Alam et al. (2013) [25]. In the study, moderately correlation was observed between TGW and GY in the season of 2018-19 (r^2 = 0.657) (Table 3). In addition, very low correlation between TGW and GY was depicted in the period of 2019-20 (r^2 = 0.152) (Table 4, Figure 6E). TGW of triticale was varied in different genotypes, evidenced by Tratwal and Bocianowski (2021) [46] and Feledyn-Szewczyk et al. (2020) [44]. In both seasons, the more GY was produced by E5 and E6 compared to other genotypes (Figure 2C). GY of triticale was influenced by meteorological conditions, location, and yield contributing characters [16, 39, 44]. GY exhibited more in the season of 2019-20 than the season of 2018-19 might be influenced by lower temperature and more rainfall prevailed in that growing period (Figure 2C, Figure 3, Figure 4, Figure 5). Higher FSPMS in the season of 2019-20 might be other important reason for higher yield in same season. Same findings were resolved by Sarker et al. (2006) [18], Bezabih et al. (2019) [36], and Panek et al. (2020) [47]. In the investigation, in both seasons, relatively more GY demonstrated by E5 and E6 might be due to their high genetically inheriting capability and adaptability into multi-environmental factors, such as temperature, rainfall, and relative humidity, and edaphic factors [48].

V. CONCLUSIONS AND THE FUTURE SCOPE

Long span of DH and DM, and more number of FSPMS obtained in comparatively lower temperature were observed in the 2019-20 than the 2018-19. GY was exhibited more in the 2019-20 than the 2018-19, evidencing TGW exhibited negatively correlated with DH, DM and FSPMS same season (2018-19). Positive correlation observed between FSPMS and GY was also other evidence of higher yield in the 2019-20. Moreover, comparatively lower PH, but more FSPMS and TGW were exhibited by E5 and E6 than check varieties both seasons. Moreover, the relatively more grain yield was also depicted by E5 and E6 than check varieties. The summarized results provoked that the lines E5 and E6 may be released as high yielding variety (ies) to increase triticale yield production in Bangladesh.

ACKNOWLEDGMENT

The authors would like to extend their sincere appreciation to the Director General of the Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur, 5200, Bangladesh. The research work was performed with the core research fund of the Ministry of Agriculture, The Government of the People's Republic of Bangladesh [Grant number 135015200 of 2018 and 2019)

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Trend Analysis of Millet Production and Trade in Nepal in Order to Assess its Base while Celebrating International Year of Millet 2023

Khanal Arjun Prasad

Master in Agricultural Economics, Agriculture and Forestry University, Chitwan, Nepal
*Corresponding Author

Received:- 04 October 2023/ Revised:- 12 October 2023/ Accepted:- 18 October 2023/ Published: 31-10-2023

Abstract— *The main objective of this study was to analyze the status of millet production and trade in Nepal in order to assess its base in context of celebration of international year of millet (IYM) 2023 by using trend analysis technique. The foundation of this study is based on the data of millet published by Ministry of Agriculture and Livestock Development (MoALD), Singhadurbar, Kathmandu in various years. The growth rate in the area of millet in Nepal was found in 'decreasing trend' while the growth rate of both production and productivity of millet was found in 'increasing trend' in the period of 10 years between 2011/12 to 2020/21. Nepal was found involved in trade of just 'single item' of millet i.e millet seeds in the period from 2017/18 to 2021/22 which is a clear indication that trade of millet in the country lacks product diversification and value addition strategies. The growth rate in export of millet seeds was found in 'decreasing trend' in terms of quantity of export and 'increasing trend' in terms of monetary value of export in the same period. It might have been seen due to the fluctuation in the price of millet in the international market. The growth rate in import of millet seeds was found in 'decreasing trend' both in terms of volume and value of imports. It is the clear indication of lower preference of the farmers for growing millet over other crops in one hand and in another hand it clearly reflects the lower preference of consumers to consume millet over wheat and rice as it is perceived as the 'crop of poor' in society. The base of Nepal in the production and trade of millet was found 'weak but with tremendous possibility to improve' its performance in global market. In the scenario of declaration to celebrate 2023 as the International Year of Millet (IYM) by seventy fifth session of United Nations General Assembly, Nepal has opportunity to strengthen the trade of millet in Nepal through appropriate policy instruments for expansion of millet area, promotion in the use of improved varieties of millets, production based incentives, providing trainings and capacity building programs for farmers along with assured market mechanisms for achieving the actual motive of celebrating IYM and to bring the existing 'underutilized' status of millet into the limelight of 'commercialization'.*

Keywords— International Year of Millet, Nepal, trend, Underutilized.

I. INTRODUCTION

Millet (*Eleusine coracana* L.) is fourth most important crop of Nepal after rice, wheat and maize in terms of area and production [1]. It is mainly grown under maize/millet relay system in mid-hills of Nepal [2]. It is mainly produced in marginal hilly areas of Nepal and plays an important role in the food security of Nepalese poor and marginalized farmers [3], [4]. According to Luitel [5] around 39.7% (58512.71 km2) area of Nepal is highly suitable for finger millet, with cultivation mostly between 96 and 2300 m above sea level. Eastern and central parts of Nepal have more suitable areas than western parts. According to MoALD [6] it contributes 1.19% on Agriculture Gross Domestic Product (AGDP) of Nepal.

Millet can easily thrive in low fertile marginal land and less dependent on chemical fertilizer [7]. It is a hardy crop which can tolerate the scarcity of water in the brink of climate change. Hence it is a very important crop to maintain food security in the country even in the adverse circumstances of climate change [8], [9], [10]. Tesfaye [11] had claimed millet as the alternative crop to corn and soybean. According to Li [12] though millet being underutilized crops it has high nutritional value and health

benefits. They contain high amount of vitamin A, protein and oil contents than maize. As the recognition of the nutritious value, climate resilient capacity and potential to diversify global food system the United Nations General Assembly has declared 2023 as the International Year of Millets [13]. It an opportunity for Nepal for achieving the United Nations Sustainable Development Goals (SDG) or Agenda 2030 especially Goal 2 of ending hunger [14] and maintaining food security in the country. Besides celebrating IYM 2023 is equally helpful in improving the decreasing attraction of Nepali farmers' towards millet production and trade [15]. This study is carried out with the main aim of assessing the base of millet production and trade in Nepal in context of celebrating IYM 2023.

II. MATERIAL AND METHODS

This study is based on the secondary source of information. The data of millet published by Ministry of Agriculture and Livestock Development (MoALD), Singhadurbar, Kathmandu in various years was collected and analyzed by using Microsoft Excel 2013. Trend analysis technique is adopted for assessing the millet area, production, productivity, import and export of millet in Nepal. Similarly, the descriptive analysis of the current status of millet production in Nepal was done in both graphical and tabular forms.

III. RESULTS AND DISCUSSION

3.1 Production Status Millet in Nepal (Fiscal year 2021/22 and 2020/21)

In Nepal, Millet was found grown in 267,071 Ha land with the production and productivity of 339,462 MT and 1.27 MT/Ha respectively in fiscal year 2021/22. The Gandaki province was found contributing highest in production (32.45%) and area of production (32.60%) of millet. Similarly, Koshi province was found having highest productivity (1.44 MT/Ha) among the seven provinces of Nepal in the fiscal year 2021/22. (Table 1). The production of millet in the fiscal year 2021/22 was found improved (i.e increased from 326,443 to 339,462 MT) than in the fiscal year 2020/21 (Table 1, Fig. 1). It may be due to the programs for promotion of marginal cereals in Nepal such as finger millet and buckwheat as they are sustainable, environmentally friendly and healthier alternative to wheat [16], [17]. In addition to it, the another reason for increase in the production of millet in Nepal may be due to increasing concern in general public about potential negative health impacts of high wheat consumption [18], [19] and increasing concerns of people on the health benefits (positive health impacts) of millet such as hypoglycemic, anti-ulcerative and antioxidant properties [20], [21]. The domestic demand of millet is very high for making alcoholic beverages such as *Jand, Tangba and local rakshi* [22], [23], [24], According to Gyawali [25] Nepal has the comparative advantage (CA) for production of millet due to its climatic adaptability capacity, potential to resist drought, tolerance capacity to insect and easy management requirements. In the fiscal year 2020/21 the production of the millet was found maximum in Gandaki Province (107,952 MT) followed by the Koshi Province (96,828 MT), Bagmati Province (70,867 MT) and Karnali Provnice (20,752 MT). The production of the millet was found minimum (1,669 MT) in Madhesh Province (Fig. 1). In case of Koshi Province, the production area (23,794 Ha) and production (26,949 MT) of the millet was found highest in the Khotang district (Fig. 2). Similarly, the Sarlahi district of Madhesh Province was found having highest production area (709 Ha) and Production (638 MT) of the millet (Fig. 3).

The apex institution that look after the matter of agriculture and livestock affirs i.e Ministry of Agriculture and Livestock Development (MoALD) is located in Bagmati province. In this province, Sindhupalchok district was found having highest area (17,139) and production (22,457 MT) of millet (Fig. 4). In case of Gandaki Province, the Baglung district was found having highest production area (18,456 Ha) and production (23,247 MT) of millet (Fig. 5). Gulmi district of Lumbini province was found having highest production area (2927 Ha) and production (3,317 MT) of millet (Fig. 6).

The Karnali Province and the Far Western Province are respectively on the Mid western and Far western side of Nepal. The Mugu district of Karnali province was found having highest production area (4,264 Ha) and Production (4,196 MT) of millet in that province (Fig. 7). Similarly, the Doti district of Far Western Province was found having highest production area (4,625 Ha) and production (5,533 MT) of millet (Fig. 8). In Nepal, Katel [26] found variations in the consumption patterns of cereals across the country in different cultural preference and socioeconomic settings. It may be one of the strong reason for the variation of production of the millet in different provinces of Nepal.

TABLE 1
PRODUCTION STATUS MILLET IN NEPAL (2021/22)

Province	Production (MT)	Area (Ha)	Yield (MT/Ha)	Remarks
Koshi	98400 (28.99)	68483 (25.64)	1.44*	Figure in parenthesis indicates percentage * Indicates highest contributor among the seven provinces of Nepal ** Indicates lowest contributors among the seven provinces of Nepal
Madhesh	1669 (0.49)**	1656 (0.62)**	1.01**	
Bagmati	67628 (19.92)	59759 (22.38)	1.13	
Gandaki	110151 (32.45)*	87072 (32.60)*	1.27	
Lumbini	13711(4.04)	10383 (3.89)	1.32	
Karnali	24677 (7.27)	20115 (7.53)	1.23	
Far Western (*Sudurpashchim*)	23226 (6.84)	19603 (7.34)	1.18	
Nepal (Total)	339462 (100)	267071 (100)	1.27	

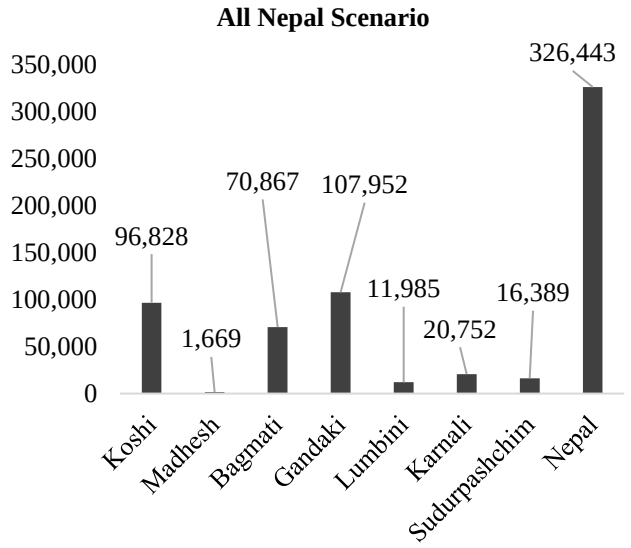

FIGURE 1: Production status of millet by province (2020/21)

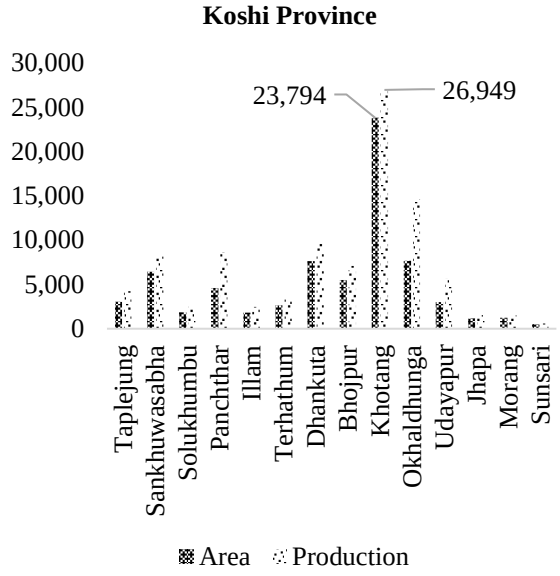

FIGURE 2: Production status of millet in Koshi province (2020/21)

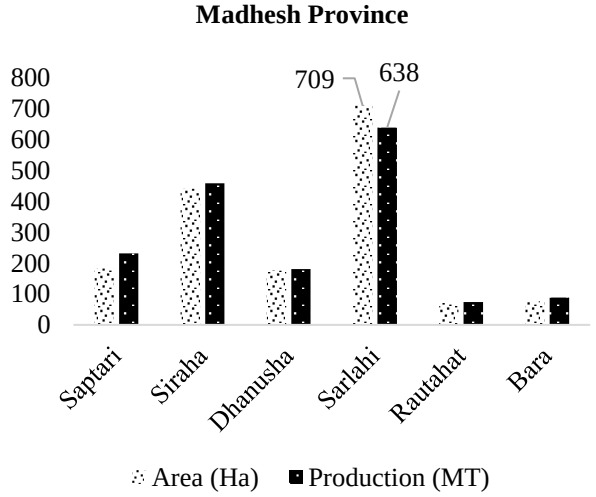

FIGURE 3: Production status of millet in Madhesh province (2020/21)

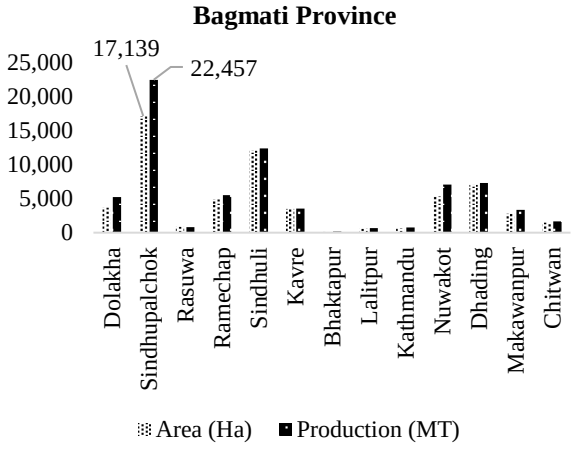

FIGURE 4: Production status of millet in Bagmati province (2020/21)

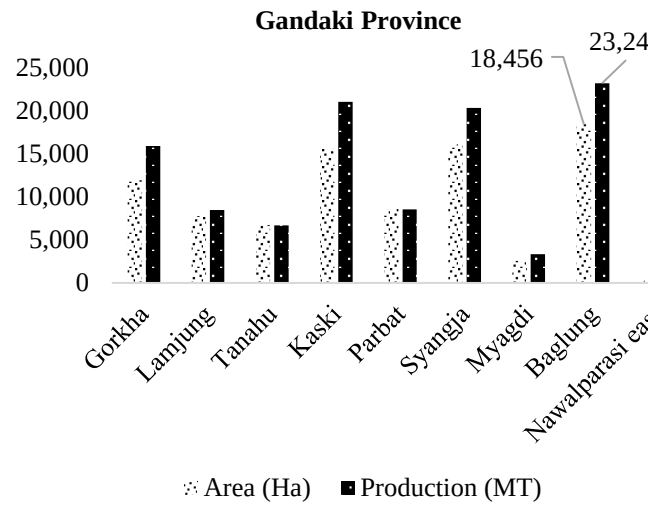

FIGURE 5: Production status of millet in Gandaki province (2020/21)

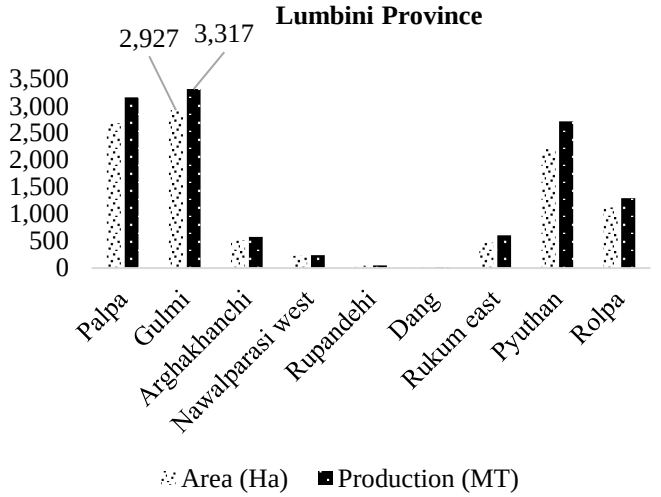

FIGURE 6: Production status of millet in Lumbini province (2020/21)

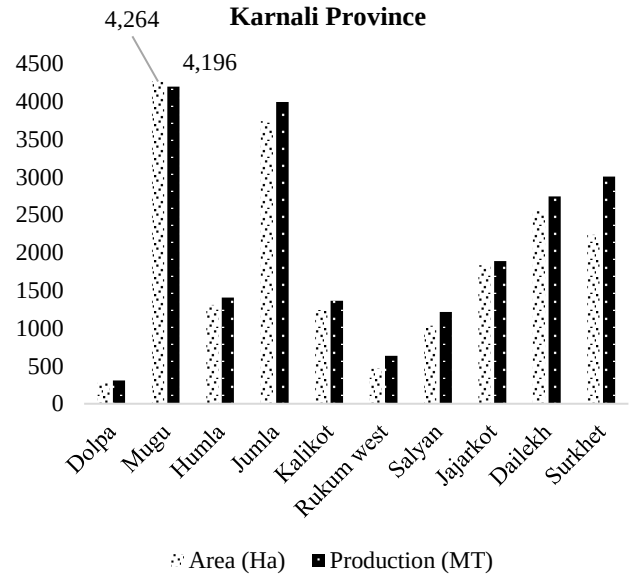

FIGURE 7: Production status of millet in Karnali province (2020/21)

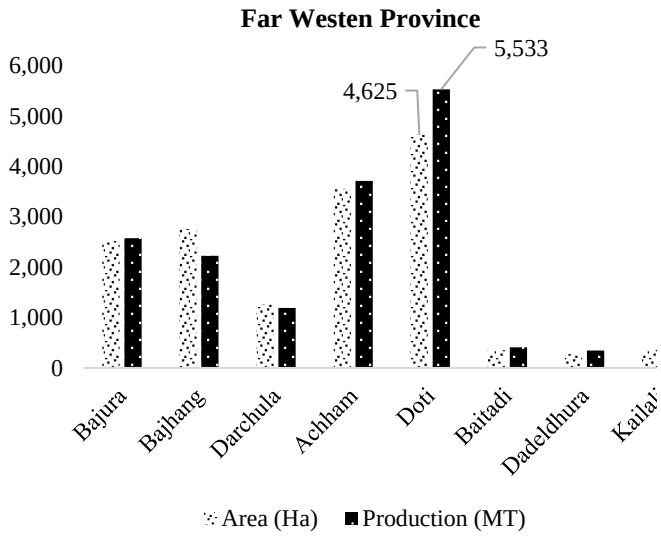

FIGURE 8: Production status of millet in Far Western province (2020/21)

3.2 Trend of millet production area (Ha), production (MT) and Yield (MT/Ha) in Nepal from 2011/12 to 2020/21

The growth rate in the area (Ha) of millet in Nepal was found 1531.8 in negative direction i.e decreasing trend (Fig. 9) while the growth rate of production of millet was found 1705.1 i.e increasing trend (Fig. 10) in the period of 10 years between 2011/12 to 2020/21. Similarly, the trend in the growth of productivity of millet (MT/Ha) was found following the increasing trend. However, the rate of growth in productivity is very low i.e 1.32% per year (Fig. 11). Gautam [27] had also found similar findings from their study of production and trade status of underutilized crops including millet in Nepal. According to Dixon [28] the dietary habits in Nepal is changing and urbanization is also increasing that led to shift in existing cereals such as maize and millet towards wheat based diets. It may be one of the reason for decreasing trend of area of millet production in Nepal. Besides, the social perception towards indigenous crops like millet as the symbol of backward and low status food that led to shift of consumption towards rice and other imported food grains [29] is also one of the important reason for decreasing trend of area of production of millet. In the scenario of increasing global food demand there is an immense need to come out of the major cereals preferences box [30] and move towards local hardy crops like millet is necessary to maintain the food and nutritional security in the country [31]

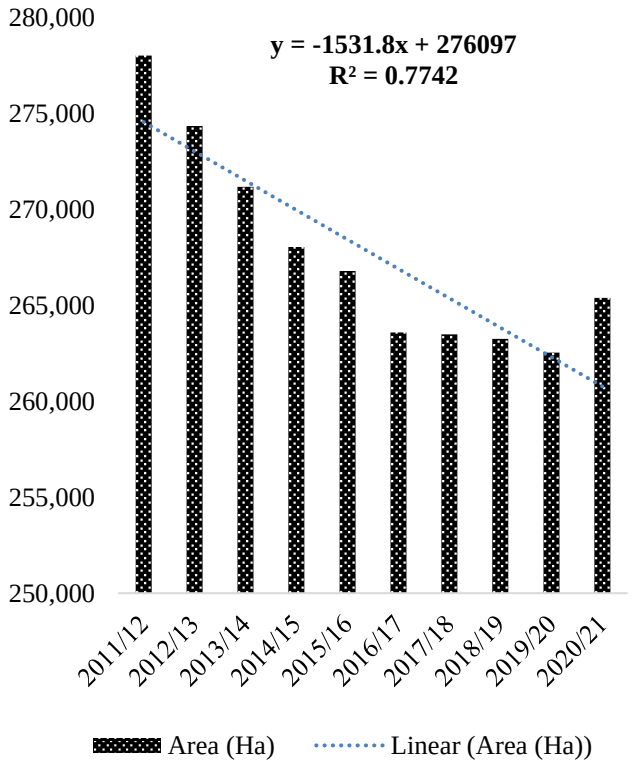

FIGURE 9: Trend of Area (Ha) of Millet in Nepal from 2011/12 to 2020/21

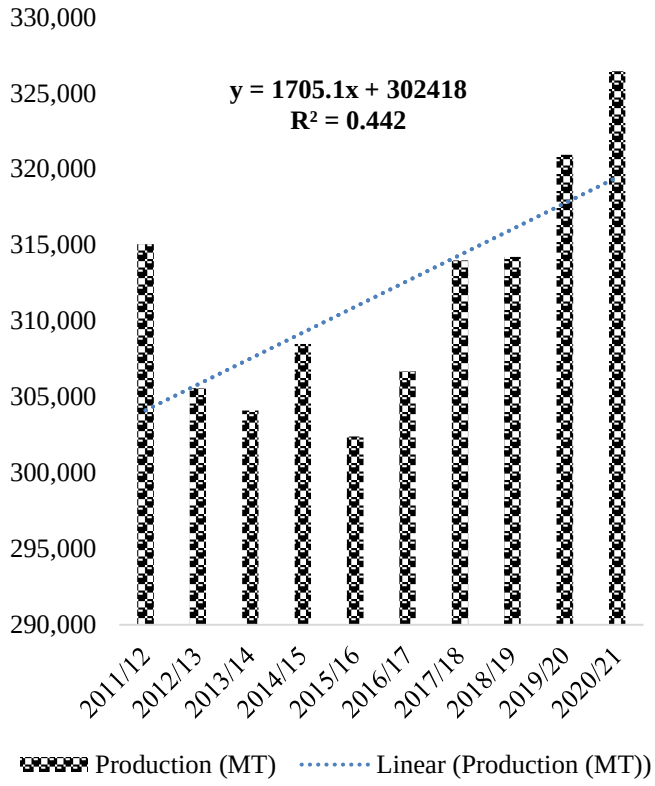

FIGURE 10: Trend of production (MT) of Millet in Nepal from 2011/12 to 2020/21

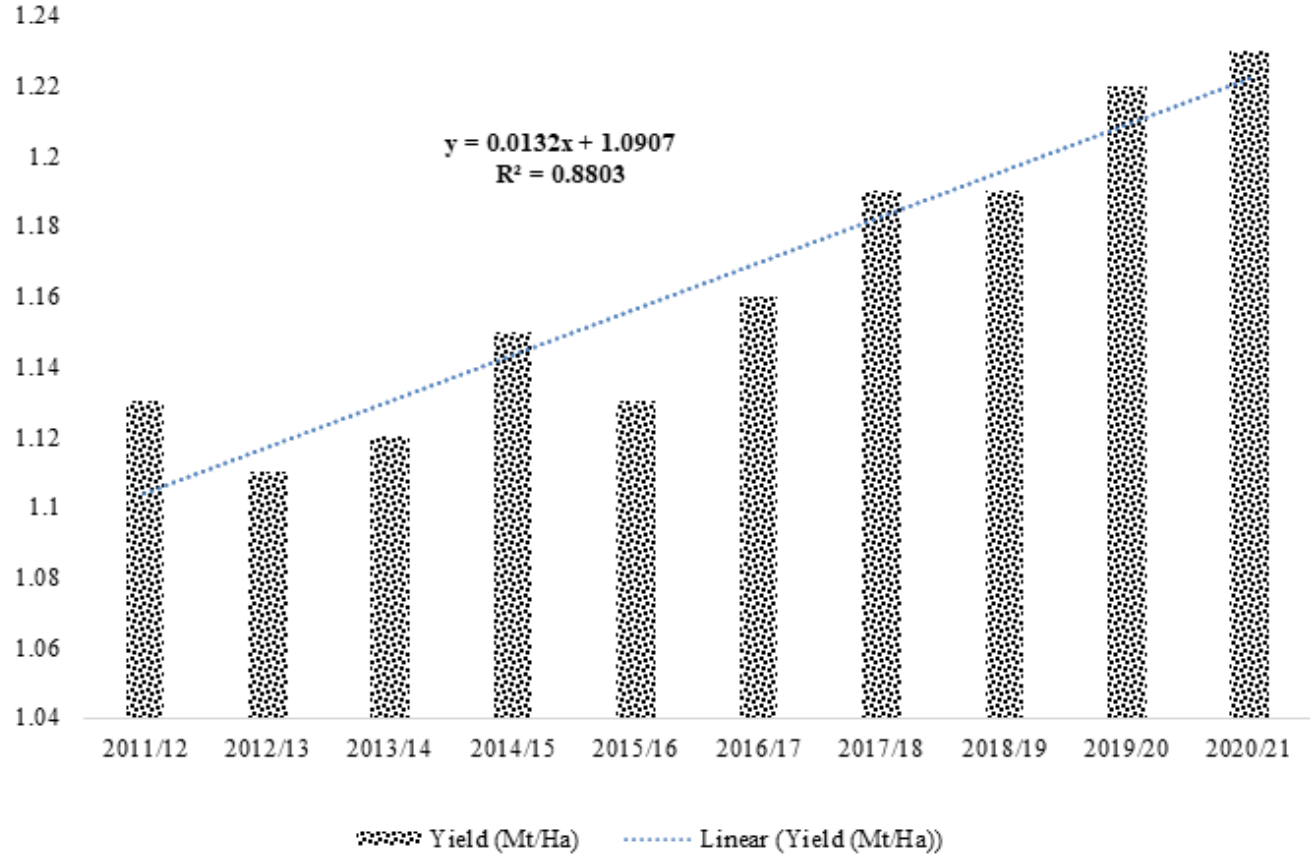

FIGURE 11: Trend of Yield of millet from 2011/12 to 2020/21

3.3 Trend in import and export of millet in Nepal from 2017/18 to 2021/22

Nepal was found only in the import and export of one item i.e millet seeds in the period from 2017/18 to 2021/22. It clearly indicates that Nepal trade of millet lacks its products diversification and it is in the primitive stage in the trade of millet. The growth rate in export of millet was found 6983.9 kg per year in negative direction i.e. decreasing trend (Figure 12). However, the growth of export value (000 NPR) was found in increasing trend of NPR 16,338,000 per year. In the year 2020/21 Nepal was found exporting comparatively less quantity of millet than in the year 2018/19 but found fetching more price in year 2020/21 than 2018/19. It may be due to the fluctuation in the price of millet in the international market (Fig. 12), (Fig. 13).

The growth rate in the quantity of import of millet seeds in Nepal was found 123,972 kg per year in negative direction i.e decreasing trend (Fig. 14). Similarly, the expenditure of the government in the import of the millet seeds was found in decreasing trend of NPR 79,140,000 per year (Fig. 15). Similar kind of finding in the trend of import of millet was found by Gautam [27] from their study of underutilized crops including millet in Nepal. In this context, according to study by Gairhe et al., (2021) [32] large amount of the millet is imported from India in Nepal and majority of imported millet was found used in making liquor (local alcohol) while only a small amount goes for consumption as food and feed. The decreasing trend of both export and import of millet in Nepal is clear indication of alarming decrease in consumption of millet in Nepal. The social perception toward millet as the food of poor and low status people [29] should be changed in order to promote millet trade in Nepal.

The base of millet production and trade in Nepal was found comparatively low as compared to neighboring countries especially India. In the scenario of declaration of celebration of international year of millet 2023 by the United Nations [13], Nepal should have to strengthens its ground of millet production and trade by area expansion of millet, promotion in the use of improved varieties along with the conservation of local varieties, change in the social perception among the framers as well as consumer on the nutritional and health benefits of the millet through awareness and education programs in order to achieve the motive of international year of millet 2023.

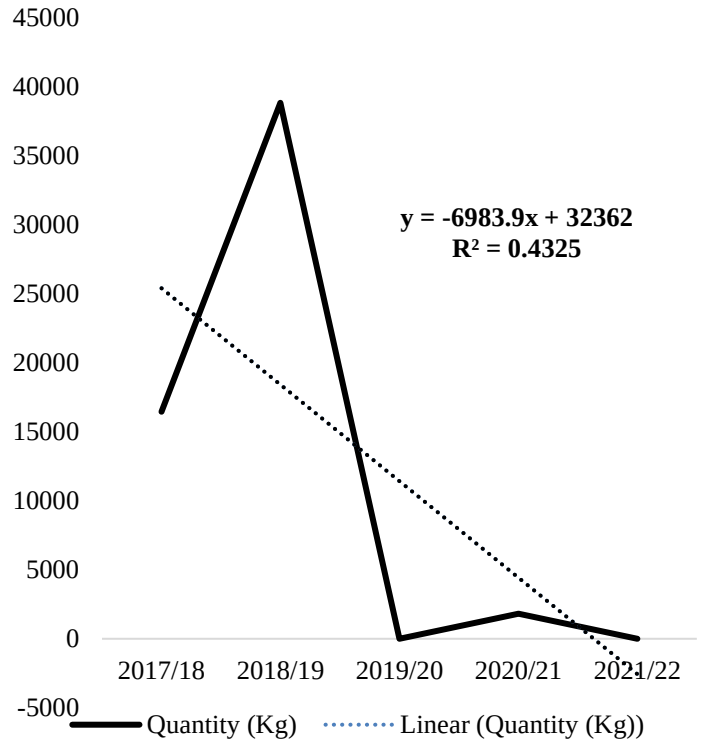

FIGURE 12: Trend in Export of Millet seeds from 2017/18 to 2021/22 (Kg)

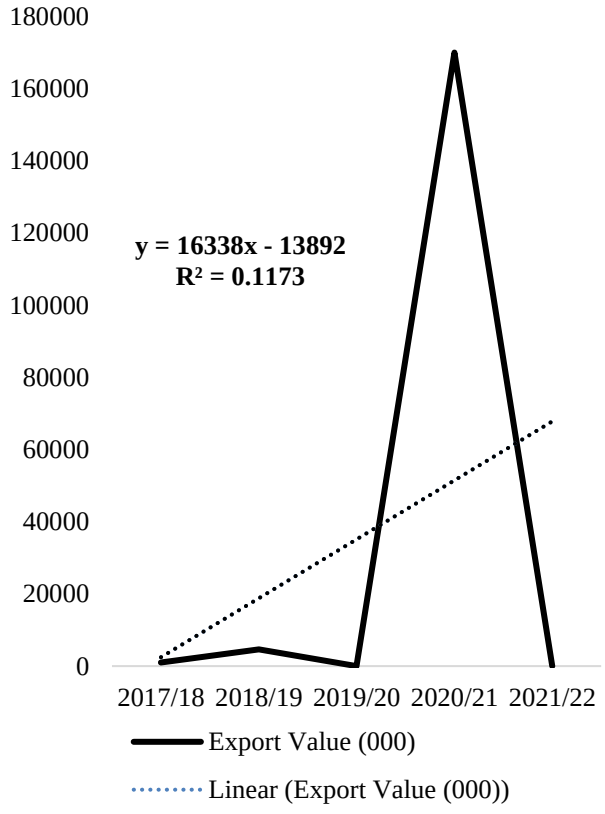

FIGURE 13: Trend in Export Value (000 NPR) of Millet seeds from 2017/18 to 2021/22

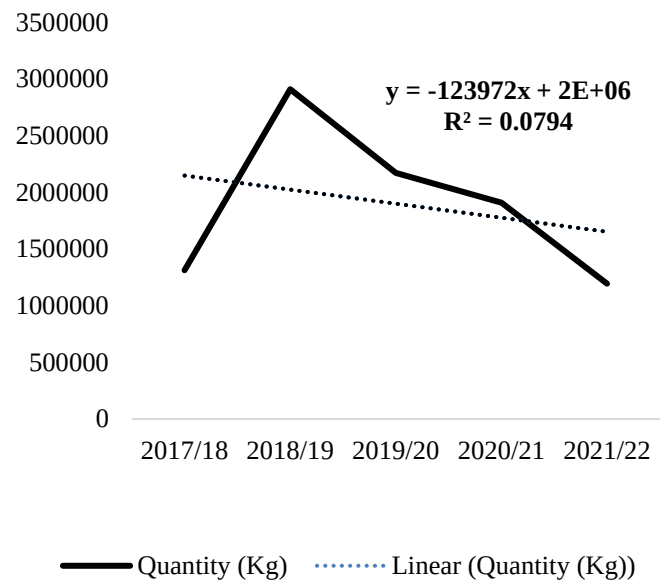

FIGURE 14: Import of Millet seeds from 2017/18 to 2021/22 (Kg)

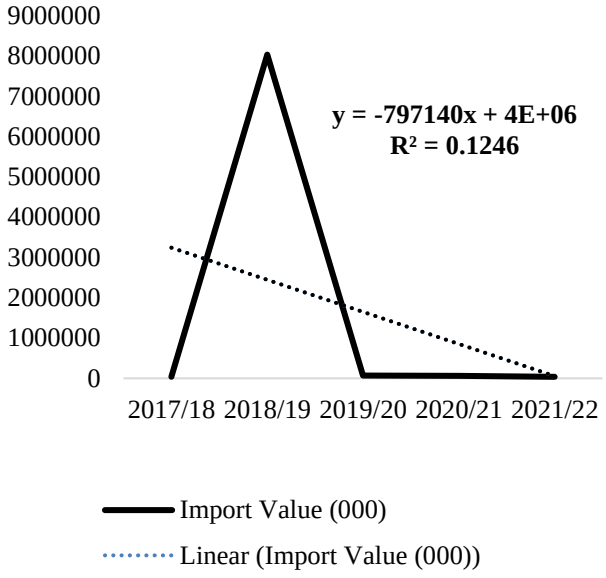

FIGURE 15: Trend in Import Value (000NPR) of Millet seeds from 2017/18 to 2021/22

IV. CONCLUSION

Millet is underutilized but highly potential crop of Nepal. In the period of a 10 years between 2011/12 to 2020/21 the growth rate in the area of millet was found in 'decreasing trend' while the growth rate of both production and productivity of millet was found in 'increasing trend'. The existing social perception towards millet as the crop of 'poor and backward people' can be one of the major reason behind the decreasing trend in the area of millet. Nepal was found very primitive in terms of trade of millet because it was found involved in trade of just a 'single item' of millet i.e millet seeds in the period from 2017/18 to 2021/22. It alarmingly indicates that the government of Nepal and other concerned stakeholders should have to move toward products diversification and value addition strategies of millet in order to get benefit from the trade. The growth rate in millet seed export was found 'decreasing trend' in terms of volume of export and 'increasing trend' in terms of monetary value of export throughout the same time period. The variation in the price of millet in the global market could be one of the reason behind it. In terms of volume and monetary value of imports, the growth rate in import of millet seeds was found in 'decreasing trend' in that period. It is the clear indication of lower preference of farmers in selecting millet crops for farming over the rice and wheat crops. Considering the soil, health and climate resilience value of millet crop, the seventy fifth session of United Nations General Assembly had declared to celebrate 2023 as the 'International Year of Millet (IYM 2023). This study found the 'weak base but with tremendous possibilities' in production and trade of millet in Nepal. Hence, the IYM 2023 can be a best opportunity to Least Developed Country (LDC) like Nepal to bring the millet crop from its existing state of 'marginal, underutilized and poor man crop' into the 'commercial, trade potential and high status crop' of Nepal. Similarly, development of appropriate strategies for expansion of millet area, promotion in the use of improved varieties of millet, product diversification (coming out of the box of millet seeds to other products of millet) and establishment of linkage with global market should be done by government of Nepal in order to transform the opportunity created by IYM into success in trade of millet. In one hand, the world had already prioritized millet through the declaration of IYM 2023 and in another hand, the inner Terai and Hilly regions of Nepal has tremendous potential for production of quality millet. It is like a situation that the 'Iron is already hot' and it is up to Nepal either to give it a proper shape or just to watch its cooling process and miss that valuable opportunity. Nepal have to take action in time in order to give proper shape in the trade of millet in context of IYM 2023.

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Seaweed Marine Algae: Nutritional Values and Plant Growth Regulators for Sustainable Agriculture

Pawan Kumawat[1*], Vidhya Kumawat[2]

[*1]M.Sc. (Agri.) Agronomy, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, 211007, India.
[2]B.Sc. Seed Technology, Vikram University, Ujjain, Madhya Pradesh, 458001, India
*Corresponding Author

Received:- 07 October 2023/ Revised:- 13 October 2023/ Accepted:- 21 October 2023/ Published: 31-10-2023

Abstract— *Marine plants weeds as "Seaweeds". Seaweeds also known as macroalgae are primitive non-flowering plants without true root, stem and leaves. Seaweeds occur in the intertidal, shallow and deep waters of the sea upto 180 m depth and also in estuaries and backwaters. Seaweeds are classified three main groups; green, brown and red of macroalgae based on the presence of photosynthetic pigment. Macroalgae have been estimated at 9000 species and mainly categorized into three groups. In marine algae macronutrients include sodium, calcium, magnesium, potassium, chlorine, sulfur and phosphorus the micronutrients include iodine, iron, zinc, copper, selenium, molybdenum, fluoride, manganese, boron, nickel and cobalt. Seaweeds are rich in vitamins, especially in B and B_{12}, Omega-3 fatty acids (1-3%), protein contain dry matter rang 5-11% to 30-40%, fiber content, 32% to 50% of dry matter, and organic compounds which includes several common amino acids inter alia aspartic acid, glutamic acid and alanine. Marine algae source for the production of phytochemicals such as agar, carrageenan and algin. Seaweed liquid fertilizers are useful for achieving higher agricultural production, because the extract contains growth promoting hormones like; Auxins, Gibberellins, Cytokinins, Gibberellins, Abscisic acid, Ethylene, Betaine and Polyamines other than the trace elements, vitamins, amino acids, antibiotics and micronutrients. Sea weeds and their extracts are integral to sustainable farming because of their multifarious utility in various fields of agriculture including nutrient and crop management, growth promotion and plant protection etc.*

Keywords— Macroalgae, seaweed, brown, green, red algae, nutritional value, growth regulators.

I. INTRODUCTION

In earlier days, usages of these marine aquatic plants otherwise called weeds (Marine algae) were not understood well. Hence the name was given to these marine plants weeds as "Seaweeds". Seaweeds also known as macroalgae are primitive non-flowering plants without true root, stem and leaves. Marine algae are aquatic plants belonging to the kingdom *Thallophyta* and considered an essential part of the marine ecosystem that inhabits the coastal regions. Seaweeds occur in the intertidal, shallow and deep waters of the sea up to 180m depth and also in estuaries and backwaters. They grow on rocks, dead corals, stones, pebbles, solid substrata and on other plants. Macroalgae have been estimated at 9000 species and mainly categorized into three groups. There are three main groups; green, brown and red of macroalgae based on the presence of photosynthetic pigment. Approximately 221 seaweeds species (Red Algae Rhodophytes 125, Brown Algae Phaeophytes 64 and Green Algae Chlorophytes 32) are using for commercial development worldwide, and out of 145 species are utilized as food, traditional medicines 24 species, almost 25 species in agriculture, including animal feed and compost. Marine algae source for the production of phytochemicals such as agar, carrageenan and algin. The luxuriant growth of seaweeds is found in southeast of Tamil Nadu, Gujarat Coast, Lakshadweep and Andaman-Nicobar Islands. Rich seaweed beds occur at Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhituam, Pulicat Lake and Chilka Lake.

Seaweed extract is a new generation of natural organic fertilizer containing highly effective nutrients. The brown algae are the most commonly used seaweed in agriculture. Seaweed extracts contain different phytohormones like; Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Betaine and Polyamines and other growth promoters along with trace elements and minerals, protein, amino acids, iodine, bromine, antibiotics, vitamins and many bioactive substances to promotes growth and yield as well as enhance the resistant ability of many crop from biotic and abiotic stress, which enhance the yield and yield

attributes of crops when applied exogenously. Unlike chemical fertilizers, extract derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animal and birds **(Dhargalkar *et al*., 2005).** Seaweeds and various seaweed extracts have been utilized in agricultural practices since long. Sustainable agriculture is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources **(CGIAR, 1978).** Seaweeds and seaweed extracts which are important components of organic farming are a promising avenue for yield maximization through their biostimulatory role on crop plants. Seaweeds and their extracts are integral to sustainable farming because of their multifarious utility in various fields of agriculture including nutrient and crop management, growth promotion and plant protection etc.

II. TYPES OF SEAWEED MARINE ALGAE:

Classified according to the main pigments used for photosynthetic processing and their colour. The most basic seaweeds are found among the cyanobacteria, also known as blue-green algae and green algae (division *Chlorophyta*), which are typically found growing as threadlike filaments, uneven sheets, or branching fronds closest to the coast in shallow seas. The majority of seaweeds found in temperate and polar regions are brown algae (division *Phaeophyta*), which have brown pigment that conceals chlorophyll's green colour. They develop between 50 and 75 feet below the surface (15-23 m). The red seaweeds (division *Rhodophyta*), many of which are delicate and fern-like, are found at the deepest depths (up to 879 ft/268 m); their red colour helps them to absorb the blue and violet light present at those depths.

2.1 Brown Algae:

It belongs to the phylum of *Phaeophyta*, which means "dusky plants," and is the largest and fastest-growing form of seaweed. In temperate or arctic seas, brown algae are brown or yellow-brown in colour. In addition to the accessory pigments carotenes and xanthophylls, chlorophyll a and c are present as primary pigments. As a means of securing themselves to a surface, brown algae commonly have a root-like structure termed a "holdfast." range from tiny (1 cm) filamentous forms to massive (20–60 m) kelps. The number of species of brown algae in the world ranges between 1500 and 2000. 289 species in 37 genera have been reported from the waters off the coast of India **(Kaliaperumal and Kalimuthu, 2004).** Brown algae known as kelp grows only in saltwater, most often along rocky coastlines. All brown algae contain alginic acid (alginate) in their cell walls, which is extracted commercially and used as an industrial thickening agent in food and for other uses.

Examples of brown algae genera available in India are: Sargassum, Turbinaria, Spatoglossum, Rosenvingea and Chnoospora.

FIGURE 1: Brown Algae (*Phaeophyta)*

2.2 Red Algae:

Belongs to the phylum of *Rhodophyta*. The red colour of these algae is caused by the pigments phycoerythrin and phycocyanin, which cover over the other pigments chlorophyll a (no chlorophyll b), beta carotene, and a variety of distinctive xanthophylls.

Red algae are found in over 6,000 different species. Red algae rarely grow longer than 50 cm, however a few species can reach lengths of 2 m. Red algae are widespread in coastal environments but are few in freshwaters. Freshwater ecosystems are home to about 5% of red algae species, with warmer regions having higher populations. Due to its ability to absorb blue light, these algae can survive at greater depths than brown and green algae. Red algae known as coralline algae play a crucial role in the creation of coral reefs. Red algae have a long history of use as a source of nutritional, functional food ingredients and pharmaceutical substances. They are a source of antioxidants including polyphenols, and phycobiliproteins and contain proteins, minerals, trace elements, vitamins and essential fatty acids. Traditionally red algae are eaten raw, in salads, soups, meal and condiments. **(Kandale *et al.*, 2010).**

Example of red algae: Kappaphycus alvarezii, Gelidiella calcicola, Gelidium, Euchema, Porphyra, Acanthophora, and Palmaria

FIGURE 2: Red Algae (*Rhodophyta*)

2.3 Green Algae:

Belongs to the phylum of *Chlorophyta*. It's commonly found in both freshwater and saltwater environments. Green algae range from unicellular motile species to multicellular parenchymatous types. Chlorophylls a and b are recognisable pigments. Carotenes, lutein, and zeaxanthin are examples of secondary pigments. Similar in size to the red seaweeds, green seaweeds are also rather small. Green algae can be found in freshwater or marine environments, and some even flourish on damp soil. Green algae occur in more than 4,000 different species. 213 species under 43 genera have been documented from the Indian waters **(Kaliaperumal and Kalimuthu, 2004).**

Examples of green algae: *Monostroma, Ulva spp., Caulerpa*

FIGURE 3: Green Algae (*Chlorophyta)*

2.4 Nutritional values of seaweed:

The mineral macronutrients include sodium, calcium, magnesium, potassium, chlorine, sulfur and phosphorus; the micronutrients include iodine, iron, zinc, copper, selenium, molybdenum, fluoride, manganese, boron, nickel and cobalt. Seaweeds are rich in vitamins, especially the B vitamins, including B_{12}. They also have significant amounts (1-3%) of Omega-3 fatty acids. Protein content in seaweed varies somewhat. It is low in brown algae at 5-11% of dry matter, but comparable in quantitative terms to legumes at 30-40% of dry matter in some species of red algae. Seaweed has high fiber content, making up 32% to 50% of dry matter. The soluble fiber fraction accounts for 51-56% of total fibers in green (ulvans) and red algae (agars, carrageenans and xylans) and for 67-87% in brown algae (laminaria, fucus, and others). Seaweeds contain a diverse range of organic compounds which includes several common amino acids inter alia aspartic acid, glutamic acid and alanine in commercially important species. Alginic acid, laminarin and mannitol represent nearly half of the total carbohydrate content of commercial seaweed preparations. Seaweed draws an extraordinary wealth of mineral elements from the sea that can account for up to 36% of its dry mass.

2.5 Uses of marine seaweed algae:

Seaweeds are used to make phytochemicals like agar, carrageenan, and alginate, which are widely utilised as gelling, stabilising, and thickening agents in a variety of sectors, including food, confectionary, pharmaceutical, dairy, textile, paper, paint and varnish, etc.

- **Agar:** It is manufactured from red algae like; *Gelidiella, Graciiaria, Gelidium and Pterocladia*.
- **Carrageenan:** It is manufactured from red algae like; *Eucheuma, Chondrus, Hypnea and Gigartina.*
- **Alginate:** It is obtained from brown algae such as: *Sargassum, Ttlrbinar, Laminaria, Undaria, Macrocystis and Ascophyllum.*

Seaweeds are also a source of other chemical compounds, including mannitol, iodine, laminarin, and furcellarin. Moreover, they function as antioxidants and medications **(Subba Rao *et al*. 2009).** Red algae are utilised in soups, salads, vegetables, and cereal that are consumed by people. A few marine algae can also be used in the production of food items as jam, jelly, chocolate, pickles, and wafers. In addition to being used as food for animals, seaweed is also used as a fertiliser for various land crops (**Kaliaperumal *et al.*, 1987b, 1995).** As a potential source of bio ethanol, seaweed is now being considered. Further uses of dairy include its use as a cosmetic, paint, and toothpaste ingredient, as well as in industrial products including paper coatings, adhesives, dyes, gels, and explosives, as well as in operations like drilling, paper sizing, textile printing, and hydro-mulching. A large number of bioactive substances can also be obtained from seaweeds. **(Chennubhotla *et al.*, 1981, 1987a).**

III. PLANT GROWTH REGULATORS FOUND IN SEAWEED EXTRACT:

Seaweed marine macroalgal extracts contain a number of phytohormones and plant growth regulators, including Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Betaine, and Polyamines, which, when given exogenously, simulate plant growth.

3.1 Auxins

Auxins or auxin-like compounds are known to occur endogenously in many marine algae. The presence of indole-3-acetic acid (IAA) has been recorded in a range of marine algae, like *Nereocystis spp., Ecklonia maxima, Macrocystis pyrifera, Ascophyllum nodosum, Porphyra perforata, Fucus vesiculosus, Caulerpa paspaloides* and *Sargassum heterophyllum* etc. **(Crouch and Van Staden, 1991).** Role of Auxin on plant essential for cell division, cell elongation, cell differentiation, organogenesis, embryogenesis andcallus formation.

3.2 Cytokinins

Cytokinin is the most common phytohormone recorded from Seaweed extracts. Cytokinins have been detected in fresh seaweeds **(Hussein and Boney 1969)** as well as seaweed extracts **(Brain *et al.*, 1973)**. The cytokinins present in seaweed extracts include trans-zeatin, trans-zeatin riboside, and dihydro derivatives of these two forms **(Stirk and van Staden 1997).** The role of cytokinins on plant are adventitious in shoot formation, Inhibition of root formation, Cell division, Callus formation and growth, Stimulation of outgrowth of axillary buds and delay senescence.

3.3 Gibberellins

The presence of gibberellin-like substances in seaweeds is well known. The presence of gibberellic acid in *Enteromorpha prolifera* and *Ecklonia radiata* has been confirmed **(Jennings, 1968).** At least two compounds have been recorded that behave like the gibberellins GA_3 and GA_7, although these may be vitamins A_1 and A_4 **(Stephenson, 1968).** A terpenoid, α-tocopherol a major component of the E group of vitamins present in Seaweeds, may mimic gibberellin activity. Role of Gibberellins; plant hormones that regulate growth and influence various developmental processes, including stem elongation germination, dormancy, flowering, enzyme induction and leaf and fruit senescence.

3.4 Abscisic Acid

The presence of water soluble growth inhibitors like Abscisic acid has been confirmed in *Laminaria digitata, Ascophyllum nodosum* **(Hussian and Boney, 1973)** and *Ulva lactuca*. There is presence of higher level of abscisic acid in some commercial extracts of *A. nodosum*. ABA is also present in the green algae *Enteromorpha compressa* **(Niemann and Dorfiiing, 1980).** Abscisic Acid plays a role in dormancy development in embryos, buds and bulbs, and in leaf abscission.

3.5 Ethylene

There are few studies on ethylene, but the precursor of ethylene, 1-Aminocyclopropane-1-carboxylic acid (ACC) was found in the Seaweed concentrate prepared from the brown kelp *E. maxima*. The level of the ethylene-releasing compound was estimated at 9.29 nmol/ml **(Nelson and Van Staden, 1985).** Ethylene affects fruit-ripening. Normally, when the seeds are mature.

3.6 Betaines

Betaines are the compounds found in the extracts of Seaweeds which behave like cytokinins. Betaines have been isolated from many of the species of brown algae used for the production of seaweed extracts. *Ascophyllum nodosum* extracts contain c-aminobutyric acid betaine, d-aminovaleric acid betaine and laminine whilst *Laminaria species* have a range of betaines including glycine betaine **(Blunden *et al.*, 1986).** Betaine improves growth and survival of plants counteracting metabolic dysfunctions caused by stress.

IV. CONCLUSION

Seaweeds are naturally abundant in bioactive compounds as well as minerals, vitamins, polyunsaturated fatty acids, and other nutrients. They can provide as a reliable supply of nutritious nourishment. Seaweed consumption on a regular basis may also assist with solving the issues of protein, carbohydrate, and mineral deficiencies in human nutrition. Furthermore, seaweeds not only promote plant growth but also grant immunity from biotic and abiotic stress. The use of chemical-synthetic fertilizers caused soil degradation as well as health and environmental risks. Seaweeds provide an organic fertilizer replacement that increases agricultural productivity and helps to fulfill the world's food requirement. Due to its low cost and environmental friendliness, the demand for seaweed extract is rising daily. In addition to lowering the usage of toxic agrochemicals, the use of Seaweed extracts in agriculture also contributes to environmental protection. Its incorporation into widely used farming techniques around the world can increase crop yield in a sustainable way.

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The Impacts of Mining on Livelihood and Development in Nyoenpaling Chiwog under Phuntshopelri Gewog, Samtse

Chheku Wangchuk[1*], Karma Nidup[2], Karma Chophel[3], Karma Dorji[4], Sonam Penjor[5], Sonam Tshewang[6], Tshelthrim Pelden[7], Kinley Dem[8]

[*1]Yebilaptsa Central School, Ministry of Education and Skills Development, Bhutan.
[2]Wanakha Central School, Ministry of Education and Skills Development, Bhutan.
[3]Darla Middle Secondary School, Ministry of Education and Skills Development, Bhutan
[4]Sherubgatshel Middle Secondary School, Ministry of Education and Skills Development, Bhutan.
[5]Panbari Middle Secondary School, Ministry of Education and Skills Development, Bhutan
[6]Nganglam Central School, Ministry of Education and Skills Development, Bhutan.
[7]Nganglam Middle Secondary School, Ministry of Education and Skills Development, Bhutan.
[8]Zhemgang Central School, Ministry of Education and Skills Development, Bhutan
*Corresponding Author

Received:- 09 October 2023/ Revised:- 18 October 2023/ Accepted:- 24 October 2023/ Published: 31-10-2023

Abstract— *Mining plays a key role in facelifting the economic status of the people of its catchment area and nation particularly for developing countries, and Bhutan is no exception. In Bhutan mining provides employment and livelihood to a good number of people. Nyoenpaling Chiwog under Phuntshopelri Gewog, Samtse has been an important mining site for limestone, and dolomite since a few decades ago and will be hereafter too. However, the contribution of mining activity to livelihood and development is unclear today. So, there is a need for a thorough study on the impact of mining in Nyoenpaling Chiwog. The objective of this paper is to document the impact of mining in mining catchment areas. The data were collected from mining site localities through a mixed-method research approach. The study reveals that local people are not very positive about having mining sites in their area. There is an indication that local people are not benefiting as expected. The responses of residents suggest that adequate infrastructure development like a paved transport network, safe drinking water, bridge, and river embankment could ease their living in the area. Therefore, the study aims to explore the possibility of addressing these issues by concerned stakeholders. Addressing these issues can have a greater positive impact on the livelihood of people living here.*

Keywords— Benefits, Challenges, Economic Welfare, Environment Impact, Mining.

I. INTRODUCTION

In recent years, there has been growing concern about mining activities' social, economic, and environmental impacts on the locality. The impact of mining on the locality has been a subject of research for decades, with numerous studies examining the environmental, social, and economic impacts of mining activities. The study focuses on the specific case of Nyoenpaling Chiwog, Bhutan, where mining activities have been increasing in recent years. The research aims to explore the impacts of mining on local communities and their livelihoods, as well as the potential effects on overall development in the region. The study utilized both qualitative and quantitative research methods, including interviews with residents and stakeholders' surveys, and data analysis was carried out. The study explored the potential benefits and drawbacks of mining for the local economy, environment, and social dynamics. The study also explores potential strategies for mitigating negative impacts and promoting sustainable development in the region.

One of the key findings of this research is that mining activities can have significant negative impacts on the environment, including soil erosion, water pollution, and air pollution. This research underscores the need for sustainable mining practices that take into consideration the long-term impacts of mining on the locality. The impact of mining on the locality is a

multifaceted issue that requires a comprehensive understanding of the social, economic, and environmental dimensions of mining activities.

1.1 Perception of the impact of mining

Bhutan has a huge richness of mineral resources, including coal, dolomite, limestone, slate, and copper. A thorough enough geological map of 33% of the country has been created, according to the 2017 Mineral Development Policy. Only 0.04% of the land is now exploited for mining. The sector, despite being relatively tiny, is expected to have a big impact on Bhutan's economic growth, and the government is committed to taking advantage of its untapped resources (Gyelmo, 2021). However, the nation's mining and quarrying industries are expanding, and there have been reports of negative effects on local people and the environment. Many people are increasingly worried about the consequences that have an adverse influence on local populations and the delicate alpine ecosystems (National Council, 2013)

Mining can have significant impacts on people's livelihoods and the standard of living in the surrounding communities. According to National Council Report (2018), mining and quarrying seem to be an economically lucrative business in Bhutan, the evidence of corporate income tax declared by the sample mines reveals that it is lucrative for some and not for others. These impacts can be both positive and negative, depending on a range of factors such as the scale and type of mining operation, the level of community involvement and consultation, and the regulatory and governance frameworks in place (Viveros, 2014). Mining can lead to the forced relocation of communities, resulting in the loss of homes, land, and livelihoods (Lawson & Bentil, 2013). This can have significant impacts on the social and economic well-being of affected communities, including loss of income, social networks, and cultural heritage (Matlaba et al., 2017). On the other hand, mining can also have positive impacts on livelihoods and the standard of living. However, it is important to note that the positive impacts of mining on livelihoods and the standard of living are not always guaranteed. In some cases, mining companies may fail to create local employment opportunities or provide adequate support for local development initiatives. There may also be unintended negative consequences, such as inflationary pressures and the displacement of small-scale agricultural and pastoralist communities (Plank et al., 2016).

Mining in Bhutan has been controversial due to concerns over its impact on the environment and the local communities. While mining activities have contributed to the country's economic growth, there are also concerns about the negative effects on the environment and the well-being of local communities. According to a study conducted by Yangka (2021), mining activities have caused environmental degradation and loss of biodiversity in several areas of the country. The study also found that mining activities have led to soil erosion, water pollution, and other environmental issues. Additionally, the study highlighted the negative impacts on the health and livelihoods of local communities, particularly those living near mining sites. Similarly study by Pollut (2018) in Ghana reveals that the majority of Ghana's mining communities have suffered from environmental degradation brought on by mining processes, including air and water pollution.

Furthermore, a report published by (Kuenga, 2017) also highlights the negative impact of mining on the environment and communities in Bhutan. The report notes that mining activities have resulted in the loss of fertile land, the destruction of forests, and the displacement of communities. The report also points out that there is a lack of proper regulations and monitoring mechanisms to ensure that mining activities are carried out in an environmentally sustainable and socially responsible manner. The study by Galay (2006) argues that mining can contribute to the country's economic growth, improve infrastructure development, and reduce dependence on foreign aid. It is perceived as an opportunity to leverage the country's mineral resources for economic diversification and poverty reduction. Despite these potential positive impacts, it is important to ensure that mining activities are conducted responsibly and sustainably to minimize negative impacts on people's livelihoods and standard of living and promote long-term development in mining communities.

1.2 Impact of Mining on employment opportunities

Mining activities can provide employment opportunities for local communities, particularly in areas with high unemployment rates (Walser, 2020). Mining companies often require a diverse range of skills, including engineering, geology, and environmental science, as well as a range of support services, such as catering, transportation, and security. This can lead to improved income levels and reduced poverty, as well as increased skills and training opportunities for local workers (Bebbington, 2018). Although mining companies in Bhutan do not seem to provide a permanent source of employment, the study revealed that 61% of the workforce is comprised of Bhutanese and half of that comes from local communities (National Council Report, 2018).

According to a report by the World Bank (2018) and UNDP (2018), mining can provide direct and indirect employment opportunities. Direct employment includes jobs in the mining industry such as miners, engineers, and geologists, while indirect employment includes jobs created in related industries such as transportation, manufacturing, and services. The report notes that in some regions, mining can be a major employer, with some mines employing thousands of people. However, the report also highlights that the employment benefits of mining can be limited in some cases. For example, the report of William Baah-Boateng (2018) states that mining operations may require specialized skills that are not available locally, leading to the need to import labour or bring in workers from other regions. In addition, automation and technological advancements in the mining industry may lead to a decrease in the number of jobs available.

1.3 Role of Mining on Infrastructural Development in the Community

Mining has been shown to play a significant role in the development of infrastructure in communities. Various studies have explored the relationship between mining and infrastructure development in communities. The study by Agbogidi and Okonjo (2018) examined the impact of mining on the development of infrastructure in the rural communities of Nigeria. The study found that mining activities have positive effects on the development of infrastructure in these communities, including the provision of roads, water supply, and electricity. Similarly, another study by Adjei and Yamoah (2018) explored the relationship between mining and infrastructure development in Ghana. The study found that mining has contributed significantly to the development of infrastructure in the country, including the provision of roads, hospitals, schools, and other public facilities.

In contrast, a study by Baffour-Kyei et al. (2021) examined the impact of mining on the development of infrastructure in rural communities in Ghana and found that although mining has contributed to the development of some infrastructure, it has also led to the degradation of existing infrastructure such as roads and water supply systems. Another study by Chun-Chao et al., (2019) examined the impact of mining on the development of infrastructure in China. The study found that mining activities have contributed significantly to the development of infrastructure in the country, including the provision of roads, railways, and power plants. Mining companies can contribute to local development through infrastructure development initiatives such as building schools, health clinics, and roads (Reed & Miranda, 2015). This can improve access to basic services and enhance the quality of life for communities. Many mining companies have adopted corporate social responsibility initiatives aimed at improving the social and economic well-being of communities affected by mining activities (Marutle, 2017). These initiatives can include education and training programs, health and safety initiatives, and support for small-scale enterprises. Therefore, the literature suggests that mining has a significant impact on the development of infrastructure in communities. However, the nature and extent of this impact vary depending on the location, type of mining activity, and the policies and regulations in place to manage the industry.

II. METHODOLOGY

2.1 Research Approach

The study employed a mixed methods research approach as it offers a better way of addressing the research problem than qualitative and quantitative in isolation. The research approaches are plans and procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation (Creswell & Creswell, 2018). The strengths of one method overcome the limitations of another method. Hence, it validates its practice in the current context of the research to explore the impact of mining in Nyoenpaling Chiwog.

2.2 Research Design

To conduct this study a convergent mixed methods research design is seen as an appropriate design that can help to guide this study. According to Creswell & Creswell (2018), a convergent parallel mixed-methods design will simultaneously collect both quantitative and qualitative data, merge the data, and use the result to understand the problem investigated. Following this design, both forms of data were collected at the same time and then integrated the information in the interpretation of the overall results. Thus, this study was carried away using both quantitative survey questionnaires and qualitative interview questions simultaneously.

2.3 Target Population

A target population is a group of individuals or organizations from the population with some common defining characteristic that the researcher can identify and study (Creswell, 2014). The target population is the source of primary data to answer the

research questions. In this study, the target population was the household who were directly impacted by mining activities in their Chiwog.

2.4 Sampling Technique

Sampling is the process of selecting a representative group from the population for the study. Sampling is vital for research since it determines the accuracy of the research. Moreover, Palys (2015) iterated that there is no best sampling strategy because which is best will depend on the context in which researchers are working and the nature of their research question. Therefore, purposive random sampling was used. It is also known as judgmental sampling and a non-probability sampling technique used in research where the selection of participants is based on the researcher's judgment or knowledge of the population being studied. The researchers identified the participants who were representative of the population and then randomly selected from that group. This technique was used as the population was difficult to define and the research question was focused on a specific subgroup within the larger population.

2.5 Sample Size

The sample size was determined using purposive random sampling. According to Schumacher (2010), the sample size is a critical consideration when conducting and evaluating research. The sample size will be decided in such a manner to include relevant persons, even though not all will be expected as part of the sample (Simons, 2009). Trochim (2006) stated that the researcher must focus on purposive sampling since the researcher will sample with a purpose in mind and has one or more specific predefined groups based on the purpose of the research. The sample size is the group of participants in a study selected from the target population from which the researcher generalizes to the target population (Creswell, 2014). For this study, 62 households from the Nyeonpaling chiwog under Phuntshopelri Gewog was the sample size. These participants were directly impacted by the mining activities in their community.

2.6 Survey Questionnaire

In the quantitative phase, the survey questionnaire was used to collect data from the respondents. According to Trueman (2019), a survey questionnaire is a series of questions asked to individuals to obtain statistically useful information about a given topic. The quantitative data was collected using 30 questionnaires based on three themes. The tools were developed based on 6 Likert Scale Items. As per Joshi et al. (2015), the Likert scale is applied as one of the most fundamental and frequently used psychometric tools in educational and social sciences research. The Likert scale is a set of statements (items) offered for a real or hypothetical situation under study. Participants were asked to show their level of agreement (from strongly disagree to strongly agree) with the given statement (items) on a metric scale.

2.7 Semi-Structured Interview

An interview is one of the most prominent forms of qualitative data collection since it enables researchers to understand people's perceptions, meanings, and situations (Punch, 2015). Likewise, Cohen et al. (2007) iterated that an interview is a flexible tool for data collection enabling multisensory channels to be used. Semi-structured interviews were used for the collection of qualitative data. The interviews were conducted with 12 participants for the qualitative sample based on 8 semi-structured questions developed, and sub-questions were asked as necessary.

2.8 Data Analysis

Quantitative data collected was entered into Statistical Package for the Social Sciences-22 (SPSS 22) and cleaned for statistical analysis. Descriptive statistics (mean and standard deviation [SD]) are used to describe and summarize the findings. The Raw data gathered from the interview are transcribed, coded, and categorized into various themes for the interpretation of the qualitative component of the data. According to Turner (2018), qualitative data is often elusive to researchers. Transcripts allow one to capture original, nuanced responses from the respondents. You get their response naturally using their own words—not a summarized version in your notes (Turner, 2018).

III. RESULTS AND DISCUSSIONS

This chapter presents the result and discussion for the field trip topic: "The Impacts of Mining on Local Livelihood and Development in Nyoenpaling Chiwog under Phuntshopelri Gewog, Samtse". Both quantitative and qualitative result analyses are presented in this chapter. The quantitative result analysis was based on survey questionnaires collected from 62 participants.

The qualitative analysis was done based on the results obtained from 12 interviewed participants. The chapter presents the demographic profile of participants and a theme-wise analysis of data.

TABLE 1
DEMOGRAPHIC REPRESENTATION OF THE SURVEY PARTICIPANTS

Gender	Count	Percentage
Male	27	43.5
Female	35	56.5
Total	62	100

TABLE 2
DEMOGRAPHIC REPRESENTATION OF THE INTERVIEW PARTICIPANTS

Gender	Count	Percentage
Male	6	50
Female	6	50
Total	12	100

TABLE 3
PERCEPTION OF MINING

Perception of the impact of mining					
	N	**Mean**	**Std. Deviation**	**Level of Acceptance**	**%**
B1. Mining activities are the source of economic development in the community.	62	5.19	0.99	Highly Positive	86.5
B2. Mining activities have led to an increase in household income.	62	5.13	0.97	Positive	85.5
B3. It reduces income inequality in the community.	62	4.34	1.02	Positive	72.3
B4. Mining activities increase my consumption level due to higher income and purchasing power over the years.	62	4.58	0.88	Positive	76.3
B5. I noticed changes in the cost of living since the establishment of mining companies.	62	4.76	0.78	Positive	79.3
B6. The establishment of mining companies enhanced my standard of living over the years.	62	4.85	0.97	Positive	80.8
B7. Mining has led to many improvements in community development, such as infrastructure and social services.	62	4.89	1.04	Positive	81.5
B8. The local community supports the mining project.	62	4.19	1.32	Slightly positive	69.8
B9. Mining activities have environmental impacts, including air and water pollution, deforestation, and the destruction of natural habitats.	62	2.76	1.4	Slightly Negative	46
B10. The mining company has implemented effective measures to mitigate the negative impacts of mining on the environment.	62	3.94	1.23	Slightly Positive	65.7

Note: ***1.00 – 1.82=Highly Negative, 1.83 – 2.65=Negative, 2.66 – 3.48= Slightly Negative, 3.49 – 4.31= Slightly Positive, 4.32 – 5.14= Positive, 5.15 – 6.00 Highly Positive. Adapted from Pimentel (2019)***

The study aims to investigate the community's perception of mining activities in terms of economic, social, and environmental impacts, the impact of mining on employment opportunities, and the role of mining on infrastructural development. The study collected data from 62 respondents using a structured questionnaire and twelve interviews based on semi-structured. The data triangulation is done based on survey questionnaire responses, interviews, and literature review to get a holistic result. The key findings are presented in terms of the mean (M) scores and standard deviation (SD) for each perception statement, which help us measure how positively or negatively the community views the impact of mining activities.

The highest mean score in the quantitative dataset (Table 3) was found for statement B1, which indicates that the community perceives mining activities as a significant source of economic development. The mean score of (M = 5.19, SD = .99) suggests a highly positive perception and a remarkable 86.5% of the participants hold this view. This implies that the community generally believes that mining has brought about economic benefits and opportunities. Similarly, statement B2 reveals a positive perception, with a mean score of (M = 5.13, SD = .97) and 85.5% of participants agreeing that mining has led to an increase in household income. This is another indicator of the community's positive view of the economic impact of mining activities. Further, the qualitative data supports that mining activity positively impacts the community's economy as residents are employed in mining. For instance, participants (P1, 3, 4, 7 & 9) state that compared to past years communities have increased purchasing power and they reason mining activity as the source of income generation. This was evidenced through the field visit by the researchers. According to the National Council Report (2013), state that mining and quarrying seem to be an economically lucrative business in Bhutan. According to Galay (2006), mining can help the country's economic growth and infrastructure development and reduce reliance on foreign aid. It is viewed as an opportunity to use the country's mineral wealth to diversify the economy and reduce poverty.

On the other end of the spectrum, the lowest mean score was recorded for statement B9. Here, participants expressed concerns about the environmental impact of mining, with a mean score of (M = 2.76, SD = 1.140) suggesting a slightly negative perception. Nearly half of the respondents, 46%, are worried about issues such as air and water pollution, deforestation, and habitat destruction caused by mining. Most responses from qualitative data agree that due to mining activity, there is a lot of air pollution, noise pollution, and diversion in the flow of rivers especially in monsoon season due to the dumping of waste from mining. According to the 2013 assessment study, unlawful dirt dumping in rivers and ravines is a typical occurrence close to mining and quarrying operations (Gyelmo, 2021). It was observed on a field visit that the surroundings were full of dust in the afternoon hours. It was definite since mining in this particular area is open-cast mining. In Bhutan, only opencast mining is practiced because of the nature of the topography and mineral deposits (Norbu, 2013). Mining in Bhutan has been controversial due to concerns over its impact on the environment and the local communities. While mining activities have contributed to the country's economic growth, there are also concerns about the negative effects on the environment and the well-being of local communities. According to Yangka (2021) research, mining activities have resulted in environmental deterioration and biodiversity loss in numerous sections of the country. According to the study, mining activities have also resulted in soil erosion, water pollution, and other environmental difficulties. Furthermore, the study emphasized the harmful effects on local residents' health and livelihoods, particularly those living near mining operations. Similarly, Kuenga, (2017) also underlines the negative impact of mining on the environment and communities in Bhutan. According to the research, mining activities have resulted in the destruction of forests, the loss of agricultural land, and the displacement of communities. The report also highlights that there is a lack of effective rules and monitoring procedures in place to ensure that mining activities are carried out in an environmentally sustainable and socially responsible manner. Nevertheless, it was found that mining companies try to address these issues to their capacity like sprinkling water on dusty unpaved road networks and providing waste bins. But its impact is very minimal. However, it was learned that the mining company takes full responsibility for reclaiming the mining site once mining is completed. For instance, PCAL has reclaimed its previous mining site at Utari, and the regain of the environment was found positive during the field visit.

The current study explores the community's opinion of mining activities in terms of their economic, social, and environmental consequences. According to the findings, the community has a positive impression of mining's economic and social consequences, but a negative perception of its environmental impact. The study also suggests that the mining company needs to implement more effective measures to mitigate the negative impacts of mining on the environment. Other concerned

stakeholders can also play an important role in formulating valuable measures to bring positive change on the impact of the environment.

TABLE 4
IMPACT OF MINING ON EMPLOYMENT OPPORTUNITIES

Impact of Mining companies on Employment Opportunities					
	N	**Mean**	**Std. Deviation**	**Level of Acceptance**	**%**
C1. Mining has contributed to the growth of the local economy through business opportunities.	62	4.92	0.93	Positive	82
C2. Mining has contributed to the creation of several job opportunities in the business sector.	62	5.27	0.96	Highly Positive	88
C3. It led to a significant increase in employment opportunities for the local community.	62	5.29	0.97	Highly positive	88
C4. There is no issue of unemployment in the community	62	4.5	1.07	Positive	75
C5. Local resident prefers to work in the mining as they can earn more income.	62	5.1	0.74	Positive	85
C6. Working in the mining industry is only the source of income for the people in the community.	62	5.11	0.83	Positive	85
C7. The mining companies recruit more residents than others.	62	4.52	0.88	Positive	75
C8. The mining company has collaborated with local government and community organizations to support employment opportunities.	62	4.32	0.9	Positive	72
C9. The mining company has respected workers' rights and provided safe working conditions.	62	4.95	0.86	Positive	83
C10. The mining company has provided training and skill development programs for the local workforce.	62	4.74	0.96	Positive	79

The analysis of both quantitative and qualitative data in Theme 2 (Table 4), " Impact of mining companies on employment opportunities," provides valuable insights into how communities perceive the potential impact of mining on employment opportunities offered by two mining (PCAL & SMCL) company. The findings reveal that communities hold positive perceptions regarding on employment opportunities. Notably, item C3, which suggests that the community overwhelmingly perceive mining as a significant contributor to employment opportunities with mean score (M = 5.29, SD = .97) and was rated as highly positive by 88.2% of respondents. This indicates that the majority of the community believes that mining activities have led to a substantial increase in employment opportunities, which is a crucial aspect of local economic growth. C2 closely follows as the second-highest rated statement, with a mean score of (M = 5.27, SD = .96) and 87.8% of participants expressing highly positive sentiments. This finding underscores the community's strong belief that mining has not only created jobs but also contributed to the expansion of opportunities in the local business sector. In the absence of a different labour force mining cannot be carried out. In employing labour preference is given to affected community. According to Subba (2020), the National Assembly enacted a new clause in the Mines and Minerals Bill 2020 requiring at least 30% of job possibilities to be supplied to members of the local community. According to NSB (2022) mining and quarrying alone has given employment to 1446 who are primarily in mining. Further mining activities also create employment opportunities in business, transport system and many more in manufacturing unit. The qualitative study also reveals that mining companies have employed good numbers of labours from the community especially the low-skilled in the mining site. In the interview, a few respondents stated that “70% of labours are employees from the local community.” However, the qualitative study (P3, 4, 7, 10 &12) reveals that there are unemployment issues in the community. Further, the study reveals that most skilled labourers are from other parts of the country. According to Subba (2020) Pugli spokesperson in the television justify that , just approximately 10% of the job chances are allocated to local citizens. "However, the majority of those employment are blue-collar. "People from the community do not get jobs at the supervisory levels," The rationale behind can be mining activity requires different skilled labour, and mining company might have faced shortage of required skilled labour from particular community hence left with no option rather than looking from other locations.

Conversely, the lowest mean score was observed for statement C8, which suggests that the community's perception of collaboration between the mining company, local government, and community organizations to support employment opportunities is less positive. The mean score (M = 4.32, SD = .90) and 72% of participants holding a positive view indicate that while the majority see positive collaboration, there's room for improvement in this area. The majority of qualitative responses share similar opinions (P1, 3, 5, 6, 7, 9, 11, & 12) that strong collaboration among communities, mining companies, and other relevant stakeholders can have better implications and other advantages for the community. There is room for enhancing collaboration between the mining company, local authorities, and community organizations to further improve employment opportunities and support for the workforce.

TABLE 5
ROLE OF MINING ON INTRACULTURAL DEVELOPMENT

Role of Mining on Infrastructural Development in the Community					
	N	**Mean**	**Std. Deviation**	**Level of Acceptance**	**%**
D1. Mining plays a critical role in improving the quality of infrastructure in local communities.	62	4.69	1.21	Positive	78
D2. Mining helps in developing better communication facilities in the community.	62	4.63	1.15	Positive	77
D3. The residents are enjoying better road facilities.	62	4.02	1.45	Slightly Positive	67
D4. People are accessible to better health facilities.	62	4.11	1.19	Slightly Positive	69
D5. People are accessible to better education facilities for their children in the community.	62	4.68	0.92	Positive	78
D6. People are accessible to better banking services.	62	4.48	0.99	Positive	75
D7. People are provided with adequate and safe drinking water facilities.	62	4.18	1.57	Slightly Positive	70
D8. The mining company has contributed to the development of local roads and transportation systems.	62	4.52	1.18	Positive	75
D9. Local communities are enjoying a better power supply.	62	4.84	0.89	Positive	81
D10. The mining company has contributed to the development of local emergency services and disaster response systems.	62	4.39	1.05	Positive	73

Table 4 presents quantitative data on the role of mining on infrastructural development in the community. These findings offer a numerical perspective mean and standard deviation ranging from (M = 4.02, SD = 1.45) lowest to mean (M = 4.84, SD = .89) highest. Overall the table indicates the positive level of acceptance. This suggests that, on average, respondents perceive mining has led to certain development of infrastructures in the community.

The highest mean score was recorded for statement D9. This statement indicates that the community overwhelmingly believes that mining has contributed to improved power supply, with a mean score of (M = 4.84, SD = .89). An impressive 80.7% of participants express a positive view in this regard. This suggests that most of the community feels that mining activities have positively impacted access to reliable power, which is a vital component of infrastructure development. Similarly, D1, with a mean score (M = 4.69, SD = 1.21) with 78.2% of participants holding a positive view. This statement highlights the community's belief that mining plays a critical role in enhancing the quality of local infrastructure, emphasizing the positive impact on various aspects of community life. Proper road network and power supply are a must in mining. These are the basic infrastructures to function in mining activity smoothly. The qualitative analysis also supports the fact that the area contains essential amenities such as roads, schools, and health care, which assist the local community indirectly. Adjei and Yamoah (2018) investigated the relationship between mining and infrastructure development in Ghana. According to the research, mining has substantially contributed in the construction of the nation's infrastructure, which includes highways, hospitals,

schools, and other public structures. Similarly, according to Agbogidi and Okonjo's (2018) mining research in Nigeria, the mining business has a positive impact on the development of local infrastructure such as roads, water supplies, and power.

However, statement D3 (The residents are enjoying better road facilities). This statement suggests that the community's perception of improved road facilities is less positive, with a mean score of (M = 4.02, SD = 1.45) with 67% of participants expressing a slightly positive view. This indicates that while the community acknowledges some positive changes in road infrastructure, there is room for further improvements. The field visit findings reveal the same. It was found that road conditions were not smooth at all. Roads were full of potholes, bumpy and dusty. Hundreds of heavily loaded trucks playing daily on the road could have caused damage. Communities impacted by mining activities claim that there is no advantage to mining in their communities, while the consequences threaten their livelihood and health (Subba, 2020). He further stated a representative from Samdrupjongkhar's Phuntshothang hamlet stated that excavation activities had impacted their water sources and crop output. According to him, farmers were only able to harvest roughly 50kg of paddy from a field that used to produce about 300kg. A similar view was shared by a representative of the afflicted Nyoepaling community, who expressed similar concerns. He claimed that large and heavy vehicles were a major issue on the roadways and caused dust. "There should be more tankers to sprinkle water on the road to reduce the dust problem." This was further supported by a qualitative study where participants stated,“Road conditions are not that good and it turns bad during the summer season owing to heavy rainfall. Moreover, there is no proper drainage and is full of dust.”

These findings underscore the community's belief that mining has had a positive impact on various aspects of infrastructure development, such as power supply, overall infrastructure quality, and improved communication facilities. However, it is also important to note that the community's perception of road facilities needs more attention and improvements. The study findings emphasize the multifaceted role of mining in influencing infrastructure development within a community. It underscores the need for mining companies and local authorities to work together to address infrastructure challenges and further enhance the positive impact on community well-being. These community perspectives are invaluable in assessing the holistic effects of mining activities on local development.

IV. CONCLUSION

Mining activity in the Nyoenpaling community has both negative and positive impacts. While mining has provided employment opportunities and increased economic growth as well as the development of infrastructure in communities, it has also caused environmental degradation, air pollution, land pollution, and social disruptions. It is important for stakeholders to carefully consider these impacts and implement measures to minimize negative consequences while maximizing the positive ones. However, the benefits of mining must be carefully balanced against its potential negative impacts, and it is important to ensure that mining activities are conducted in a way that minimizes harm to the environment and respects the rights of local communities. Overall, the impact of mining on local livelihoods is a complex and challenging issue that requires a multidisciplinary and collaborative approach. By working together, governments, communities, and mining companies can ensure that mining activities are conducted in a way that respects human rights, protects the environment, and supports sustainable economic development. This will require ongoing monitoring, evaluation, and adaptation of policies and practices to ensure that the benefits of mining are maximized while its negative impacts are minimized. The study findings recommend the following points for sustainable mining with minimum impact on local communities.

1. Mining companies may engage with local communities and involve them in the decision-making process. Community engagement should be an ongoing process that includes regular consultations and open communication channels.
2. Mining projects may prioritize local employment and provide opportunities for skills development and training. This can help enhance the livelihoods of community members by creating job opportunities and building their capacity to participate in the mining industry or other sectors.
3. Mining companies may promote local economic development by creating job opportunities for local residents, supporting local businesses, and investing in local infrastructure development.
4. Mining companies may conduct regular environmental and social impact assessments to monitor the effects of mining on the local environment and communities.
5. Mining companies may contribute to the development of social infrastructure like healthcare facilities, education, transportation, and other essential amenities that can improve the livelihood of the community.

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