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Volume 3 | Issue 2 | July 2021 | Page1-62
NASS Journal of Agricultural Sciences

Contents

ARTICLE

REVIEW

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ARTICLE

Exploring Constraints and Opportunities for Sorghum Production in Dry Regions of Zimbabwe

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ABSTRACT

The objective of the study was to explore the constraints and opportunities for small-holder sorghum farmers in dry regions.Two hundred and fifty farmers were sampled by using the simple random and snowball sampling to provide the information that answered the research questions. Questionnaire and interviews were used as the research instruments. Out of 250 participants, 80% were males and 20% were females showing that more males were selected for the research. Data was coded and processed using excel. Descriptive statistics were used to describe results. Of all the participants, 4% were in the age range of 25-30 years, 10% in the age range of 31-35 years, 14% in the age range of 36-40 years, 16% in the age range of 41-45 years and 56% in the age range of 46 years and above. Out of all the participants, 20% attained primary education while 68% had attained secondary education. Only 12% had tertiary education. Results indicated availability of resources (60%) such as certified seed, fertilizers, herbicides and draught power as the major constraint in the production of sorghum. Lack of technical knowhow (20%) of sorghum production, poor farming methods (9.6%) such as mono-cropping, *Striga* weed (12%), outbreak of fall armyworm (14.4%) and marketing of produce (8%) were also amongst the major constraints indicated by most participants. 66% of the 250 participants showed that they produce sorghum due to its drought tolerant nature. Beer brewing was just slightly above half (52%) whilst making mealie meal was slightly below half (48%). Lack of knowledge, resources and poor markets hindered sorghum production in dry regions. Farmers were using retained seeds which are populated and affected by diseases and this contributed to low yields. Opportunities such as reducing poverty, food insecurity and income generation drives some farmers to venture into sorghum production.

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1. Introduction

Sorghum (*Sorghum bicolor* L. Moench) is ranked as the fifth important cereal crop in the world after wheat (*Triticum aestivum* L.), rice (*Orzya sativa.* L) and maize (*Zea mays*. L.) [16,35], with over 80 % of the crop being grown in Africa and Asia. Sorghum is mainly cultivated in the Semi-arid regions where rainfall received is below the average and is intensively grown in continents like Africa, Asia and North America [45,5,25]. The crop is drought tolerant and can be used for alleviating food insecurity in dry regions [24,26]. Sorghum does well in different types of soils and perform best under clay soils which are fertile giving more yields [46].

The crop is useful for food security of households especially in marginalised and dry land areas where rainfall is very low [25] and used as staple food in many African countries including Zimbabwe [26], Kenya [37,24]. Sorghum is a drought tolerant crop which does well in low rainfall areas compared to maize and other cereals as it is ecologically compatible [13,17]. The ability of sorghum to adapt to drought, salinity and high temperature regions can be an advantage of farmers in these regions to use it as food insecurity alleviation [35]. Sorghum have various uses which include staple food, stover for broom production, animal feed, beer brewing [6] and industrial raw material for bio fuel production [35]. Industrially, the grain is used to manufacture wax, starch, syrup, alcohol, dextrose agar and edible oils. There is high demand for sorghum mainly in brewing industry to replace barley, yet the amount produced by farmers is too low to satisfy the market demand [36]. Sorghum can be used in weed control due to production of allelochemicals (cyanogenic glycosides and phenolic acids) which suppress broad-leaved weeds without affecting grass [2]. In Zimbabwe, 62.2 % of the total population of communal farmers lives in Natural Regions IV and occupying 71.8 % of the communal lands [41,46].

Constraints to sorghum production include quelea birds, shoot fly and armoured crickets [6,11] and *Striga* species [35,40]. There is also poor reinforcement of sorghum seed quality control since the crop is treated as peripheral in mainstream agricultural development [19] reported the use of seeds by several farmers from varieties which were grown by their ancestors and did not even know the variety they were growing. Access to working capital remains a challenge in African agriculture since sorghum farmers have no access to credit from banks. Most farmers in the semi-arid regions prefer to grow maize rather than small grains because of their low productivity [7].

Opportunities of growing sorghum include ability to be grown on marginal soils and shorter growing season. Products such as such as porridge, sadza, beer, and livestock feed and fodder are obtained. The lower variable cost of sorghum can help growers spread risk by producing another crop at lower cost and spreading limited capital across more acres. Sorghum is well suited for dry conditions, areas with uneven rainfall distribution that may adversely affect the growing season of other crops and high year to year variations in rainfall and water supplies. Therefore, the objective was to explore constraints and opportunities for small holder sorghum farmers.

2. Materials and Methods

2.1 Study Site

The study was carried out in the ward 11 of Bikita district in the eastern side of Masvingo town, in Masvingo province. It lies between latitude 20 05' 00'' South and longitude 31 37' 00' East. The area is in natural region IV which receives 400-650 mm annual rainfall. The temperature ranges from 18 ^{0}C to 25 ^{0}C. The area is in semi-arid region. The area receives rainfalls which are mainly confined in the summer season – normally from late November to late March-but the rains are at most times unevenly distributed which makes it very difficult for farmers to get good harvests most of the time. The soil is sandy to sandy loam which are inherently infertile. The main agriculture activities are livestock and small grain production.

2.2 Population and Sample Size

The area has a population of 750 households and there are 15 villages. Stratified random sampling method was used to select five (5) villages from the ward. Names of households of all selected villages were collected from ward councillor and were assigned numbers according to each village. Ten (10) households were selected from each village using random numbers generated using a computer. Number corresponding to household name on the village list was selected. If the number was out of range, the process was repeated until the number produced is in the range. Snowball sampling was also used to identify sorghum farmers in the ward and if households were not in the list, they were interviewed to gather more information as these were sorghum farmers who can highlight constraints and opportunities of growing sorghum.

2.3 Research Design

A descriptive survey was used as the research design. It gives a broader range where the questionnaire and interview method of data collection was used. [8] suggested that a descriptive survey method is used because it covers both

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qualitative and quantitative data. Descriptive studies are designed to describe something for example characteristics of users of a given product. Data was collected using questionnaires, interviews and focus group discussions. Questionnaires were pilot tested using households from villages which were not selected to be part of the survey. Face to face interviews were done individually to prevent interference of response by participants.

2.4 Data Analysis and Presentation

IBM Statistical Package for Social Sciences (SPSS) version 25 was used to generate descriptive statistics obtained from questionnaires and interviews. Data from questionnaire were coded for easy analysis. Bar graphs, frequency distribution tables, percentage distributions, means were used as descriptive statistics.

3. Results

3.1 Household Characteristics

Out of 250 participants, 80% were males and 20% were females showing that more males were selected for the research. This shows that most women are not into sorghum production because they consider it to be laborious. Of all the participants, 4% were in the age range of 25-30 years, 10% in the age range of 31-35 years, 14% in the age range of 36-40 years, 16% in the age range of 41-45 years and 56% in the age range of 46 years and above. Out of all the participants, 20% attained primary education while 68% had attained secondary education. Only 12% had tertiary education (Table 1).

Table 1. Demographic characteristics of participants

Characteristics	Frequency(n)	Percentages (%)
Gender		
Male	200	80
Female	50	20
Age (years)		
25-30	10	4
31-35	25	10
36-40	35	14
41-45	40	16
46 and above	140	56
Educational level		
Primary	50	20
Secondary	170	68
Tertiary	30	12

3.2 Major Constraints Faced by Small-scale Sorghum Producers

The 250 respondents who are found to be the producers of sorghum in the questionnaires ticked the major constraints they faced in the production of sorghum as highlighted in the table above (Table 2). Availability of resources (60%) such as certified seed, fertilizers, herbicides and draught power was the major constraint in the production of sorghum. There was lack of NGOs and government support in supplying the farmers with seed. Participants also highlighted constraints such as lack of technical knowhow (20%) of sorghum production, poor farming methods (9.6%) such as mono-cropping, *Striga* weed (12%), outbreak of fall armyworm (14.4%) and marketing of produce (8%) were also amongst the major challenges indicated by most participants. Farmers indicated that they mainly sell sorghum to local markets because they do not have transport to carry their produce to the GMB. GMB also buys the produce but on a smaller scale because of government financial constraints. Some ordinary people especially from nearby places buy the produce for consumption and resell to other places. Some of the participants indicated labour costs (48%) in weeding, harvesting and threshing of sorghum. Sorghum is laborious in terms of production and processing. During the interviews respondents highlighted that from planting to harvesting it requires attention as compared to maize.

Table 2. Table showing constraints in relation to number of farmers facing them

Constraints	Number of farmers facing constraints N=250	Percentage (%)
Availability of resources	150	60
Labour costs	65	26
Lack of technical knowhow	50	20
Poor farming methods	24	9.6
Striga weed problem	30	12
Outbreak of FAW	36	14.4
High plant populations	10	4
Marketing of the produce	120	48
Soil fertility	60	24
Pests and diseases	105	42

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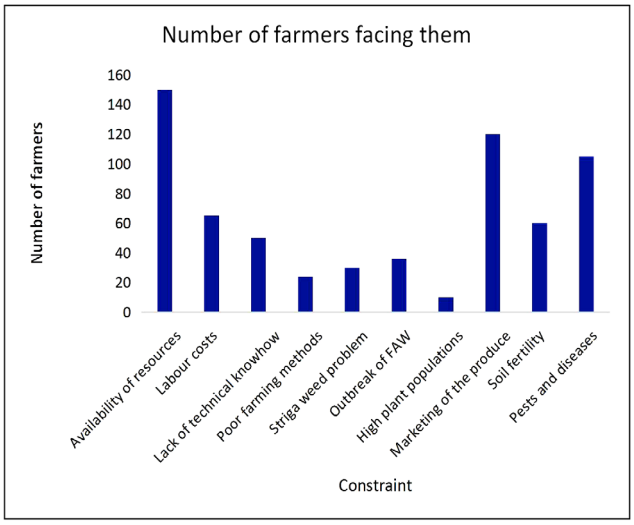

Figure 1. Bar graph showing constraints in relation to number of farmers facing them.

3.3 Major Opportunities for Small Scale Sorghum Producers

Results in Table 3 and Figure 2 below shows that 66% of the 250 participants indicated that they produce sorghum due to its drought tolerant nature. The opportunity of beer brewing was just slightly above half (52%) as indicated by the participants. Slightly below half (48%) of the participants indicated that sorghum can be used in making mealie meal. From the 250 participants, yield assurance as compared to maize in dry areas was slightly below half (46%). Obtained results highlighted that 30% of the respondents noted that sorghum can be used as animal feed. Some of the participants (46%) indicated that there is yield assurance of sorghum as compared to maize in dry areas where rainfall is erratic Results also indicated that income generation (22%) and highly nutritious (10%) were also realised from the respondents. The least opportunities indicated by the respondents were high demand ad fits in all types of soils which scored 4 and 6% respectively.

During the interviews, most producers indicated that sorghum can be stored in for a long time without losing quality; hence it is a major food security crop. The crop can be used for beer brewing and can increase household income through selling beer and also selling the grain to local people. Sorghum has very low cases of pests both stored or field pests and disease incidents. It can even do well on soil with low fertility. Sorghum is nutritious as compared to other cereals.

Table 3. Table showing major opportunities for small scale sorghum producers

Opportunities	Number of farmers ticking the opportunity N=250	Percentage (%)
Drought tolerant	165	66
Livestock feed	75	30
Making mealie meal	120	48
Low storage costs	25	10
Income generation	55	22
Fits in all soil types	15	6
Seeds can be retained and used for many years	25	10
Beer brewing	130	52
Good substitute for maize	35	14
High demand	10	4
High nutritional value	25	10
Yield assurance as compared to maize in dry areas	115	46

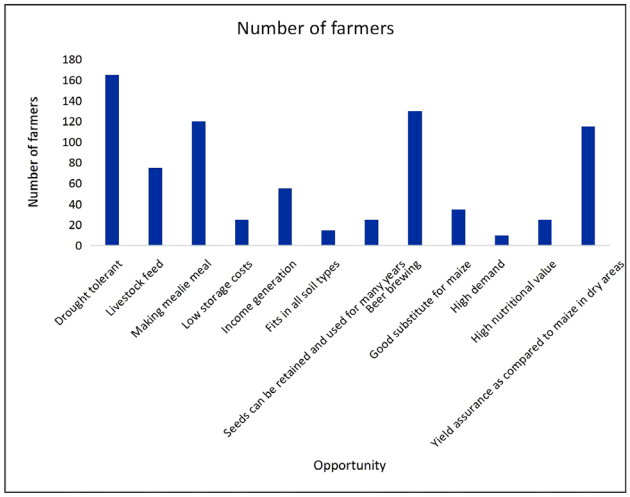

Figure 2. Bar graph showing major opportunities for small scale sorghum producers

4. Discussion

4.1 Constraints to Sorghum Production

Soil infertility and lack of knowledge about growing of small grains has been a major challenge which farmers failed to explore and this was witnessed by poor yields. Results were affirmed by [4] who highlighted the need for education especially the young generation. Farming of

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small grains like sorghum requires morphological and botanical knowledge especially during weeding time as it tends to have weeds that look exactly like the plant such as *Sorghum halepense* [21]. Many assume that once the crop is planted, it grows up to harvest without weed control. Lack of fertilisers use on small grains by farmers caused low yields. This coincides with findings by [1] and [28]. Several studies have indicated that most farmers in Su-Sahara Africa do not use fertilisers in production of crops [22,23,36] leading to realisation of lower yields [10,42]

In previous years, government support on small grains were very little and this affected sorghum production with many farmers preferring maize which fails almost every year in semi-arid and arid regions. This is supported by the [15,18] which reports that the Zimbabwe government support measures for small grains have been shown to be relatively minimal compared to maize and the latter has encroached into sorghum and millet land. Results concurs with findings by [15,31,32,45] who noted that government policy and agricultural services target maize production, aggressive marketing by seed houses and millers, favourable pricing policies and good demand [32,45]. [35] indicated major constraints of sorghum which include pests (birds), diseases, drought, *Striga* weed, low yields and marketing. *Striga* constraints were also concurring with report by[40] who reported that *Striga* species are one of the worst weed in cereal production including sorghum. Pest such as birds were also a major constraint in sorghum production especially at grain filling stage. This causes low adoption by farmers. This was in support of results by [27,45] who all reported negative effects of birds on sorghum production and other small grains including millets. The results were also supporting reports by [11] who reported that quelea birds are dangerous in sorghum production as they reduce yields sometimes to zero.

Sorghum producers were also facing lack of resources such as seeds and labour especially during harvesting and threshing. Farmers end up using retained seeds which are polluted and have been affected by diseases causing low yield per unit area. This was in support of results by [7,43]. High labour demand for harvesting, threshing and winnowing was also a constraint for sorghum production since there are few people in rural area and many of them are of old age. This was supporting ideas by [3] who reported high labour cost. Lack of market also affected sorghum production as most people in better regions prefer maize than sorghum. Limited marketing opportunities for sorghum in Zimbabwe especially white varieties are at high. This was supporting results by [1,21] causing many farmers to grow sorghum for own consumption or others shifting to maize production [29,30]. Most smallholder farmers are resource poor farmers who lack resources such as transport to transport sorghum over long distances in search of market. This concur with findings by [39] who reported high transport costs to GMB and affirmed by [44] who indicated that transport cost is a major challenge to smallholder farmers.

4.2 Opportunities for Sorghum Production

Since sorghum is drought tolerant and can be grown in all soil types, this brings in many opportunities such as poverty reduction, food security, and income generation, substituting maize in stock feed production [21,25] and reducing pressure on maize for food. These coincides with results by [12] and [35]who reported that sorghum can be used as food insecurity alleviation in drought prone regions in Africa and other continents. The idea was also supported by [17,31,45] who all indicated that sorghum production reduced poverty and food insecurity in many countries including dry regions of Zimbabwe. Sorghum together with other small grains can be adopted by farmers to reduce malnutrition, death by hunger and food insecurity in many countries across the world [[9,14,17,20,26].

5. Conclusions

Lack of knowledge, resources, markets and inadequate availability of certified seeds to smallholder farmers reduces sorghum production and number of farmers who adopt sorghum as a source of human food. Sorghum production in smallholder farmers could have been at a high level if government support for small grain production was introduced earlier than later especially in drought prone regions of Zimbabwe. Failure by researchers to provide government with information on small grain production as climate risk alleviation in areas which receive low rainfall also hindered sorghum productivity. Sorghum was cultivated by many smallholder farmers in early years but lack of support, markets, outbreak of quelea birds and high labour costs reduces burden on old aged farmers hence opting for maize. Although sorghum has opportunities such as income generation from beer brewing, substituting maize in stock feed manufacture, reducing poverty and food insecurity in dry regions, farmers are opting for maize due to many constraints than opportunities. To increase sorghum production in drought prone regions, there is need for government to support small grain production, provide certified seeds to farmers and market as well as training farmers about how to sustainably grow sorghum.

Conflicts of Interest

Authors do not declare any conflicts of interest.

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ARTICLE

Rediscovering Pride in Agricultural Heritage through Cultivation of African Indigenous Vegetables (AIVs) as Climate Acquiescent Vegetables, Immune and Health in Response to COVID-19 Pandemic in Zimbabwe

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ABSTRACT

African Indigenous Vegetables are asserted to cope with climate variability besides their great potential as both food and medicine in Zimbabwe. They can be easily grown in drought prone areas with low rainfall as they are resistant to adverse environmental factors. Inimitable opportunities are offered through cultivation of AIVs to diversify farming systems so as to ensure food security and are cheap alternatives as compared to their expensive exotic counterparts. Alternative approaches to reduce escalating numbers of current Covid-19 patients and death is to introduce nutrient intervention through rediscovering of pride in agriculture through cultivation and commercialisation of AIVs in Zimbabwe. AIVs have great potential to improve immune response by supplementing dietary requirements (micronutrients) of an individual and can have a positive impact on COVID-19 outcome as they play a significant role in the immune system. AIVs have antifungal, acaricidal, antiviral, anticancer and act as immune stimulants. There is need for persuasive research based information, suitable national legislation and information campaigns on cultivation and consumption of AIVs in Zimbabwe.

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1. Introduction

Current evidence shows that climate change is affecting crop productivity with direct impacts on the nearly 70% of people in agro-based rural areas of developing countries [121,122]. Indigenous traditional vegetables are plants that are endemic or introduced whose leaves, flowers and/fruits have been utilised for decades and many generations thereby becoming part of the culture and tradition of communities [85,76]. African Indigenous vegetables (AIVs) production has gained traction as a viable adaptation option in Zimbabwe especially in dryland regions. AIVs production has a potential to build capacity and enable rural communities to be resilient against the quirks of climate change impacts. In Zimbabwe, indigenous communities have relied on AIVs for food security, medicinal, social, cultural and income generation [85].

AIVs are asserted to cope with climate variability beside their great potential as both food and medicine. Most of the AIVs grow naturally in certain areas and generally they are adapted to harsh environments [76]. They can be easily grown in drought prone areas with low rainfall as they are resistant to adverse environmental factors [98]. [111] highlighted that the most consumed AIVs include vegetable amaranth (*Amaranth species*), spider plant (*Cleome gynandra*), African kale (*Brassica carinata*), jute mallow (*Corchoru solitorius*), African nightshades (*Solanum species*), cowpeas (*Vigna unguiculata*) and African eggplant (*Solanum aethiopicum*).Notably, AIVs are generally compatible with starchy staples and therefore striking a balanced between cost and quality nutrition for the poor in both urban and rural areas [112,85,75].

AIVS provide nutrients such as vitamin A, C, iron and proteins which are essential for human growth and development [6,123,55]. [45] postulated that African indigenous vegetables play a significant role in reducing malnutrition, increasing incomes, and maintaining biodiversity. [4]AIVs have been neglected by researchers, policy makers and funding agencies and have yet to be fully integrated into the mainstream of agricultural production. Although production of these vegetables is generally on a small-scale where traditional knowledge is employed [100], marketing of AIVs is becoming an important driver of income generation in SADC Region, [71]. Research is therefore needed on cost effective ways to increase the consumption of indigenous vegetables by promoting their nutritional, medicinal, cultural and culinary properties.

Of particular concern is underutilisation of AIVs, which is linked with loss of indigenous knowledge, food and genetic diversity [99]. In commercial farming systems, AIVs are considered as weeds and therefore they continually destroyed and this is contrary to the issue of food shortages, malnutrition and high unemployment in rural communities [86]. Concisely AIVs are critical in diversification of farming systems, which enhances food security at household level [86,76]. AIVs contribute positively to the level immunity in an individual and offer cheaper alternatives to the more expensive commercially produced vegetables due their nutritious nature [53].

The uniqueness of AIVs lies in their ability to grow quickly and mature early thereby becoming an integral part of sustainable nutrition-intervention programmes [75]. Several authors have indicated that interventions designed to increase vegetable consumption among adults and children can be effective [64,92,108]. It needs therefore, to unravel the potential opportunities of AIVs as immune stimulation and perceived constraints faced by poor smallholder farmers in cultivating indigenous vegetables so as to be able to devise adoption and dissemination strategies to best meet their needs. Limited demand and discrimination have been major constraints to the production of AIVs in Zimbabwe. Lack of research on AIVs has led to the loss of indigenous knowledge systems and thus this review seeks to document cultivation of (AIVs) as climate acquiescent vegetables, immune and health in response to Covid-19 pandemic in Zimbabwe.

Exotic crops such as rape, cabbages, tomatoes and onions are conversantly taught in Zimbabwean Agricultural classes. AIVs are mentioned as wearisome weeds. The review paper seeks to revive pride in agricultural heritage through cultivation of African Indigenous vegetables (AIVs) as climate acquiescent vegetables in Zimbabwe in response to Covid-19 pandemic awareness.

2. AIVs as Immune Promoters in Response to Covid-19 Pandemic

According to [10], coronavirus disease-19 (COVID-19) is a highly contagious disease that was identified in China in December 2019 and is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) a single-stranded RNA virus.

The Huanan Seafood Market in Wuhan, China, was implicated as the origin of the novel coronavirus (SARS-CoV-2) [69]. Coronaviruses are diverse RNA viruses that exist in two important hosts: mammals and birds. These viruses mainly cause respiratory and, less often, gastrointestinal diseases [25]. The major respiratory symptoms caused by coronaviruses normally range from mild influenza like symptoms which usually appear 5–6 days after infection to severe pneumonia [39]. The other symptoms linked to COVID-19 include sore throat, fever, muscle

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and body aches and loss of smell or taste in some cases [124]. According to the RNA sequencing SARS-CoV-2 and bat coronavirus possess a similarity of gene sequence up to 96.2%, and this suggests bats as the possible source of SARS-CoV2 [39].

The role of the immune system is to protect the host from invading agents particularly pathogens such as bacteria, viruses, fungi and worms [21]. The protective effect of the human immune system lies in the existence of body barriers and immune system cells. Immune responses after infection are coupled with increased metabolic rate, where metabolism is an active process that allows biosynthesis of critical substrates and regulatory molecules [43]. The energy utilised in biosynthesis is derived from the diet and therefore AIVs provide some of nutrients for optimum functioning of the immune system [20]. Disturbingly, SARS-CoV-2 is novel to the human immune system and therefore lack of primary natural immunity against the virus [21].

Nutrients play a central in supporting the immune system, providing antiviral defences, overcoming gut microbial dysbiosis and in calming cytokine storm [21, 39]. Individuals with underlying conditions such as diabetes, cardiovascular disease, respiratory disease and suppressed immune systems are particularly susceptible to severe symptoms and mortality [13]. Although the search for vaccines that offer immune protection against SARS-CoV-2 has yield positive results, most countries including Zimbabwe are still to get hold of these vaccines [66]. In the meantime, it is critical for individuals' immune systems to be strengthened. Among other strategies, nutritional intervention is central in boosting the immune system. In addition to this, there is a high chance of antimicrobial resistant infections emerging in a number of societies, and in such instances, nutritional status is imperative in the maintenance of a strong immune system against the virus [11].

AIVs are excellent sources of vitamins A and C, and iron, protein, minerals and fibre [102]. [110] declared that these micronutrients are an essential component for people without access to meat or other sources of protein. Micronutrients forms an essential component of dietary requirements of an individual and have a positive impact on COVID-19 outcome as they play a significant role in the immune system [24]. Generally, immune cells require enough energy, macronutrients and micronutrients to maintain an effective immune response [22]. Besides providing micronutrients and macronutrients, AIVs are sources of secondary metabolites with antioxidant potential. Methanol extraction of spider plant (*Cleome gynandra*) produced total antioxidant potentials [88]. These anti-oxidants have the ability to bind harmful free radicals in the body which cause diseases such as cancer and diabetes[81]. Studies by [90] postulated that vegetable antioxidants enhance natural kill cells ad lymphocytic activity and increase interleukin-2-production.

3. Micronutrients and the Immune System

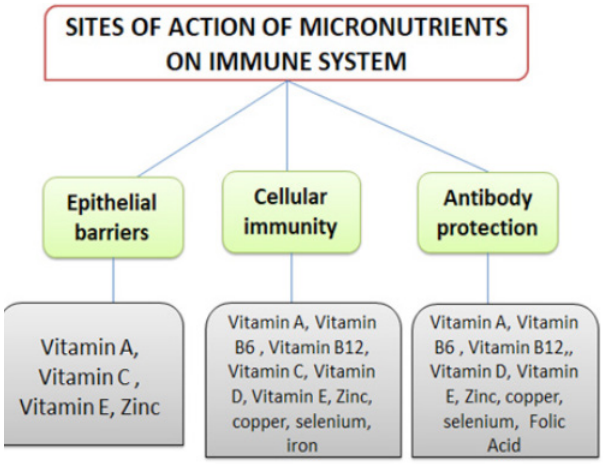

Figure 1. Sites of action of micronutrients: Adapted from [82]

[1] highlighted that drug shortages have been reported hence natural sources to supplement these elements are required to boost the immune system. Drugs and vaccines are under trial whilst the number of people succumbing to Covid-19 is on the rise in Zimbabwe. Alternative approaches to reduce escalating numbers is to introduce nutrient intervention like the commercialisation of AIVS in Zimbabwe so as to improve immune response against this disease. AIVs becomes a recommendation for the dietary supplementation of essential micronutrients. [56,21] proposed the use of nutrients to protect against many infectious diseases and reduce lung damage in pulmonary infections.

4. African Indigenous Vegetables (AIVs) as Climate Acquiescent Vegetables

With the changing climate and marginal soils common among the resource poor farmers, AIVs can produce better yields in marginal and poor conditions with fewer inputs and less labour than other staples [19]. AIVs show substantial biodiversity and can be grown with minimal external inputs [29,50]. With their ability to grow in diverse environments with minimum resources, traditional vegetables can support conventional agricultural practices, and provide insurance against drought and crop failure [85]. AIVs ensures food security and highly nutritive food while backing to the resilience of the community to changes in

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Table 1. Some of the nutrients and minerals from AIVs and their significance on the immune system and combating COVID-19

Nutrient/mineral	Role in immune system	Other roles in reducing effects of COVID-19	Source (s)
Vitamin C	• Vital in collagen biosynthesis and maintenance of epithelial integrity. • Important in leucocyte migration to sites of infection, phagocytosis and bacterial killing • It is critical in natural killer cell activity, T lymphocyte function (especially of CD8+ cytotoxic T lymphocytes) and antibody production.	• Decreases the duration and severity of upper respiratory tract infections, • Reduces exposure of the respiratory system to serious infections including pneumonia.	[11] [30] [82] [13] [21] [47] [23]
B-group Vitamin	• Important in intestinal immune regulation, and contributes to gut barrier function. • Maintain and support the activity of natural killer cells and CD8+ T lymphocytes, and this plays an important role in antiviral defence. • Generally, vitamin B6 increase the percentage and total number of circulating lymphocytes, • It improves T and B lymphocyte proliferation and IL-2 production.		[131] [21] [82]
Vitamin A	• Immune cell maturation and function • Innate immunity modulation • Controls neutrophil, dendritic cell and CD4+ T lymphocyte maturation • Maintains balance between T helper 1 and T helper 2 lymphocytes • Supports phagocytic activity and oxidative burst of macrophages, • When vitamin A is metabolised produces 9-cis retinoic acid and this metabolite promotes T helper 1 responses. Moreover, retinoic acid is critical in the movement of T lymphocytes to the gut lymphatic system and in CD8+ T lymphocyte survival and multiplication. Retinoic acid is important in the normal functioning of B lymphocytes and in antibody synthesis	• Allows normal differentiation of epithelial tissue • Reduce entry pathogens modulation of body barriers	[18] [68] [34] [101] [82]
Iron	• Prevents thymus atrophy, thereby increase production of naive T lymphocytes • Improves bacterial killing, natural killer cell activity, T lymphocyte proliferation and production of T helper 1 cytokines.	• It promotes impairment of respiratory burst • Although complex, presence of iron reduces susceptibility to infections	[91] [26] [40] [125]
Zinc	• Inlvolved in DNA synthesis and cell proliferation thereby important in the production of immune cells • It is critical in the regulation of innate and adaptive immune responses, and cell signalling. • Is an inhibitor of RNA polymerase, which is central in multiplication RNA viruses like coronaviruses.	• Lowers susceptibility to diarrhoeal, respiratory and skin infections. • Reduces chances of recurrent respiratory tract infection in children and shorten the duration of common cold in adults.	[48] [109] [80] [82]
Magnesium	• Is an electrolyte that aids strengthening of the immune system's natural killer cells and lymphocytes. • It is a source of energy (adenosine triphosphate (ATP)) for cellular biosynthesis and other energy requiring process.		[11] [13]

climatic conditions because they are well adapted to the ecological conditions of the area [19]. Disease suppression and buffering against climate variability is of great relevance to smallholder farmers with limited resources [70].

4.1 Food Security and Nutritional Security

Generally, AIVs have a great potential in addressing poverty and nutritional security issues considering affordability and accessibility [95]. More importantly, AIVs easily grow, require minimum production inputs, have high vitamin and mineral content, and are rich important immune boosting secondary metabolites [85]. Until this day, food security continues to be a serious problem in several rural communities in Zimbabwe [76]. Traditional vegetables previously preserved by drying become very important in household food security during the period of relish shortage, especially in the dry season (the relish-gap period[86]. [77] pointed out that access to sufficient nutritious food which meet dietary requirements to be healthy and active is termed food security. Moreover, food security can be defined as access by all people at all times to enough food for an active and healthy life [76]. AIVs grow quickly and

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Table 2. Selected indigenous vegetables consumed in some parts of Zimbabwe

Scientific name	Common name	Local shona/ Ndebele name	Utilization
Amaranthus hybridus Amaranthaceae	Pigweed	Bonongwe, mowa	Young, tender leaves are cooked fresh or after drying
Adansonia digitata Bombacaceae		Derere-muuyu	Young, tender leaves are cooked fresh or after drying
Ceratotheca sesamoides Tiliaceae		Bupwe	Young, tender leaves are cooked fresh or after drying
Scenicio erubescence Astereceae		Chirevereve/ Chiribwiribwi	Young, tender leaves are cooked fresh or after drying
Abelmoschus esculentus	Okra	Derere chipodzi	Fruit
Corchorus olitorius Tiliaceae	Jute mallow	Derere gusha	Young, tender leaves are cooked fresh or after drying
Corchorus tridens Tiliaceae	Jute	Derere munda	Young, tender leaves are cooked fresh or after drying
Adansonia digitata Bombacaceae		Derere-muuyu	Young, tender leaves are cooked fresh or after drying
Cleome monophylla Capparaceae	Spindle weed	Mujakari, musemwasemwa	Young, tender leaves are cooked fresh or after drying
Cleome gynandra Capparaceae	Spider , Cat whiskers	Nyeve, rhude/ ulude	Young, tender leaves are cooked fresh or after drying
Bidens pilosa Asteraceae	Black jack	Tsine, mhuuyu	Young, tender leaves are cooked fresh or after drying
Galinsoga parviflora	Gallant soldier	Teketera	Young, tender leaves are cooked fresh or after drying
Legenaria siceraria	Gourds		Fruit
Vigna unguiculata	Cow peas	Munyemba	Young, tender leaves are cooked fresh or after drying
Cucumis anguria		Cucumber	Young, tender leaves are cooked fresh or after drying ad fruit consumed raw
Cucurbita maxima	pumpkins	Boora	Matured fruit cooked and leaves are cooked fresh or dried
Curcubita pepo	pumpkins	Boora	Fruit and leaves are cooked
Solanum nigrum	Nightshade		Young, tender leaves are cooked fresh or after drying

Modified table: source [87, 86, 95]

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Table 3. Nutrient content of the analyzed selected wild vegetables per 100 g dried portion

Nutrient	*Cleome gynandra*		*Amaranthus hybridus*		*Bidens pilosa*		*Corchorus tridens*	*Adansonia digitata*
	uncooked	cooked	Uncooked	Cooked	Uncooked	cooked	Uncooked	uncooked
Crude protein (g)	5.82±1.0	4.70±0.50	4.94±0.46	4.66±0.33	4.4±0.78	3.7±0.30	5.10±0.54	4.23±0.68
Crude fiber (g)	1.57±0.39	1.7±0.49	1.5±0.08	1.7±0.19	1.7±0.45	2.1±0.09	4.2±0. 78	3±0.48
Carbohydrate (g)	8.94±0.17	7.58±1.9	8.7±0.9	6.9±0.68	8.84±1.39	6.40±0.77	14.0±1.78	18±2.10
Fat (g)	0.4±0.091	1.3±0.23	0.4±0.27	1.0±0.46	0.5±0.50	0.6±0.37	0.3±0.12	0.4±0.29
Potassium (mg)	129±58	131±69	550±98	530± 7	600±53	580±95	370±93	1090±109
Calcium (mg)	120±58	115±99	798±112	530±88	370±67	300±79	380±97	400±120
Magnesium (mg)	97±17	70±23	440±111	343±118	600±126	570±119	290±96	370±99
Phosphorus (mg)	14±4.0	10±5	550±117	450±134	500±109	480±115	623±123	66±11
Iron (mg)	13.12±2.46	9.5±1.09	11.4±0.77	7.3±0.99	17.47±3.4	15±2.7	8.67±1.77	23±3.68
Zinc (mg)	10.36±2.43	1.73±0.55	5.8±1.09	4.90±0.73	22±2.65	19.12±2.3	4.45±0.97	20.1±1.13
Copper (mg)	2.87±0.68	9.77±1.17	7.65±0.89	5.12±0.78	10.61±1.94	9.06±0.79	1.8±0.89	23.71±3.25
Ascorbic acid (mg)	18±3	10±2	64±6	46±7	70±7	40±9	78±12	55±8

Source: [87]

become harvestable within a short period (usually within 3-4 weeks) makes them useful in supporting nutrition-intervention programmes [79]. These vegetables are readily accessible to the low income communities in rural and urban areas in dryland regions. Moreover, they offer an opportunity of providing affordable nutrition to avert malnutrition in combination with small grain cereals (sorghum and millets) complementing the dietary requirements of individuals. [126] cited in [81] postulated that 'hidden hunger' or malnutrition as a result of micronutrient deficiency afflicts over two billion people worldwide. This has resulted in poor health, low worker productivity, increased rate of chronic diseases (coronary heart disease, cancer, stroke and diabetes) and cognitive abilities of infants born to micronutrient deficiency mothers [126]. AIVs food security is mainly due to their higher nutrient content compared to their counterparts' exotic vegetables [27,8,14]. AIVs contribute significantly towards food security in Southern Africa, especially as a dried form during winter [95].

Consequently, food security cannot be delinked from nutrition security to which consumption of indigenous vegetables significantly contributed [57]. [19] proposed that there is need for investments in AIVs research and development so as to battle against poverty and hunger. Inimitable opportunities are offered through cultivation of AIVs to diversify farming systems so as to ensure food security and are cheap alternatives as compared to their expensive counterparts with lower nutritional value [19]. Table 1 shows examples of selected indigenous vegetables consumed in some parts of Zimbabwe.

4.2 Nutritional Composition of Selected AIVs

[118] and [4] reports on chemical composition of indigenous vegetables and fruits highlighted that they contain important amounts of phytochemicals including crude protein, fat and oil, energy, vitamins and minerals. [96] suggested that AIVs are sources of high quality nutrition. [102] postulated that AIVs are excellent sources of vitamins A and C, and iron, protein, minerals and fibre. These micronutrients are an essential component for people without access to meat or other sources of protein [111].

Several studies have indicated that these vegetables are cheap for rural people and they are said to contain vitamins and minerals in quantities which far exceeds those found in most exotic vegetables [97,118,115].

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Table 4. Nutritional comparison of selected Indigenous vegetables and common exotic vegetables grown in some parts of Africa (Nutrient content per 100g fresh weight)

Nutrient	Indigenous vegetables			Common exotic vegetables				
	Cleome gynandra	*Amaranthus hybridus*	*vigna unguiculata*	*Corchorus tridens*	*Solanum nigrum*	*Kale*	*Cabbage*	*spinach*
Protein (%)	5.1	4	4.7	4.5	4.6	2.5	1.4	2.3
Vitamin (mg)	144	135	87	187	131	93	33	28
Calcium (mg)	262	480	152	360	442	187	44	93
Iron (mg)	19	10	39	7.7	12	32	0.8	32
B-carotene (mg)	2.7	10.7	5.7	6.4	8.8	7.3	1.2	5.1

Modified table: Source [78, 3, 86]

4.3 Challenges in Cultivation of AIVs

Cultivation of African indigenous vegetables is affected by lack of seeds and planting materials. There is overreliance of unimproved landraces i.e self-retained seeds, poor quality seeds and lack of distinct varieties [63]. Some seeds exhibit dormancy during winter periods and resume germination in summer. Currently, there is lack of extension services on agronomic aspects such as planting, optimum spacing, use of fertilisers and manure. Other challenges related to the production of AIVs include lack of technical knowledge, pest and diseases, water requirements and expected yield per hectare. Lack of irrigation facilities in smallholder farmers acts as a barrier in overreliance on rain-fed production making it an unviable enterprise in providing alternative cheap but nutritious relish and a steady income flow.

Perceptions by many households influence the consumption of indigenous vegetables [63]. AIVs are considered to be inferior in their taste as compared to exotic vegetables resulting in reduced frequency of consumption over the years [123]. Poverty and primitive practices are associated with low intake of indigenous vegetables and they are associated with the concept of social backwardness [62]. This explains why young household members shun indigenous vegetables as they are associated with poverty, backwardness and bitterness [123, 130, 35, 89, 7]. Youngsters have active taste buds that are replaced each time of growth. They shun to consume bitter taste foods as compared to adults whose taste buds don't get replaced each time they grow. Intensity of consuming indigenous vegetables is influenced by many other socio economic factors, such as gender, education and age of household head, market options and household monthly income. [123] and [62] as cited in [95] highlighted that men have less preference for consumption of indigenous vegetables than women.

5. Steps towards Improving the Cultivation of AIVS in Zimbabwe

5.1 Seed Breeding and Certification

Most farmers are using informal retained seed for subsistence farming. Currently there is no formal breeding of IVs being done for commercial production. There is need to improve high seed quality access that allows holistic varietal selection amongst smallholder farmers. The government of Zimbabwe through the Plant protection unit should ensure that there is proper seed certification by formal seed systems. This will ensure access for smallholder to a wide variety of seeds.

5.2 Improve Current Cultivation Practices

There is need to invest in research and innovation as prescribed in the doctrine of Higher and Tertiary education which spelled out heritage based philosophy 5.0. Farmers should be trained on new techniques by capacity building of extension officers. Researchers and agronomist must create manuals on good practises based on indigenous knowledge to combat pest and diseases so as to disseminate knowledge on commercialisation of AIVs.

5.3 Develop Low-cost, Innovative Technology for Post-harvest Processing

There is need to share knowledge on processing and handling techniques with various community back-

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grounds. Threshing machines, de-saponification machines and affordable cooling and storage technologies should be developed for post-harvest processing.

African Indigenous Vegetables (AIVs) are highly prone to spoilage due to lack of sufficient processing capacity and lack of market due to stiff competition from exotic vegetables [46]. Lack of appropriate production technology has much contribution to the low production of AIVs and poor distribution in Zimbabwe. To curb this problem of AIV spoilage, drying has been an indigenous technology system of processing leafy vegetables to prolong their shelf by preventing spoilage making them available during periods of scarcity. It is of significance to note that production of AIVs with extended shelf life can help reduce losses posed by perishables there by improving the population's income and supply situation. However, sun drying method which is mostly employed to dry these AIVs, often yields poor quality products due to wind dust, microbes and or animals spoilage.

Food engineers have devised the drying equipment used in industrialised countries that curb these problems but it requires a good capital investment and well developed infrastructure [45]. To minimize post-harvest losses and to ensure regular supplies of African indigenous vegetables from the production areas to consumer's market centres, Zimbabwe's economy through the ministry of Agriculture and food security should develop and promote locally appropriate processing techniques which are affordable by the farmers. AIVs suffer under utilisation and under exploitation mainly due to lack of processing amongst other constrains such as marketing and nutritional details [45]. [19] processing plays a very critical role in transforming vegetables from perishable state thereby prolonging their shelf lives which helps in their transportation and distribution within the country and abroad.

5.4 Value Addition and Marketing Improvement

Value addition such as drying, mixed flour of maize and indigenous vegetables so as to prolong shelf life[63]. There is need to increase marketing options through investing inadequate infrastructure and transportation means. Raising of awareness must be done through social media, cooking tutorials on TV. Eco labelling will ensure that there is proper dissemination of information on AIVs in Zimbabwe.

5.5 Holistic Approach to Promote Value Chain of AIVs

[104] and [67] as cited in [63] highlighted that there is need to integrate a holistic approach from genetic diversity, capacity building, seed supply services, cultivation practices, harvest and post-harvest processing, value addition and marketing. This will ensure successful market development in Zimbabwe by promoting value chain of AIVs thereby increasing their consumption and cultivation.

5.6 Improve on Policy Frameworks on Cultivation of Heritage Based Indigenous Vegetables in Zimbabwe

Zimbabwean policy frameworks and decisions are now increasingly emphasizing the importance of traditional food species from a nutritional perspective. The doctrine of heritage based philosophy 5.0 prophesied by the Ministry of Higher and Tertiary Education underlines the need to transform smallholder agriculture from low-productivity subsistence activities to innovative agribusiness enterprises. There is need for persuasive research based information, suitable national legislation and information campaigns on cultivation and consumption of AIVs in Zimbabwe. [128] postulated that research on drought-tolerant crop varieties as well as organic farming is important to achieve the vision 2030 of achieving a middle class economy. Zimbabwe is adopting an education system that imparts knowledge suitable for exploitation of locally available indigenous resources to achieve an industrialised and modernised economy hence promoting mass production of African indigenous vegetables. Marondera University of Agricultural Science and Technology in 2020 was funded by the government to research on sustainable production and commercialisation of indigenous vegetables for suitability in specific food, drink and feed formulation addressing innovation and industrialisation.

6. Opportunities for AIVs

6.1 Livestock Feed

Black jack and gallant soldier can be used as feed for rabbits. [28] pointed out that leaves of spider plants can be used as feed for bovines, camels, equines and game animals. Seed is used as feed for birds. Oil is said to be extracted by simply pressing without complications of refining as indicated [83]. Production of seedcake was also observed by [84] which is used as animal feed.

6.2 Medicinal Properties

[13] cited in [44] indicates that 43 % of the population in sub-Saharan Africa suffers from chronic food shortages and deficiencies of essential nutrients such as iron, vitamin A and iodine.

UN (2010) indicated that roughly one in every three

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children under the age of five years in Zimbabwe is chronically malnourished. Access and intake of adequate nutrients is the predominant challenge which emanates to micronutrient deficiencies as they occur in the presence of adequate energy intake [36]. Medicinal therapy in fighting HIV/AIDS can be supplemented by including AIVs in the diet. [130] highlighted that consumption of AIVs can be important in alleviating malnutrition, improve nutrition and help to alleviate HIV/AIDS.

Bitter gourd (*Momordica charantia*) and tropical pumpkin (*Cucurbita moschata*) are important indigenous vegetables in the tropics and possess good nutrient density. Fruits of bitter gourd are a rich source of β-carotene, vitamin C, folic acid, magnesium, phosphorus and potassium [132]. Its fruits are often used in traditional medicine to treat type II diabetes which is most prevalent in many countries in the South and Central Pacific [127,51]. Tropical pumpkins proliferate in α- and β-carotenes and lutein which a rich source of dietary fiber. As a precursor of vitamin A, β-carotene is required for the proper development and working of the eyes whilst lutein has an important photo-protective function in the macular region of the retina [16].

[116] highlighted that *Cleome gynandra* contains a lot of phenols which can be used to cure cancer, asthma, diabetes and cardiovascular diseases. Currently, reports by several authors indicate that individuals and elderly with complication such as hypertension, diabetes and cancer are mostly prone to Covid-19 pandemic [73,49,33].Therefore, eating *C. gynandra* can reduce such complications as suggested by [116]. Several researchers indicated that spider plant is used to cure migraine, vomiting, diphtheria, vertigo, headache, pneumonia, septic ears, stomach ailments, as eyewash [65,32,110]. [17] suggested that spider plant has ethno medicinal properties such as treatment of piles, rheumatism, anti-tumour activity and malaria [41]. Studies by Imanirampa and Alele (2016 observed antifungal activity of *Cleome gynandra* L. aerial parts for topical treatment of *Tinea capitis*. Findings by [103] hypothesised that boiled drink of the plant can be used as a remedy for scurvy and marasmus and consistent consumption eases pregnant women during child birth [65]. [53] also highlighted that consuming of spider plant by pregnant women reduces labour time also. Results by [88] declared that methanol extraction of spider plant produced total antioxidant potentials. These anti-oxidants bind harmful free radicals which when left in the body may cause diseases such as cancer and diabetes [81].

Black nightshade (*S. nigrum*) is a highly valued as it is consumed for its perceived health benefits and flavour. [61] as cited in [15] indicated that black nightshade leaves are consumed to combat diabetes, high blood pressure, anaemia, peptic ulcers, colds, coughs and sight problems.

6.3 Crop/Plant Protectant

Insecticidal, antifeedant and repellent characteristics have been observed in *Cleome gynandra* [119,120,105,106,114,72,107,9,12,14]. [94] in Kenya observed that intercropping spider plant with roses in greenhouses at 8.3 plants/m^{-2} reduced the populations of red spider mites (*Tetranychus urticae*) and diamond back moth (*Plutella xylostella*) as well as thrip attacks. [38] observed that intercropping spider plant reduced the population of thrips (*Thrips tabaci*) in onions. [28] reported that leaves of spider plant have repellent and acaricidal properties against the larvae, nymphs and adult *Rhipicephalus appendiculatus* and *Amblyomma variegatum* ticks. *Cleome gynandra* aqueous extracts exhibit insecticidal and insect repellent properties which can reduce aphid and thrip populations [110]. Isothiocyanates from spider plant and phenolic compounds and acid volatile oil posses' antimicrobial and insecticidal properties [83, 74].

7. Future Prospects

In response to COVID-19, some of the selected AIVs have great potential to be used in ameliorating its risks. In the review, it is postulated that black nightshade leaves are consumed to combat diabetes, high blood pressure, anaemia, peptic ulcers, colds, coughs and sight problems hence giving room for medicinal studies against this pandemic. *Cleome gynandra* contains a lot of phenols which can be used to cure cancer, asthma, diabetes and cardiovascular diseases. Several researchers indicated that spider plant is used to cure migraine, vomiting, diphtheria, vertigo, headache, pneumonia, septic ears, stomach ailments, as eyewash. This gives researchers the plummet to research on the ethno-medicinal properties of AIVs plant on symptoms of COVID-19.

8. Conclusions

AIVs are excellent sources of micronutrients such as vitamins A and C, and iron, protein, minerals and fibre as compared to their counterparts (exotic vegetables). Micronutrients forms an essential component of dietary requirements of an individual and have a positive impact on COVID-19 outcome as they play a significant role in the immune system. Realisation of UN's proposed Sustainable Development Goal 6 is going to be achieved through a holistic approach of involvement of various stakeholders involved in AIVs value chain. AIVs production has a potential to build capacity and enable rural communities to be resilient against the quirks of climate change impacts, hence ensuring food and nutritional security.

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Recommendations

There is need for persuasive research based information, suitable national legislation and information campaigns on cultivation and consumption of AIVs in Zimbabwe. Productivity of AIVs and small grains in Zimbabwe should be increased in order to ensure nutrition and food security as they are well adapted to changing climate. There is need for training and capacity building of seed and vegetable growers in Zimbabwe. Value chain of AIVs should be strengthened.

Conflicts of Interest

Authors do not declare any conflicts of interest

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REVIEW

From Novelty to Normalcy: Making Entomophagy a Common Diet

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ABSTRACT

This paper presents an analysis of the future of insect eating in two dimensions: the barriers of making insect eating popular and possible pathways to make entomophagy a common diet. Firstly, the brief introduction is stated to make a clear statement of normalizing insect eating, discuss the topic's relevance with current news regarding COVID-19 and provide a clear thesis statement. Then, the obstacles that prevent many people eating insects are evaluated through the framework of Failure of Diffusion Theory and "Yuck" factors. In the last part, possible solutions are offered accordingly, to help accomplish the goal of making insect food popular. Finally, some end notes and closing thoughts are included in the conclusion.

1. Introduction

The year of 2020 was experiencing a war between human beings and the nature globally, which typically can be demonstrated by the outbreak of COVID-19. People are aware of that corona virus pandemic has a close relation with the wild animals like bats, seafoods and Paguma larvata, which are the original materials of the food in many places around the world [1]. Under this special background, sustainable ways of eating are getting more and more attentions and concerns. People at this time are eager to learn about how to live with the earth in harmony by changing their eating habits and chooses. At the same time, over-population with increasing demands for food and serious world hunger are also hot topics within environmental study field.

Considering these contexts above, making eatable insects to become a common food source will be discussed in this paper. The arguments are provided as follows. Meat production has been questioned for its not pro-environment characteristic for a long time. As a green way of eating, entomophagy, which has a long and profound history in the human civilization, however, still remains unpopular, especially among Europe and North America areas. Meanwhile, eating occupies a big part of human activities and affects the environment to a large degree. To find an effective way of improving the relationship between people and the environment, insect eating is a good target. Therefore, it is worthwhile to investigate a deep research on the topic of insect eating.

In order to understand why a great deal of people are unwilling to accept the idea of eating insects and people only accept eating very few amounts of insects in their lives, it is significant to study the potential barriers of insect eating so as to figure out the most relevant factors that influence people's mindsets and behaviors on eating

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insects. Exploring and examining possible solutions are also very important to produce the most recommended methods in this issue to accomplish the goal of putting insects into people's daily menu. In this part of discussion, the theory of change will be applied mostly.

2. Discussion of Barriers of Insect Eating

2.1 Failure of Diffusion Theory Offers Five Perspective for Unwillingness of Insect Eating

According to the theory of failure of diffusion (Dol), advanced by Rogers (2003), relative advantage, compatibility, low complexity, trialability, and observability are the five key drivers to let innovations succeed in diffusing among the public. Eating insects is not a traditional way of eating for modern citizens in many places. Thus it can be seen as a type of innovation, if making it a common diet. The first discussion of barriers in insect eating presents the connections between the five elements of the theory of failure of diffusion and entomophagy, providing reasons for why entomophagy appears unpopular throughout the world.

To begin with, the low relative advantage of entomophagy is discussed. Firstly, the social status cost of inviting insects into people's table is relatively high. It is still possible to change this idea that insects are dirty and terrible, because the similar situation happens on the example of lobster. Based on the description of Shandrow [2], lobsters have been successfully entering the food market with its previous background of the food of prisoners. However, insect eating is treated as the symbol of poverty and low living quality. From the view of relative advantage, insects are less competitive than beef, mutton, chicken and other kinds of meat that are considered cleaner and nobler. Consequently, no wonder why insects are not as popular as these types of foods. Secondly, there are various pro-environment alterations other than consuming insects. People can reduce the amount of production and consumption of eating beef and other high environmental costing foods to achieve lower greenhouse gas emissions, higher feed conversion efficiency and lower land use, instead of changing their meals into insects [3]. Insect eating is not considered as a sole method to cut the carbon footprint, so, it fails to get the most attention. Less attention results in fewer people together with funds to study and advocate the choice of insect eating. Thirdly, the collecting process of insects can be harmful to the environment. According to the Schauff [4], the equipment and chemicals used during the preserving procedures can damage soils and grass in the long term. As can be seen, the advantage of environmentally friendly trait fails to become extremely attractive when thinking about the whole process of insect eating. Additionally, when taking the convenience into consideration, insect eating has low accessibility, because only certain shops have insect products, which are usually expensive [5]. The supply chain in reality is not supportive enough to let insects enter the common food market easily.

Then, the perspective of compatibility in popularizing insect menus is discussed in the following. Unsatisfactory past experiences affect people's impressions on insects. For example, when talking about insects, people tend to relate them to contaminants and inedibility, worrying the sanitary condition of this kind of food. Even worse, a great deal of people refuse to see insects as real food [6]. The fear in their minds stops their attempts to accept insects as a daily food option. Besides, bad sensory appeal of insects plays a vital role on people's determination of selecting foods. D'Costa [7] argues that the physical appearance of insects is not consistent with people's notion of normal foods. Namely, people hardly accept insects when they have a large difference from their expectations of eatable foods. Moreover, conservationists' disagreements give more resistances to the diffusion of insect eating. Some environmentalists say that many insects are facing endangered situations and expanding food choices on them will put new threats on original ecological circles and ecosystem balances (Shelomi, 2015). In a sense, not all the pro-environmental group favor the idea of insect eating. Furthermore, the current insect eating movement is incompatible with the public needs. Statistics indicate that the majority of western people don't need to worry about low-priced protein since most of them are not in the position requiring putting heavily thoughts on the prices of protein [8]. Specifically, the green insect market in the West is not big enough, and the market is only restricted to an educated and youthful subset of the potential consumer pool.

Next, the complexity of the issue of insect eating is discussed. A different recipe request is needed if insects are putted into the food market. Unlike other foods, the insect has its own characteristics: small size and crust adding the complexity of insect food cleaning and cooking process. These traits will lead to higher costs and difficulties in monitoring food safety. However, a good point is put forwarded by Mai [9] that the cooking practices of some insects are particularly like seafoods, so people have some similar experiences and skills to deal with insects.

In addition, the ineffective trialability of insect eating is worth mentioning. Nowadays, there are multiple ways to promote the idea of insect eating, such as exhibition and try-eating activities [10]. Yet the problem is that the conducts are far from enough to have actual impacts on

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people's behavior changing. The low degree of trialability prevents people from implementing insect eating in their normal eating habits.

Last but not least, observability of entomophagy is small. Even though a number of evidence suggest the benefits of eating insects, it is not easy to observe these advantages by normal people. Dunning [11] says that people often view the act of eating insects as a symbol of bravery attempt, rather than an environmentally friendly action. The novelty of insect eating overshadows its normalization. The insect foods should have fewer bizarre eats look, since the world now is lack of familiar environment to show accessibility of eatable insects, which is essential to help normalize the diet of insect eating. In the meantime, expanding insect supply lines is an important way to defeat the obstacle regarding the goal of diffusing insect eating.

2.2 Power of "Yuck" Factors on Preventing Eating Insects

Yuck emotion generates huge influences, and people usually underestimate its power. Yuck factors play an important role in people's decision on food choosing. The first reason for its strong impact is that the disgust feeling is embedded in human's origin and genes. "One only has to look again at our own look of disgust: it is a shadow of its origins, the gag reflex of animals, with lips pulled back and eyes squinting" [12]. This tells us that the yuck factor is a longstanding element on stopping people from tasting insects, which is inborn, not absolutely cultivated by society and culture. Under this circumstance, the difficulty of getting rid of some parts of drivers in people's genes are extremely high.

An experiment conducted by Pizarro and his research groups reveals the profound power of disgust with data and observing facts [13]. This finding manifests that the disgust emotion is a much more potent trigger for people's choices and behaviors than people's previous thoughts. Specifically, the study shows the great impacts of yuck factors are closely related to people's decisions that reduces their chances of choosing insects as foods. This tendency can prevent people from accepting eating insects for a long time.

3. Explorations of Effective Diffusion of Insect Eating

3.1 Introducing More Insects to Medicine Industry

One gradual way to let insects enter people's food market is to let them become a common medicine material first. This method is to give people time to get used to the existence of insects in their daily life [14]. People get sick from time to time, so medicine is necessary to be taken. Thus, making more insect pills will help people feel more comfortable when they come across eating insect meals. They have already had the environment to consume insects, and they will not feel it quite weird to put insects into their mouths. It is also worthwhile to mention that produced insect chemicals have a large room to explore in the field of antibacterial and anticancer drugs. The recent medicine industry does not give enough value on it, but people should further encourage the insect collection and commercialization in medicine world (Lehman, et al., 2006). Lehman and his groups suggest more research and studies on this field, which can be quite effective for letting more people accept the idea of eating insects.

3.2 Tapping the Potentials in Insect Business

Another great breakthrough point is tapping the potentials in insect business. Wong (2016) points out that there is still a big gap in insect economy to let companies to investigate. The promising future in insect business means that the opportunities for diffusing insect eating are enough and worthwhile to invest. Also, Shelomi (2015) implies that tackle the issue of inadequate supply of insect market is a more effective way to change insects' social value.

Apart from business workers, many economists are interested in the economic prospect of insect eating. On May 30, 2020, I interviewed my economics professor in person at the Pacific Coffee with a few questions about the possibilities of inviting insects into food market from the microeconomic angle of view. Bruce McFarling is a highly-experienced expert in the field of microeconomics and regional food economics. He spent the several years in Africa, where he got the access to eat many insect species and obtained the insect business experiences from there. Dr. McFarling was asked to give some advice on introducing insects into the world food market. He mentioned that "one thing should be noticed in insect business is that the companies and businessmen ought to set up a new, exclusive label name for eatable insects" (B. McFarling, personal communication, May 30, 2020). From his point of view, the first thing people will recognize the food is by its label. If the eatable insects be given a delicious-sounding name, people will be less likely to connect the dirty raw look of it with the insect product. Therefore, creating a brand-new name, exclusively for certain insect products is vital.

3.3 Application of Change Theory in Insect Eating

The theory of change offers a picture of important destinations and guides people on what to look for on

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the journey to ensure they are on the right pathway. The theory of change narrative is composed of three parts: ultimate outcomes, intermediate outcomes and activities. According to Krasny (2020), a professor in Cornell Civic Ecology Lab, the theory claims a more effective way to change people's environmental behavior. That is achieved by firstly setting up ultimate outcomes, and be supported by several intermediate outcomes and specific activities.

Some ecological professors are interested in the application of change theory in insect eating. My environmental science course professor, Maxim Titushin is one of them. On June 5, 2020, I had an online interview with him to ask a few questions about his suggestions on practicing the theory into insect eating educational courses. Maxim Titushin is a well-experienced expert in the field of environmental science and biology, and he is currently teaching International College Beijing of China Agricultural University. Dr. Titushin was asked to give some instructions on enlightening students' awareness of eating insects. "As an environmental science teacher, I would stress the smaller carbon footprint of the insect-based food. Many data and research prove that plant-based food is absolutely sufficient, more environmentally friendly and is the ultimate diet goal of the humanity. Being aware of the power of habit and it would be unwise to promote insect eating as an alternative to red meat only to struggle to eradicate this habit in the future" (M. Titushin, personal communication, June 5, 2020). As can be seen, the emphasis on the actual environmental effect of insect eating is the most important thing in an environmental science course.

Also, apart from the course designing suggestions, Dr. Titushin commons on useful ways to achieve the target of making entomophagy a common diet. A good way to promote entomophagy is to keep people ignorant about the source of their food. This strategy has proved efficient with meat consumption. Many people maintain an unreasonably high level of meat consumption with being unaware of arguably inhumane practices of meat manufacturing as well as their devastating environmental impacts. A problem with entomophagy, however, is that one can't put a smiling face on a food label — insect larvae prove to be rather non-photogenic, but a butterfly image may work and sell better as well. Ironically, education can also promote entomophagy along the same environmental line. Insect protein is much less expensive for the environment than red meat protein. When the yuck effect is avoided and a new tradition is established, insect protein may find its own way into protein additives, broth cubes, or athlete formulas. What he said can be summarized into three key phrases: appearance overlook, label effect and environmental education (M. Titushin, personal communication, June 5, 2020).

4. Conclusions

In the world today, there is an increasing interest in edible insects, but the reality of insect industry still remains unpopular. Insects as common food of human beings are proved to have a large potential. After evaluating the barriers of insect eating normalization, we know that there are a lot of efforts need to be done in the future to overcome these obstacles, because as mentioned above, most of them are embedded in cultures, genes and have instructional inadequacy. Among these factors, the consumer attitude is a major issue in the Western world. Lastly, research pathways to make insects a common diet has been explored accordingly: introducing more insects to medicine industry, digging out the potentials in insect business and practicing the theory of change in the matter of encouraging people to try eating insects.

In the end, some final thoughts are stated as follows. The current scholar field lacks published studies concerning factors that affect the oxidation of insect fat and protein during storage. The emphasis on insects' nutritional value can be the main factor that justifies the use of insects as a common human food. On the other hand, the key to insects being valued as a pleasurable component of a meal is its sensory appeals. Edible insects need to be processed and turned into palatable dishes. Therefore, the cooking insect methods are significant to be studied and promoted among the public, together with the innovation of insect label, which are essential elements to commercialize insects as a common human food. Many people are worried about the food safety, which may be affected by toxicity of insects, contamination with pathogens, spoilage during conservation and allergies. This concern should be dealt with as the first priority. More studies like production economics, sensory properties, optimum storage, and potential toxicity are needed to be done in the future.

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ARTICLE

Parasitoids of Agricultural Importance Collected at Atlantic Forest Biomes in Brazil: A Bibliographic Summary

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ABSTRACT

Its ecological processes evolved from the eocene, when the continents were already relatively willing as they are today. Currently, the Atlantic Forest has only 7% of its original área. Parasitoids are organisms that cause the death of their hosts to complete their development and act as parasites only in the larval stage, when they develop in only one host, with adults having a free life. The objective of the six studies was to verify the groups of parasitoids present in Atlantic Forest Biomes in Brazil with a bibliographic summary. The Hymenoptera Parasitica were collected in the Atlantic Forest biome from 2002 to 2021.

1. Introduction

1.1 Atlantic Forest

Its ecological processes evolved from the eocene, when the continents were already relatively willing as they are today (Figure 1). Currently, the Atlantic Forest has only 7% of its original area [2].

Considered one of the richest biomes on the planet, that is, with greater biodiversity, the Atlantic Forest is the second largest forest in extension in Brazil, consisting of plateaus and mountains [2].

Its area covers the east, southeast and south of Brazil and, in addition, a part of Paraguay and Argentina [2].

Among the Brazilian states, it is present in 17 of them: Alagoas, Bahia, Ceará, Goiás, Mato Grosso do Sul, Minas Gerais, Paraíba, Paraná, Pernambuco, Piauí, Sergipe, Rio Grande do Norte, Rio Grande do Sul, São Paulo, Espírito Santo, Rio de Janeiro and Santa Catarina.

The climate of the Atlantic Forest is predominantly humid tropical, influenced by the humid air masses coming from the Atlantic Ocean [2].

1.2 Characteristics of Parasitoids

In agrosystems, such as coffee, cotton, soy, sorghum, beans and wheat, dozens of families of parasitoids are found responsible for the cultivation of pests and have a high diversity of hosts, such as aphids, flies, caterpillars and mealybugs. Most parasitoids belong to the group of insects, mainly to the orders Diptera (flies) and Hymenoptera (wasps).

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Figure 1. Overview of Mata Atlantica, Brazil.

Source: pensamentoverde.com.br

Figure 2. Parasitoides (Hymenoptera). Source. researchgate.net

Parasitoids are organisms that cause the death of their hosts to complete their development and act as parasites only in the larval stage, when they develop in only one host, with adults having a free life (Figure 2).

The objective of the six studies was to verify the groups of parasitoids present in Atlantic Forest Biomes in Brazil.

1.3 Characteristics of the Families of the Main Groups of Parasitoids Present in the Studies

Braconidae are small and active insects that, like other parasitoids, have larval stages that develop on or inside other arthropods, usually insects. They have a variable degree of host specificity and most of their species attack phytophagous insects, mainly Lepidoptera, Diptera or Coleoptera. Some species attack eggs, pupae and even adults from their hosts.

Ceraphronidae is a small family of hymenopteran insects, with 14 genera and about 360 known species. Many species still remain to be described. It is a little known group as a whole, although it is thought that they are mostly parasites, especially flies.

Diapriidae is cosmopolitan, with three subfamilies, 194 genera and 2080 described species. Diapriinae, Belytinae and Ambositrinae occur in the Neotropics. Belytinae and

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Ambositrinae parasitize immature Mycetophilidae and Sciaridae (Diptera) and Diapriinae parasitize mainly Diptera, with some species associated with ants.

Encyrtidae is a large family of parasitic wasps, with about 3710 species described in about 455 genera. Most larvae are primary parasitoids in Hemiptera, although other hosts are attacked.

Eulophidae is one of the most numerous families of Chalcidoidea, comprising almost 5,600 species in about 326 genera and five subfamilies. A large number of species of Eulophidae parasitize insect larvae that develop in plant tissues, such as miners, broachers and gallers.

Ichneumonidae is a family of hymenopteran insects. These are important parasitoids of other insects. Common hosts are larvae and pupae of Coleoptera, Hymenoptera and Lepidoptera.

Figitidae is the family with the greatest diversity of species within the Cynipoidea according to the current classification this family includes twelve subfamilies, the Eucoilinae being one of the most diverse with about 85 genera and approximately 1,000 species. In general, the representatives of this subfamily are cenopionite endoparasitoids of Muscomorpha (Diptera) larvae.

Platygastridae are parasitoids of Cecidomyiidae some are idiobiont parasiotoids of Coleoptera Homoptera, Coccoidea and Aleyrodidae.

Scelionidae, attacking the eggs of many different types of insects, spiders, butterflies and many are important in biological control. Several genera are wingless, and a few attack aquatic insect eggs underwater.

Pteromalidae presents pupal parasitoids associated with flies from the families Muscidae, Calliphoridae, Sarcophagidae, Drosophilidae, Chloropidae and others.

2. Methodology

The Hymenoptera Parasitica were collected in the Atlantic Forest biome from 2002 to 2021. The survey was carried out Atlantic Forest Biome in Brazil using the Online Scientific Electronic Library (Scielo).

3. Studies Carried out

Study 1.

In the study by Silva et al (2016) in two areas of the Atlantic Forest, the parasitoids were obtained using Malaise traps and Moericke traps as shown in Figure 3. The results obtained are shown in Table 1. In the two areas studied, family Platygastridae was the most frequent.

Figure 3. Malaise trap.

Four hundred and thirty individual parasitoid were collected (BPWR) and 203 individuals were collected. Malaise trap captured a mean of 13.8 ± 3.46 individuals, significantly more than the Moericke traps (5.5 ± 1.15) ($H = 4.84$; d.f.= 1; $P < 0.05$) [5].

Table 1. Percentage of families of parasitoids in the Pachecos Banhado Wild Life.

Taxonomic Group	OR – Percentage	BPWR- Percentage
Braconidae	11.0	18.0
Encyrtidae	0	15.0
Ichneumonidae	21.0	0
Platygastridae	30.0	26.0

Study 2.

In the research by Azevedo et al. (2002) the sampling of the hymenopteran parasitoids were performed using Malaise traps and Moericke traps (Figure 4). They collected four thousand five hundred and ninety-five specimens, belonging to twenty-eight families. As shown in Table 2, the family Braconidae was the most abundant [1].

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Figure 4. Moericke trap

Table 2. Percentage and number of parasitoid hymenopterans in an Atlantic Forest área.

Taxonomic Group	Percentage	Number of specimens
Braconidae	22.5	1034
Eulophidae	14.32	658
Scelionidae	13.12	606
Total	-	2.298

The relative abundance of the parasitoid hymenopteran families found in was as follows: 34.99% for Chalcidoidea (16 families/1608 individuals); 23.48% for Ichneumonoidea (2/1079); 20.41% for Platygasteroidea (2/938); 10.05% for Cynipoidea (1/462); 5.74% for Proctotrupoidea (1/264); 2.57% for Chrysidoidea (3/118); 2.33% for Ceraphronoidea (1/107); 0.37% for Evanioidea (1/17) and 0.04%. The families Braconidae, Eulophidae, Scelionidae, Pteromalidae and Figitidae had the highest relative abundance, with 1.034 individuals (22.50% of the total), 658 (14.32%), 603 (13.12%), 536 (11.64 %) and 462 (10.05%), respectively.

Study 3.

The collection of parasitoid hymenopterans was performed using Moericke traps. Seven thousand two hundred and eight specimens were collected. The most abundant familie was Platygastridae (Table 3) [3]. They are generally idiobionts, attacking the eggs of either beetles or Hemiptera.

The families that showed the highest relative abundance were Platygastridae 1.193 of the total collected parasitoid hymenopterans, Scelionidae 1.062, Braconidae 954, Eulophidae 878, Ceraphronidae 79, Diapriidae 714, Figitidae 604 and Encyrtidae 418.

Table 3. Percentage of families of parasitoid hymenopteran collected.

Taxonomic Group	Percentage
Braconidae	13.2
Ceraphronidae	11.1
Diapriidae	9.9
Encyrtidae	5.8
Eulophidae	12.2
Figitidae	8.4
Platysgaridae	16.6
Scelionidae	14.7

Study 4.

In the present study, one thousand and three hundred individuals. Diapriidae was the most frequent [6].

The relative abundance of the parasitoid hymenopteran families found in was as follows: 34.99% for Chalcidoidea (16 families/1608 individuals); 23.48% for Ichneumonoidea (2/1079); 20.41% for Platygasteroidea (2/938); 10.05% for Cynipoidea (1/462); 5.74% for Proctotrupoidea (1/264); 2.57% for Chrysidoidea (3/118); 2.33% for Ceraphronoidea (1/107); 0.37% for Evanioidea (1/17) and 0.04% for Vespoidea (1/2). The families Braconidae, Eulophidae, Scelionidae, Pteromalidae and Eucoilidae had the highest relative abundance, with 1.034 individuals (22.50% of the total), 658 (14.32%), 603 (13.12%), 536 (11.64 %) and 462 (10.05%), respectively [5].

Table 4. Percentage of families of parasitoids collected.

Taxonomic Group	Percentage
Braconidae	15.00
Diapriidae	45.92
Ichneumonidae	12.92
Platysgaridae	6.15
Perilampidae	0.62
Pelecinidae	0.15

Study 5.

The adults were obtained using traps known as McPhail traps. Fruits were placed in trays containing sand to pupa-

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te the larvae. They were collected in closed containers for the emergence of adults and / or parasitoids.

Figure 5. McPhail Trap

Source: For Agriculture, Rs 150 /piece Harmony Ecotech Private Limited | ID: 22473045891 indiamart.com

The *Anastrepha fraterculus* (Wiedemann) (Diptera: Tephritidae), species were the most parasitized with six parasitoid species and also with a larger number of individuals 83.08%. In relation to the parasitoids *Doryctobracon areolatus* (Szépligeti) (Hymenoptera: Braconidae) it was the species that presented greater abundance with 115 individuals and the highest percentage of parasitism with 68.05%.

Doryctobracon areolatus stands out for its aggressiveness in parasitism of fruit fly larvae.

The percentage of parasitism on fruit fly larvae / pupae was calculated [% Parasitism = (Nº. of emerged Parasitoids / Nº. of pupils obtained) x 100].

The percentage of parasitism in fruit flies of the parasitoids *D. areolatus*, *D. brasiliensis* (Szépligeti), *Opius bellus* Gahan, *Utetes anastrephae* (Viereck) (Braconidae) and *Aganaspis pelleranoi* (Brèthes) (Figitidae) Pteromalidae sp1. presented 3 7.94%, 0.23%, 0.45, 2.76%, 1.45 and 30.31%, respectively.

D. areolatus, *D. brasiliensis, O bellus, U. anastrephae, A pelleranoi* and Pteromalidae sp1. presented a percentage of 68.05,% 1.76%, 3.55%. 21.89% and 4.14%, respectively.

Eugenia uniflora Juss (Mirtaceae) the specie presented the following pupae of *Anastrepha* (n) 1309, VP1 (%) 18.02 and infestation index (p / kg) 683.6. The percentage of parasitism was 11.38%. It obtained a greater abundance with the following parasitoids: *D. areolatus, D. braziliensis, O. bellus* and *U. anastrephae*. The percentage of parasitism was 11.38 [4].

Braconidae (Opiinae) are the main natural control agents of *Anastrepha,* as they oviposit third-instar host larvae to emerge from the host's pupae.

4. Conclusions

Parasitoids are important natural regulators of insects and are prominent groups of natural enemies in the agricultural system. They are also considered as bioindicators of biodiversity.

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REVIEW

Development of Micro Food Processing Sector through Food Processing Entrepreneurship in Manipur

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ABSTRACT

Micro Food processing industry is gaining its momentum in the recent years in Northeast India and particularly in Manipur. This sector plays an important role in connecting the bridge between the agricultural production and the entrepreneurship development. The region bestows by the abundance of unique and rich agro and horticultural produce gives thrust to develop the food processing sector in the region. Government schemes and projects also add to the development of this sector and to the food entrepreneur by providing financial, technical, infrastructural and business support. The state sharing its border with the Myanmar has a significant impact on the food processing industry particularly in terms of marketing and trading aspects. Food Entrepreneurs should enhance their work on diversifying the horizons of the value added products, increasing job opportunities, marketing, training and technical skills etc. which will ultimately help in developing the Micro food processing sector in the state.

1. Introduction

Manipur is a small state located in the northeastern part of India between 23.800 N to 25.680N latitude and 930.03 E to 94.780 E longitudes. The state is set in an oval valley among smoky tree-clad hills and is gifted by temperate salubrious climate. Blessed with diversified natural resources and a suitable agro-climatic conditions for growth of horticultural crops, Manipur is home to some of the major and notable high value of horticultural crops suitable for processing to enhance the shelf life, processing into value added products or potential for exporting it to other states and countries. The state produces some of the best varieties of pineapple, orange, lemon, passion fruit, king chilli, bamboo shoot, mushroom, ginger, turmeric etc., which is well known for their unique quality in India and abroad. These agro and horticultural produce can be processed and converted into a number of value added products such as Jam, jelly, squash, nectar, marmalade, candy, pickles, fruit leather and bar, instant soup mix, osmo-dehydrated products etc. So, the state has always been seen as a potential area that can give ample ground for the growth of food processing sector and adds more scope for healthy growth of food processing entrepreneurship in the region. There are adequate productions of high value horticultural crops in the region which are still to be exploited for processing and value addition and thus entrepreneurship development. The state horticultural production of major fruits, vegetables and spices during 2019-20 is 527.97

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thousand MT, 391.35 MT thousand and 27.34 thousand MT respectively[1]. This fact clearly underlines the fact that food processing sector has huge scope to grow in different areas of processing activities in the state.

2. Manipur as a Hub for Food Processing Sector

Manipur has a long history of offering fruits and vegetables to the deities in the worship and also in the festive seasons in their rituals and prayers ceremonies. Being known for their nutritional and health benefits, fruits are often given by the people whenever they visit the elderly in their homes or the patients in the hospitals. Thus, the importance of fruits and vegetables culturally, traditionally and in the health aspects directly or indirectly has been there in the state of Manipur from the recent time. Manipur has the potential to serve as India's 'Gateway to the East' via Moreh town, which is the only viable land route for trade between India and Myanmar and other Southeast Asian countries due to its geographical position. This is why food processing sector will play an important role in developing the fruits and vegetables processing industries in Manipur, in raising the economy of the state, also, it will give an opportunity to the young food processing entrepreneurs of the state to diversify their knowledge, skills and business in food processing sector. It will also help boost in the development of the new and micro-food processing industries, the Self-help groups (SHGs), Farmer Producers Organization (FPOs) etc., which in turn will generate employment for the youths and women folks in the food processing sector.

3. Food Processing Sector and Agriculture

In Manipur, micro food processing units are a growing industry that has gained traction in recent years. This industry is an important connection between the agricultural and industrial sectors of the economy. Availability of a variety of fruits and vegetables, changing lifestyle, knowledge and technologies has given a considerable push to the micro-industry growth. The food processing sector not only process the produce from the agricultural sector but also develops new methodology and practices for preserving the food, adds the necessary nutrition for the consumer health aspects, and also optimize the process parameters for the development of the new and innovative product. Strengthening this connection is important for reducing waste of agricultural raw materials, increasing the value of agricultural production by increasing the shelf life and fortifying the nutritive composition of food products, and ensuring farmers are paid fairly and consumers are able to afford food. Manipur has steadily started producing and exporting of several Agro and Horticultural crops like Pineapple from Thoubal, Churachandpur, and Imphal East districts; Ginger from Chandel district; Turmeric from Kangpokpi district; Aromatic Black rice from Kakching district; Orange from Tamenglong district; Kachai Lemon from Ukhrul district; Kiwi from Senapati district; Bamboo shoots from Tengnoupal district; King Chilli from Kamjong district; Banana from Noney district, Coconut from Jiribam district etc., to name a few. So, these Agro and Horticultural crops from the Agricultural Sector can be processed, preserved and converted into a number of value added food products, extending the shelf life of the developed products and also selling the product during the off season which will increase the value of the product and ultimately generate higher income.

4. Major Constraints for Fruits and Vegetables Processing in Manipur

The state of fruit and vegetable processing in Manipur is more or less depressing, and little attention has been paid to it. The opportunity-gap can be filled to a large extent with research and extension activities in the area, with only a minor impact. Despite the high profit margins and excellent market potential of fruit and vegetable-based goods, the rural population is uninterested in this field. The policy's goal should be for growers to make more money, for the fruits and vegetable processing sector to expand in the region, and for more people to be interested in this sector. The policy's goal should be for growers to make more money, for the fruits and vegetable processing sector to expand in the region, and for more people to be interested in this sector.

For such a bleak scenario, a number of constraints have been established. The following are the major causes of slow fruit and vegetable processing in Manipur: i) A scarcity of suitable land for the cultivation of fruits and vegetables ii) A lack of understanding of the fruits and vegetable industry's enormous potential for job creation and economic development in the area. iii) A lack of understanding of the nutritional value of fruits and vegetables. iv)A lack of processing arrangements, which becomes a disincentive for output if it happens during a glut scenario. v) Fruit and vegetable products have a lower quality due to a lack of quality standards and HACCP practises. The reach of fruits and vegetable processing is limited due to a lack of knowledge / training about quality standards among consumers and sweet makers. vii) In hilly and forested areas, there is a lack of connectivity from city to city.

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5. Government in Boosting the Food Processing Sector in the State

To ensure that this sector gets the stimulus it deserves, Ministry of Food Processing Industries (MoFPI), Government of India is implementing a number of programmes for Infrastructural development, technology up-gradation and modernization, human resource development and R & D in Food Processing Sector. Among them is the recently launched all India Centrally sponsored scheme i.e.,"PM Formalisation of Micro Food Processing Enterprises Scheme" under Aatmanirbhar Bharat Abhiyan by MoFPI, in partnership with the State/UTs Governments for providing financial, technical and business support for upgradation of existing micro food processing enterprises. The objectives under this scheme include:

i) Entrepreneurial capacity building through technological expertise, skill acquisition, and hand-holding support services.

ii) Existing micro food processing entrepreneurs would have easier access to credit for technology upgrades.

iii) Farmer Producer Organizations (FPO), Self Help Groups (SHGs), Producers Cooperative and Cooperative Societies receive support across their value chain to allow microenterprises to access common services.

iv)Support for transition of existing enterprises into formal framework for registration under regulatory framework and compliance.

v) Integration with organized supply chain by strengthening branding and marketing.

The state government of Manipur also introduces various schemes to ensure that the micro food industry unit in the region gets the maximum support for the growth, diversifying and development of the units. The government has also taken a number of steps, such as offering various tax breaks, infrastructure improvements, and financial assistance, among other things. To encourage entrepreneurship, the government runs a variety of Entrepreneurship Development Programmes (EDPs), technical programmes and other related programmes as well. Some of the supports are:

i)Government has allowed technology transfer in this sector.

ii)Financial and Institutional support for new and emerging fruit and vegetable industries

iii)Custom duty reduction on reefer trucks, food packaging machinery, food processing machinery, and other components of food related machinery.

iv)Dairy machinery is fully excluded from Central Excise Duty.

v)Grants for the construction of common areas in the Agro Food Park.

The state government has also recently introduced the 'STARTUP MANIPUR' Schemes for the young and dynamic entrepreneurs of the state including the food entrepreneurs. This scheme gives financial assistance to the entrepreneurs to start their business of their own, flourish and to be self-reliant.

6. Role of Food Entrepreneurship in Food Processing Sector

Entrepreneurship plays a critical role in the state and country's overall economic growth. Many economists believe the economic growth is only possible when there is an entrepreneurial phase. They believe that many countries are still underdeveloped as a result of a lack of entrepreneurship. Entrepreneurship boosts the availability of consumer goods, encourages capital formation, promotes the growth of local business and skills, and creates job opportunities. Small and micro-industry is a source of new jobs, and it is especially important in areas where labour is plentiful but capital is scarce. This form of feature is most commonly seen in urban areas. As a result, small and micro- food industrial development can help to increase the employment in urban as well as in the rural areas.

7. Drivers of Food Processing Entrepreneurship

In the coming years, the food processing sector has the potential to be a major driver of India's growth as well as entrepreneurship. Without an increase in the number of entrepreneurs and entrepreneurship, an economy will inevitably slow down. Entrepreneurship is critical to the development of rural areas as well as the overall economy of the country. Entrepreneurship is the source, not the result, of economic development. India has access to a variety of natural resources, giving the food processing industry a competitive edge. The five main drivers found for food processing entrepreneurship can be divided into five categories:

a.Favourable Conditions and Competitive Edge in Food Processing

Manipur has a diverse range of raw materials as a result of its favourable climatic conditions, which encourages entrepreneurship in the food processing sector and offers a wide range of opportunities.

b.Increasing Consumers Spend on Ready-to-eat Item and Processed Food

Consumers' per capita income is rising every day, and they are spending more on food products. Consumers are demanding higher quality food items and spending heav-

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ily on them as their knowledge and consciousness about health grows. The factors that drive entrepreneurship in this region are mentioned below. i.) An increase in disposable income per household leads to an increase in per capita food consumption expenditure. ii.) Increased intake of processed foods, both primary and secondary. iii.) Agro-products, fruits, and vegetables account for about half of the total consumption basket.

c.Increasing Food Retailing in Manipur

The retail food market is rising at a robust pace of 30-35 percent per year, fuelled by huge opportunity and evolving lifestyles. Various outlets and retail formats are expanding, drawing entrepreneurs looking to sell their wares in the market. The following are some of the factors that are propelling entrepreneurship and providing enough opportunities: i.) The number of outlets is growing. ii.) Food retailing is becoming more common in Manipur. iii.) Well-known brands are looking to extend their geographic reach and capitalize on backward linkages. Brands like Vishal Mega mart, Domino's Pizza, Subway, KFC, Vadilal etc. iv.) Growing retail business of food.

8. Challenges for Food Processing Sector in Manipur

Food processing sector in spite of being projected as having ample opportunities in the state is actually facing numerous constraints. Lack of surplus production, scattered distribution of produces in large marginal holdings, lack of advanced processing machinery and technologies, unavailability of skilled manpower, inadequate R&D activities, lack of training facilities, inefficient supply chain connected with weak strong backward and forward linkages, unorganized production system, weal marketing support, inadequate support infrastructures like pre-processing facilities, warehouses, cold storage, advanced food testing facilities, transportation bottlenecks and inefficient implementation of government projects in a time bound manner are the real challenges. Generation of surplus produce to run processing units in a suitable manner, integrating the scattered produces and producers in the efficient supply cum value chain, creating basic pre-processing infrastructure, ensuring advanced R&D support, creating skilled manpower base, marketing and quality control support and effective implementation of government schemes are the key factors for the success of Food Processing sector in the state [2].

9. Conclusions

Manipur Micro food processing sector is a fast growing industry and provides an ample and promising opportunity for the young and women food entrepreneurs in the state. Regardless of the abundance of the unique and quality raw materials, the geographical location of the state, and the favourable climatic conditions, the food entrepreneurs are facing a lot of challenges in the food processing entrepreneurship which are hindering the economic and viable processing units. Lack of government funding, raw material quality and quantity, seasonality, insufficient infrastructure, access to cutting-edge technology, limited access to credit, a lack of export support, a lack of qualified manpower, insufficient training methods, and wastage are all serious challenges for food processing entrepreneurship that are affecting the growth of food processing sector in the state.

To overcome these obstacles, the government must properly address and take measures to promote the growth of food processing entrepreneurs, such as through training programmes, favourable legislation, favourable initiatives/schemes, financial assistance, and infrastructural improvements, among other things.

Food Processing Entrepreneurship must concentrate on improving the shelf life of agro and horticultural produce, developing new and innovative products, adding value to the product, reducing waste, rising worker wages, and expanding job opportunities for the general public, all of which contribute to the growth of the food processing sector and the state's economy [3].

Figure 1. Women folks participating in the different Food Micro-enterprises and SHGs in Manipur

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ARTICLE

Parasitoids Collected from Animal Feces in Brazil

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ABSTRACT

The purpose of the paper is to report the species of dipteran parasitoids in poultry feces on farms, buffalo, and cattle in the field in Brazil. The experiments were carried out from April 2006 to December 2007. The pupae were obtained by the flotation method. They were individually placed in gelatin capsules until the emergency of the adult flies or their parasitoids. The specie more frequent was *Spalangia endius* Walker (Hymenoptera: Pteromalidae) with 7.2%. Were obtained from bovine feces 628 pupae of dipterous in buffalo feces, 3,437 pupae were collected and from chicken feces 2,799 pupae, from which 78, 172 and 504 parasitoids emerged, respectively. The most frequent species in bovine, of buffalo and chicken feces were: *Gnathopleura quadridentata* Wharton (Hymenoptera: Braconidae) with 25.6%, *Spalangia drosophilae* Ashmead (Hymenoptera: Pteromalidae) with 21.5% and *Pachycrepoideus vindemmiae* (Rondani, 1875) with 46.8%, respectively.

1. Introduction

Dipterans (flies) (Insecta: Diptera) are vectors of pathogens such as viruses, bacteria, protozoan cysts and parasitic worms. Can cause disease in animals and nuisance to humans both in the urban and rural environment [1].

Parasitoids (Hymenoptera) are insects that have adapted to the parasitic way of life using nutritional resources limited by the immature or acquiring nutrients during adult [6].

Therefore, the biological control of dipteran with the use of parasitoid meets the search for alternatives to the problem, as it is a safe method, easy to handle and low cost [3].

The purpose of the paper is to report the species of dipteran parasitoids in poultry feces on farms, buffalo, and cattle in the field in Brazil.

2. Material and Methods

The experiment was carried out in a poultry farm in Morrinhos, Goiás, Midwest, Brazil (18º25'S and 49º13'W). The collected feces originated birds raised in the cage system. Fresh feces, collected immediately after emission, were placed in five 30 cm diameter by 12 cm high bowls, which were left in the dry environment for 15 days: for pupae extraction by the flotation method. The pupae, which were individually placed in gelatin capsules to obtain dipterous and /or the parasitoids.

The experiment was carried out on a farm in the south of Goias (18º25'S and 49º12'W), Brazil. Every fortnight, 10 plates of fecal cake (of approximately 3 kg each) were produced from fresh bovine feces that were collected immediately after defecation in pastures of *Brachiaria brizantha* (Hochst ex. A. Rich) and in corrals. The material was collected in plastic buckets and was homogenized. It was then placed in 10 round plastic supbyts of 20 cm in diameter, with a hole to allow rainwater to drain away. This methodology was used for precise determination of

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the time between the emission of the fecal cake and its collection. The feces remained exposed (five in the pastures and five in the corrals) for 15 days. After this period, the feces were taken to the laboratory for extraction of pupae by means of the flotation method. The pupae were removed with the aid of a sieve; they were counted and individually stored in gelatin capsules (number 00) until the flies and/or parasitoids emerged. The parasitoids and flies that emerged were identified with the aid of a stereoscopic microscope and were conserved in 70% alcohol [5]. The experiments were carried out from April 2006 to December 2007.

The percentage parasitism of each parasitoid species was calculated by means of the number of pupae parasitized by each parasitoid species divided by the total number of pupae of that host and multiplied by 100. The parasitoids' preference for their hosts was tested by means of the chi-square test, with 5.0% probability.

3. Results and Discussion

Were obtained from bovine feces 628 pupae of dipterous in buffalo feces, 3,437 pupae were collected and from chicken feces 2,799 pupae, from which 78, 172 and 504 parasitoids emerged, respectively (Tables 1, 2 and 3).

Table 1. Parasitoids and their dipterans collected in the feces chicken in Brazil.

Diptera	Nº. of pupae	Parasitoids	Pupae parasitized	%
Calliphoridae:				
Chrysomya megacephala	500	*Nasonia vitripennis*	3	0.6
		Pachycrepoideus vindemmiae	3	0.6
		Spalangia endius	3	0.6
Fanniidae:				
Fannia pusio	42	*Muscidifurax raptorellus*	2	4.8
		Pachycrepoideus vindemmiae	2	4.8
Muscidae:				
Musca domestica	2083	*Muscidifurax raptorellus*	3	0.6
		Nasonia vitripennis	5	1.0
		Pachycrepoideus vindemmiae	347	16.7
		Spalangia endius	67	3.2
		Spalangia nigra	16	0.8
		Spalangia nigroaenea	2	0.1
		Spalangia sp.	15	0.7
		Tachinaephagus zealandicus	10	0.5
Sepsidae:				
Palaeosepsis sp.	81	*Nasonia vitripennis*	2	2.5
		Pachycrepoideus vindemmiae	8	10.0
		Spalangia drosophilae	2	2.5
		Spalangia sp.	10	12.3
Syrphidae:				
Ornidia obesa	93	*Pachycrepoideus vindemmiae*	2	2.2
		Spalangia cameroni	2	2.2
Total	2799	-	504	-

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Table 2. Percentage of parasitoid collected from cattle feces in Brazil

Diptera species (number of pupae collected)	*Parasitoids	Individuals number	%
Archisepsis scabra (40)	*Spalangia drosophilae*	04	10.0
Brontaea debilis (56)	*Spalangia cameroni*	01	1.79
	Spalangia nigroaenea	02	3.57
Brontaea quadristigma (49)	*Kleidotoma nigra*	02	4.08
	Spalangia cameroni	01	2.04
	Spalangia drosophilae	01	2.04
	Spalangia. endius	01	2.04
	Spalangia nigroaenea	05	10.2
Cyrtoneurina pararescita (151)	*Spalangia nigra*	03	1.99
	Spalangia nigroaenea	05	3.31
Chrysomya megacephala (51)	Absent	_____	_____
Musca domestica (10)	*Spalangia cameroni*	01	10.0
Oxysarcodexia thornax (70)	*Gnathopleura quadridentata*	20	28.6
Palaeosepsis spp. (107)	*Paraganaspis egeria*	02	1.87
	Spalangia drosophilae	02	1.87
	Spalangia endius	01	0.93
	Triplasta atrocoxalis	02	1.87
	Triplasta coxalis	08	7.48
	Trichopria sp.	01	0.93
Ravinia belforti (63)	Absent	_____	_____
	Pachycrepoideus vindemmiae	05	7.94
	Spalangia cameroni	01	1.59
	Spalangia nigra	04	6.35
Sarcophagula occidua (31)	*Spalangia nigroaenea*	06	9.52
Total pupae: 628		78	124

Table 3. Percentage of parasitoid microhimenoptera collected in feces of buffaloes in Brazil

Diptera species (number of pupae collected)	*Parasitoids	Individuals number	%
Archisepsis scabra (310)	*Paraganaspis egeria*	04	1.29
	Spalangia drosophilae	01	0.32
	Trichopria sp.	01	0.32
Brontaea quadristigma (138)	*Paraganaspis egeria*	01	0.72
	Spalangia drosophilae	02	1.45
Brontaea debilis (127)	*Spalangia cameroni*	02	1.57
	Spalangia nigroaenea	01	0.79
Cyrtoneurina pararescita (19)	*Spalangia nigra*	01	5.26
	Spalangia nigroaenea	01	5.26
Palaeosepsis spp. (1948)	*Kleidotoma nigra*	06	0.31
	Paraganaspis egeria	12	0.62
	Spalangia cameroni	04	0.21
	Spalangia drosophilae	01	0.05
	Spalangia nigra	16	0.82
	Trichopria sp.	09	0.46
	Triplasta atrocoxalis	19	0.98
	Triplasta coxalis	08	0.41
Sarcophagula occidua (931)	*Paraganaspis egeria*	11	1.18
	Spalangia cameroni	08	0.86
	Spalangia drosophilae	33	3.54
	Spalangia endius	04	0.43
	Spalangia nigroaenea	11	1.18
	Trichopria sp.	16	1.72
Total de pupas: 3473		172	5.0

The most frequent species in bovine, of buffalo and chicken feces were: *Gnathopleura quadridentata* Wharton (Hymenoptera: Braconidae) with 25.6%, *Spalangia drosophilae* Ashmead (Hymenoptera: Pteromalidae) (Figure 1) with 21.5% and *Pachycrepoideus vindemmiae* (Rondani,) (Figure 2) with 46.8%, respectively (Table 1, 2 and 3). Probably, this difference in the number of parasitoids collected in the three substrates is due to its search capabilities and its greatest competitive potential in the larval stage.

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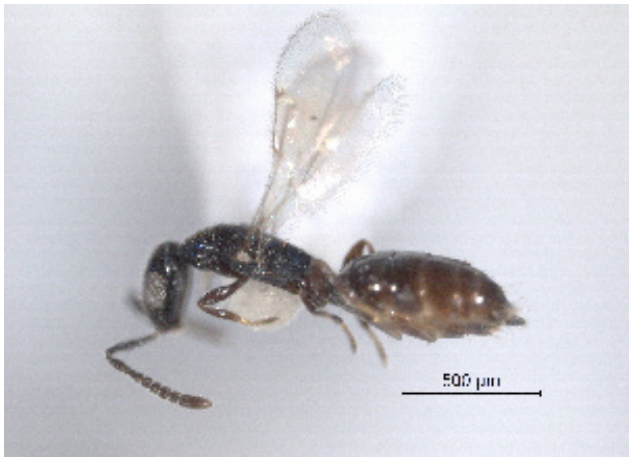

Figure 1. *Spalangia drosoplilae* (Hynenoptera: Pteromalidae)
Source: 3.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=484379

Figure 2. *Pachycrepoideus vindemmiae* (Rondani) (Hymenoptera: Pteromalidae)
Source: aspweb.org/Chalcidoidea/Pteromalidae/Pteromalinae/Pachycrepoideus/Pachycrepoideus_vindemmiae.htm

Gnathopleura quadridentata it is solitary endoparasitoids of numerous muscoids, preferably of sarcophagids. In some parts of the world they have been used for biological control program [8]. *Spalangia drosophilae* Ashmead (Hymenoptera: Pteromalidae) is a pupal parasitoid of small dipterans such as fannids, muscids and others [5]. *Pachycrepoideus vindemmiae* it is an endoparasitoid of dipterans, being found in several parts of the world as in the American and African continents [4].

The total percentage of parasitism in bovine, of buffalo and chicken feces were 12.4% (78/628), 45.0% (172/3473) (504/2799) and 18.0%. (504/2799), respectively. The highest percentage of parasitism in bovine feces was presented by the parasitoid G. *quadridentata,* with 28.6% (20/70) in the buffalo feces they were presented by the parasitoids *Spalangia nigra* Latreille (Hymenoptera: Pteromalidae) (Figure 3) with 5.26% (1/19) and *Spalangia nigroaenea* Curtis also with 5.26% (1/19) and in chicken feces it was *P. vindemmiae* with 46.8% (347/2083) (Tables 1, 2 and 3).

Figure 3. *Spalangia nigra* Latreille (Hymenoptera: Pteromalidae)
Source: flickr.com

Possibly due to the ability to search the parasitoid by food, their seasonality and the greater presence of their hosts in the collection area may explain the higher percentage of parasitism of these species.

Spalangia. nigroaenea is a pupal parasitoid being collected in some Brazilian states (Figure 4) parasitizing *Musca domestica* L. (Diptera: Muscidae) in bovine feces. *Spalangia nigra* (Letraille) is a species originating from the Holtartic region with wide distribution in North America [7,2].

Figure 4. Map of Brazil: and their regions - Midwestern Region green color.
Source: https://www.preparaenem.com/geografia/mapa-do-brasil.htm

Regarding the attraction of parasitoids to dipterans,

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it was found that *M. raptorellus* was attracted to *Fannia pusio* (Diptera: Fanniidae); *N. vitripennis* by *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae); *P. vindemmiae* by *F. pusio*, *M. domestica* and *Ornidia obesa* Fabricius (Diptera: Syrphidae); *S. cameroni* by *O. obesa; S. drosophilae* by *Palaeosepsis* sp. (Diptera: Sepsidae); *S. endius* by *C. megacephala* and *M. domestica*; *S. nigra* by *M. domestica*; *S. nigroaenae* by *M. domestica*; *Spalangia* sp. by *M. domestica*; *T. zealandicus* by *M. domestica* (X^2=711,80; GL=36; P<0,05).

Regarding the preference of parasitoids for their hosts in bovine feces, it was found that *G. quadridentata* showed preference for *Oxysarcodexia thornax* (Walker) (Diptera: Sarcophagidae); *Kleidotoma nigra* (Hartig) (Hymenoptera: Figitidae) showed preference for *Brontaea quadristigma* (Thomson) (Diptera: Muscidae); *Pachycrepoideus vimdemmiae* (Rondani) (Hymenoptera: Pteromalidae) showed preference for *Ravinia belforti* (Prado & Fonseca) (Diptera: Sarcophagidae); *Paraganaspis egeria* Díaz *et al.* (Hymenoptera: Figitidae) showed preference for *Palaeosepsis* spp. (Diptera; Sepsidae); *Spalangia cameroni* Perkins (Hymenoptera: Pteromalidae) showed preference for *Brontaea debilis* (Williston) (Diptera: Muscidae), *B. quadristigma*, *M. domestica* and *R. belforti*; *S. drosophilae* showed preference for *Archisepsis scabra* (Loew) (Diptera: Sepsidae) and *B. quadristigma* and *Palaeosepsis* spp.; *Spalangia endius* Walker (Hymenoptera: Pteromalidae) showed preference for *B. quadristigma* and *Palaeosepsis* spp.; *S. nigra* showed preference for *Cyrtoneurina pararescita* Couri (Diptera: Muscidae) and *R. belforti*; *S. nigroaenea* showed preference for *B. debilis, B. quadristigma, C. pararescita* and *R. belforti*; *Trichopria* sp. (Hymenoptera: Diapriidae) showed preference for *Palaeosepsis* spp.; *Triplasta atrocoxalis* (Ashmead) (Hymenoptera; Figitidae) showed preference for *Palaeosepsis* spp. and *Triplasta coxalis* (Ashmead) (Hymenoptera; Figitidae) showed preference for *Palaeosepsis* spp. (X^2= 250,91; GL:77; P<0,05).

Regarding the preference of parasitoids for their hosts in bovine feces, it was found that *K. nigra* showed preference for *Palaeosepsis* spp.; *P. egeria* showed preference for *A. scabra* and *B. quadristigma*; *S. cameroni* showed preference for *B. debilis* and *Sarcophagula occidua* (Fabricius) (Diptera: Sarcophagidae); *S. drosophilae* showed preference for *B. quadristigma* and *S. occidua*; *S. endius* showed preference for *S. occidua; S. nigra* showed preference for *C. pararescita* and *S. occidua*; *S. nigroaenea* for *B. debilis*, *C. pararescita* and *S. occidua*; *Trichopria* sp. for *A. scabra* and *S. occidua*; *T. atrocoxalis* for *Palaeosepsis* spp. and *T. coxalis* for *Palaeosepsis* spp. (X^2= 146,12; P<0,05; GL:45).

4. Conclusions

The most frequent species in bovine, of buffalo and chicken feces were: *G. quadridentata, S. drosophilae* and *P. vindemmiae*. The highest percentage of parasitism in bovine feces was presented by the parasitoid G. *quadridentata,* in the buffalo feces they were presented by the parasitoids *S. nigra* and *S. nigroaenea* also and in chicken feces it was *P. vindemmiae*.

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ARTICLE

Saline Irrigation Water Retards Growth of Amaranthus in Coastal Kenya

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ABSTRACT

Salinity is a major biotic factor that negatively affects growth and yield of crops. Over 90% of the coastal region of Kenya is arid and semi-arid, most farmers in the region use borehole irrigation water which is saline. Amaranthus spp. is one of the main vegetables grown in coastal region. There is limited information regarding the effect of salinity on amaranthus production. The study sought to determine the effect of saline irrigation water on amaranthus growth in coastal Kenya. Two experiments were set up, one at Mivumoni Secondary School farm in Kwale County and another at Pwani University farm in Kilifi County from beginning of September 2019 to the end of January, 2020. The experiments were laid out in a randomized complete block design and replicated three times. The six treatments tested were: fresh water alone, 75% saline water alone, 100% saline water alone, fresh water + DAP, 75% saline water + DAP, 100% saline water + DAP. Crop growth data collected were: emergence rate, plant height, leaf number, leaf area, chlorophyll content, stem thickness, root density, root weight, root volume and total plant biomass. Data obtained were subjected to analysis of variance using SAS statistical package (SAS, Version 10) and treatment effects were tested for significance using F-test. Significant means at F-test was ranked using Tukey's test at 5% level of significance. Amaranthus seeds sown in fresh water had higher emergence rate compared to seeds sown in saline water. Salinity regardless of concentration used and application of DAP, resulted in decrease in height, leaf number, leaf area, stem thickness, chlorophyll content, root length, root weight, root volume and total biomass. The study demonstrates that saline irrigation water in coastal Kenya has a negative effect on Amaranthus growth.

1. Introduction

Salinity is a major biotic factor that negatively affects growth and yield of crops [1]. With over 90% of the coastal region of Kenya being arid and semi-arid, most farmers in the region are forced to use borehole irrigation water which is mainly saline [2]. Saline water refers to any water that contains more than 1,000 parts per million (mg kg^{-1}) dissolved solids or one that has a specific conductance more than 1,400 µƱ/cm at 25 °C [3]. Salinity has a significant effect on crop and soil. Salinity results in deterioration in

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the physical structure of the soil like water permeability and reduction in soil aeration, and reduction in the osmotic potential of the soil solution. Salinity consequently result in the reduction of plant water availability and minerals uptake, increase in the concentration of certain mineral ions that have an inhibitory effect on plant metabolism and physiology which negatively affect growth and yields [4,5].

Kilifi County experiences unreliable rainfall with frequent drought [6]. Areas like Bamba, Ganze and western part of the county experience about 5-6 months of continuous dry weather. Therefore, groundwater contributes nearly 50% of the water used in the area through boreholes [7]. Kwale County on the other hand which lies on the southern part of the Kenyan coastal line is also dry and experiences unreliable rainfall. Subsistence agricultural activities within the area are rainfed while commercial agriculture mainly relies on underground saline water to complement the few rivers around.

According to Kumar and Rao [8], irrigation water quality depends on the type and quantity of dissolved salts. Salinity of the soil reduces uptake of plant phosphorus causes toxicity of ions, osmotic stress and deficiency of nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), iron (Fe) and zinc (Zn) which limits plant water uptake [9]. Elements like sodium (Na), chlorine (Cl), and boron (Bo) have specific toxic effects on plant. According to Akbarimoghaddam *et al*. [10] as well as Reynolds *et al*. [11], presence of salts in the soil affects interaction among physiological, morphological and biochemical processes like germination of seeds, growth of plant, nutrient and water uptake. Saline growth medium has adverse effects on plant growth; osmotic stress, salt stress, nutrition imbalance or combination of the factors [12]. Accumulation of salts in the soil is known to cause metabolic and physiological disturbance in crop affecting, yield, growth and crop quality [13-16]. Salt accumulation around the root zone prevents plant roots from withdrawing water from the surrounding soil decreasing available water for plant, causing stress to plant [17]. Soil salinity causes flocculation which promotes soil aeration and growth of roots; however, its increase to high level is lethal to plant growth [18]. Sodium salts accumulation in soil has an opposite effect to salinity in soil. High concentration of sodium salts causes dispersion which leads to reduced infiltration, surface crusting and reduced hydraulic conductivity [19]. In clay soil high sodium concentration causes aggregation and swelling [20]. High Na concentration causes osmotic stress leading to cell death [17].

Amaranthus spp. is an important crop for human diet and income generation in the coastal region [21]. However, its yield and quality have been declining. This has been attributed to poor soil condition and irrigation water quality, especially salinity, in addition to other factors like unfavourable weather conditions leading to poor growth and poor yields [22]. Despite the importance of salts in crops nutrient uptake, physiological and metabolic activities and the resulting yields and quality, limited research has been carried out on the effects of saline borehole water especially within the Kenyan Coast. Objective of the study was to determine the effect of saline irrigation water on amaranthus (*Amaranthus dubius* Mart. ex Thell.) growth in Coastal Kenya.

2. Materials and methods

2.1 Site of the Study

Two experiments were set up, one in Mivumoni Secondary School farm in Kwale County and another in Pwani University farm in Kilifi County, from beginning of September 2019 to the end of January, 2020. Kilifi County lies between latitude 3.63° S and longitude 39.85° E in the Coastal lowland (CL) 3-CL6. The landscape covers an area of 12,609.7 square kilometers and lies within 30 to 310 meters above sea level. It experiences average daily temperature of 21°C - 32°C and average annual rainfall of 600-1100 mm. It is dominated by sandy-loam soil which is well drained, shallow to moderately deep, dark brown to yellowish brown whose pH ranges between 4.22 - 7.80 [23]. Kwale County on the other hand lies between latitudes 4.33° S and longitudes 39.52° E in the Coastal lowlands agro-ecological zones CL3-CL5. It covers an area of 8270.2 square kilometers, altitude of between 0 - 462 meters above sea level and receives poorly distributed, unreliable annual rainfall ranging from 400 mm to 1200 mm per year and mean annual minimum and maximum temperatures are 24 °C and 27.5 °C respectively. The predominant soil in the area is sandy-clay whose pH ranges between 5.35 and 7.80 [23].

2.2 Candidate Crop

Amaranthus (*Amaranthus dubius* Mart. ex Thell.) were procured from Amiran, Mombasa, Kenya. The vegetable was chosen because it is widely grown and consumed in the coastal region.

2.3 Experimental Design, Treatment Application and Crop Husbandry

The experiments were laid out in a randomized complete block design and replicated three times. The six treatments tested were: fresh water alone, 75% saline water alone, 100% saline water alone, fresh water + DAP, 75% saline water +

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DAP, 100% saline water + DAP. Kwale county composite soils were used for Mivumoni greenhouse experiment while Kilifi county composite soil samples were used for the Pwani University greenhouse experiment trials. Four kilograms composite soil samples were measured and put in five-liter plastic pots. DAP fertilizer (250 kg/ha) was measured, incorporated in each pot that was meant for DAP treatment and mixed thoroughly. Saline water (200 ml) at 4 dS m^{-1} electrical conductivity (EC) was used for 100% saline water, fresh water of EC 0 dS m^{-1} and a mixture of the 150 ml saline water and 50 ml of the fresh water for the 75% saline water treatments were added every 2 days to compensate for evaporative losses. Twenty amaranthus seeds were then sown in each pot. Thinning was done to allow only ten seedlings per pot. Water treatments (200 ml) were applied throughout the experimental period (60 days) in the form of manual irrigation.

2.4 Data Collection

Three plants per pot were randomly selected from the pots in the inner rows and tagged for data collection. Crop growth data collected were:

2.4.1 Emergence Rate

Number of seedling emergence per treatment per day was counted from 1st day of sowing and recorded up to 10th day, recorded and percent emergence computed.

2.4.2 Plant Height

Plant height was established by measuring the height of the tagged plants from each pot using a meter rule. The measurements were carried out on weekly basis from one till tenth week after crop emergence. The measurements were taken from the ground level to the tip of the shoot and recorded in centimeters (cm).

2.4.3 Number of Leaves

Number of leaves was determined by counting the total number of leaves on the tagged plants per pot on weekly bases two weeks after crop emergence up to tenth week after emergence.

2.4.4 Leaf Area

Fully expanded leaves (third, fourth, and fifth from the shoot) of the tagged plants per pot were used to determine leaf area. The length and width of the leaf were measured using a ruler. Length and width were multiplied by a constant as in the formula: Leaf Area = Length × width × 0.75 (constant) for the triangular leaves such as amaranthus. Leaf area was measured one week after emergence and thereafter on weekly basis up to tenth week and results recorded in squared centimeters (cm^2).

2.4.5 Stem Thickness

Tagged plants per pot were used to measure stem thickness using a standard vernier caliper. The jaws of vernier caliper were placed on the stem just above the ground level and readings recorded in centimeters (cm). This was done on a weekly basis until tenth week from 1st week of crop emergence.

2.4.6 Root Growth Characteristics

Root length: on the tenth week after emergence, the tagged plants per pot were uprooted, washed. Root length measured using a ruler and recorded in centimeters (cm). Root weight (dry): on the tenth week after emergence, the tagged plants per pot were uprooted, washed, dried and weighed on an electronic weighing balance and Weight recorded in kilograms (kg). Root volume: on the tenth week after emergence, the tagged plants per pot were uprooted, roots chopped off, washed and used to determine root volume by displacement method. Known volume of water was filled into the beaker to the brim. Clean roots were immersed then displaced water was collected. Volume of displaced water was measured and recorded in cubic centimeters (cm^3).

2.4.7 Chlorophyll Content

Chlorophyll content was measured using chlorophyll meter (CCM-200, Opti-sciences, Inc. Tyngsboro, MA, USA) with a precision of ± 1.0 chlorophyll concentration index units (CCI). This was done every until the tenth week after emergence. The readings were taken from the tagged plants per pot on the third, fourth, and fifth leaves from the shoot that had fully expanded.

2.4.8 Total Biomass

On the tenth week after emergence, the tagged plants per pot were uprooted, then oven dried at 75 °C until a constant weight and used to determine biomass yield. Yield was determined by weighing on an electronic weighing balance and weight recorded in kilograms (kg).

2.5 Data Analysis

Data obtained were subjected to analysis of variance using SAS statistical package (SAS, Version 10) and treatment effects were tested for significance using F-test. Significant means at F-test was ranked using Tukey's test. All analysis was at 5% level of significance.

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3. Results

3.1 Seedling Emergence Rate

Significantly ($p \leq 0.05$) higher emergence rate of seedlings was observed in fresh water compared to those from saline water in Pwani University (95%) and Mivumoni (97%) respectively (Figure 1). This was followed by fresh water which had significantly higher rate of emergence compared to saline water plus DAP, 75% saline water plus DAP and 75% saline water were not significantly different. Saline water plus DAP had the lowest rate of emergence in both sites.

3.2 Plant Height

Amaranthus grown in fresh water plus DAP was significantly ($p \leq 0.05$) taller compared to the rest of the treatments, in both Pwani University and Mivumoni by 56% and 54% respectively (Table 1). This was followed by fresh water, 75% saline water plus DAP and saline water plus DAP. Plants grown in saline water plus DAP were the shortest.

3.3 Leaf Number

Plants grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher number of leaves, followed by fresh water compared to the rest of the treatment in both Pwani university and Mivumoni. Amaranthus grown in saline water, saline plus DAP and 75% saline which had comparable number of leaves. Plants grown in saline water had the lowest number of leaves (Table 1).

3.4 Leaf Surface Area

Amaranthus planted in fresh water plus DAP had sig-

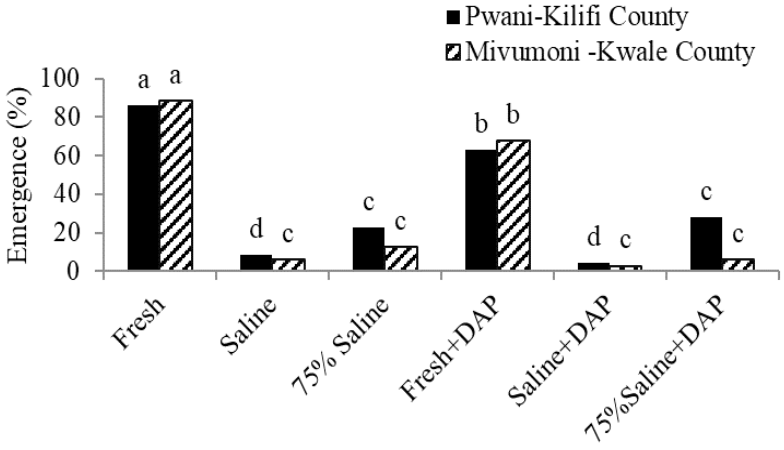

Figure 1. Effect of saline borehole water on emergence of amaranthus in Pwani University (Kilifi county) and Mivumoni (Kwale county). Means followed by the same letters within a study site are not significantly different according to Tukey's Test ($p \leq 0.05$).

Table 1. Effect of saline borehole water on growth of amaranthus in Pwani University (Kilifi county) and Mivumoni (Kwale county)

	Plant height (cm)		Leaves (no./plant)		Leaf surface area (cm^2)		Stem thickness (cm)	
Treatment	PU	MI	PU	MI	PU	MI	PU	MI
Fresh	27.8^{a}	27.4^{a}	12.6^{b}	10.2^{a}	12.7^{ab}	13.4^{ab}	1.2^{b}	1.3^{a}
Saline	13.9^{c}	14.1^{b}	4.8^{c}	4.0^{c}	4.8^{d}	8.7^{bc}	0.8^{d}	1.0^{bc}
75% Saline	18.5^{b}	18.6^{b}	7.5^{c}	5.3^{cb}	8.1^{cd}	12.0^{abc}	1.0^{c}	1.3^{ab}
Fresh + DAP	31.7^{a}	28.0^{a}	19.3^{a}	17.0^{a}	15.7^{a}	17.0^{a}	1.4^{a}	1.4^{a}
Saline + DAP	13.9^{c}	12.9^{b}	4.6^{c}	4.0^{c}	5.9^{d}	7.2^{c}	1.0^{c}	1.0^{c}
75% Saline + DAP	16.4^{bc}	16.3^{b}	7.4^{c}	7.0^{cb}	11.9^{bc}	13.2^{ab}	1.1^{bc}	1.2^{abc}
LSD (0.05)	4.0	7.5	3.3	5.3	3.8	5.6	0.2	0.2
CV (%)	6.9	13.4	12.4	23.6	13.5	16.8	5.1	6.3

Means followed by the same letter(s) within a column are not significantly different according to Tukey's Test ($p \leq 0.05$). PU = Pwani University, MI = Mivumoni.

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nificantly ($p \leq 0.05$) larger surface area compared to the rest of the treatment in both Pwani University and Mivumoni by 69% to 58% respectively (Table 1). This was followed by fresh water alone. Amaranthus plants in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable leaf surface area. Plants grown in saline water plus DAP had the lowest leaf surface area.

3.5 Stem Thickness

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher stem thickness compared to the rest of the treatments in both Pwani University and Mivumoni by 42% and 25% respectively (Table 1). This was followed by fresh water. Plants planted in saline water, saline plus DAP, 75% saline plus DAP had comparable stem thickness. Plants planted in saline water had the least stem thickness.

3.6 Root Growth Characteristics

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) larger root volume compared to the rest of the treatments, in both Pwani University and Mivumoni by 84% and 82% respectively followed by fresh water alone (Table 2). Plants grown in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable root volume. Plants grown in saline water had the lowest root volume.

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher root weight compared to the rest of the treatments in both Pwani University and Mivumoni by 91% and 86% respectively (Table 2). This was followed by those grown in fresh water alone. Plants grown in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable root weight. Plants grown in saline water had the lowest root weight.

Amarnthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) longer roots compared to the rest of the treatment in both Pwani University and Mivumoni by 73% and 55% respectively (Table 2). This was followed by fresh water alone. Plants grown in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable root length.

3.7 Chlorophyll Content

Chlorophyll content of amaranthus plants grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher chlorophyll content compared to the rest of the treatment both in Pwani University and Mivumoni by 31% and 28%. There was no significant difference in chlorophyll content in fresh water, 75% saline and 75% saline plus DAP. Plants grown in saline water had the lowest chlorophyll content (Figure 2).

3.8 Total Biomass

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher biomass compared to the rest of the treatments in both Pwani University and Mivumoni by 88% and 74% respectively. This was followed by fresh water alone. Biomass of plants grown in 75% saline and 75% saline plus DAP had comparable biomass. Plants grown in saline water and saline water plus DAP had the lowest biomass in both sites (Figure 3).

Table 2. Effect of saline borehole water on root growth of amaranthus in Pwani University (Kilifi county)

	Root volume (cm^3)		Root weight (g)		Root length (cm)	
Treatment	PU	MI	PU	MI	PU	MI
Fresh	9.0^{b}	10.0^{b}	1.5^{b}	1.4^{ab}	14.4^{b}	15.6^{b}
Saline	2.2^{d}	2.5^{e}	0.2^{f}	0.3^{b}	5.4^{e}	8.9^{e}
75 % Saline	5.8^{c}	6.0^{cd}	0.8^{d}	0.7^{b}	7.7^{c}	9.0^{de}
Fresh + DAP	13.8^{a}	14.0^{a}	2.2^{a}	2.2^{a}	19.8^{a}	19.9^{a}
Saline + DAP	5.5^{c}	5.2^{d}	0.5^{e}	0.4^{b}	7.9^{c}	10.6^{d}
75 % Saline + DAP	8.2^{b}	7.5^{c}	1.1^{c}	1.6^{ab}	13.1^{b}	13.1^{c}
LSD value	2.2	2.2	0.8	1.4	2.9	1.7
CV (%)	10.3	10.4	6.0	44.6	8.9	4.6

Means followed by the same letter(s) within a column are not significantly different according to Tukey's Test ($p \leq 0.05$). PU = Pwani University, MI = Mivumoni.

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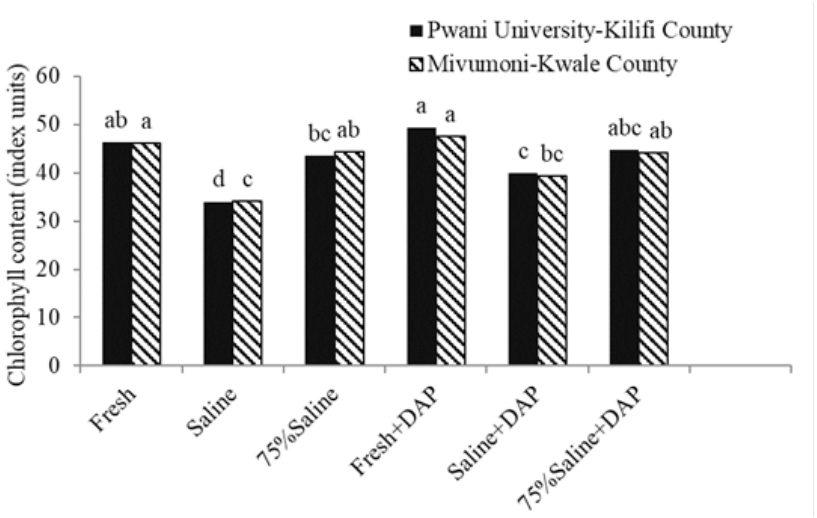

Figure 2. Effect of saline borehole water on chlorophyll content of amaranth leaves during production in Pwani University (Kilifi County) and Mivumoni (Kwale County). Means followed by the same letter(s) within a study site are not significantly different according to Tukey's Test ($p \leq 0.05$).

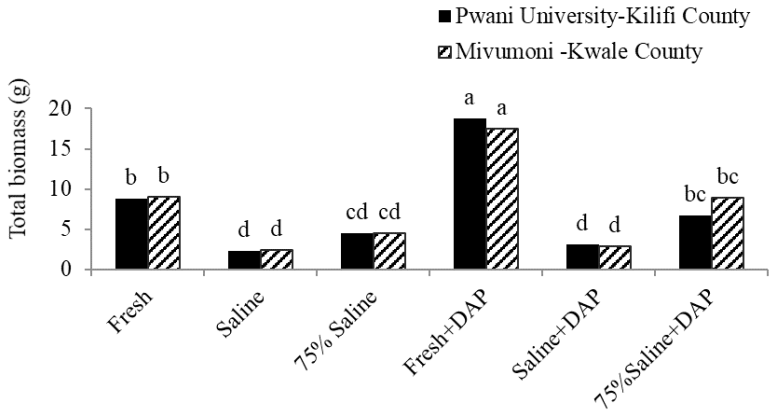

Figure 3. Effect of saline borehole water on total biomass of amaranth during production in Pwani University (Kilifi county) and Mavumoni (Kwale county). Means followed by the same letter(s) within a study site are not significantly different according to Tukey's Test ($p \leq 0.05$).

4. Discussion

Amaranthus seedlings grown from fresh water had higher emergence rate compared to those grown in saline water. Salinity may affect germination by reducing water imbibition in seeds since activities are related to germination. Additionally, salinity may have promoted absorption of toxic ions altering hormonal or enzymatic activities [24]. Cuartero and Fernandez-Munoz [25] found that seeds required more days to germinate (50%) in medium at EC 1.4 mS/cm and 100% delayed germination in medium at EC 3.4 mS/cm. Neamatollahi *et al.* [26] reported that increasing NaCl concentration in priming treatments causes higher osmotic pressure hence reducing germination percentage on fennel seeds. Asch and Wopereis [27] found that salinity levels below 4 mS cm^{-1} delayed germination by 1 - 2 days, while higher salinity delayed germination by more than a week. Osborne *et al*. [28] also observed that exposure of amaranthus to high salinity inhibits germination and reduce rate of germination. Similar findings were reported with *Eriochiton sclerolaenoides, Maireana georgei, M. pentatropis, M. pyramidata, M. trichoptera* and *M. triplera* species in semi-arid climate Australia [29].

Increasing salt concentrations resulted to decrease in height, shoot and root lengths, root volume, leaf number, leaf surface area, chlorophyll content and stem thickness. Salinity affects a number of aspects of plant growth and development like; germination, reproductive and vegetative growth. Salinity may cause reduction in water availability by decreasing osmotic potential of total soil water potential. Matric potential and osmotic potential of soil are both elements of total soil water potential and add up

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the effects on availability of water which causes decline in both yield and evapotranspiration [30,31]. Abbas *et al*. [32] found that salinity and Fe deficiency reduced chlorophyll concentration, shoot and root growth, photosynthetic, stomatal conductance and transpiration rates. Retarded growth may have been caused by osmotic inhibition of oxidative stress, water absorption and specific ions that affect crucial physiological processes in plants. Oxidative stress prevents photosynthetic performance in high saline conditions. Saline soil conditions affect stomatal aperture and reactive oxygen species that hinder activities of the enzymes and membranes related to photosynthesis [5]. Saline soils reduce the uptake of plant phosphorus significantly since phosphate ions precipitates with Ca ions [9]. Salinity has an effect on the absorption of some specific ions across the cell membranes which cause nutritional disturbances to crops [33]. This includes uptake of NO_3^- which is lowered by Cl^- and K^+ uptake which is reduced by Na^+. When sodium accumulates in the cell wall excessively, it leads to rapid osmotic stress causing death of the cells [34].

Soil physical properties can be affected by accumulation of some salts such as sodium in the soil solution as observed in the study and the exchange phase can cause clay dispersion, especially for smectitic clays, which affect soil physical and chemical characteristics by reducing its structural stability and promoting surface crust formation; increasing bulk density and mechanical resistance resulting in poor soil tilth and soil aeration. Reduction of hydraulic conductivity and infiltration rate causes significant water management problems by increasing runoff and erosion potential due to surface sealing and poor infiltration leading to poor water and nutrient uptake hence poor crop growth [35,36].

5. Conclusions and Recommendations

Results observed indicate that salinity had effects on growth characteristics of amaranthus. Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher growth characteristic than the rest of the treatments. Plants grown in saline water had the lowest growth characteristics in both sites. There was significantly higher ($p \leq 0.05$) emergence rate in seeds sown in fresh water compared to those from saline water in Pwani University (95%) and Mivumoni (97%) respectively. Fresh water plus DAP improved amaranthus growth compared to saline water plus DAP in both Pwani University and Mivumoni by 56% and 54% respectively. This was followed by fresh water, 75% saline water plus DAP, 75% saline water, saline water and saline water plus DAP.

Based on the research findings there is need for further studies on:

i. Effect of saline soils on physiology of vegetable crops in coastal region.
ii. Effects of saline irrigation water on various crops in the coastal region.
iii. Effects of saline irrigation water on availability and uptake of mineral elements.

Other policy recommendations include:

Farmers should adopt appropriate measures to manage salinity in irrigation. These measures could include diluting the saline water with fresh water, application of manure to supplement soil nutrients and improve soil structure, water retention capacity, soil microbial activities and buffer soil and appropriate method of irrigation water application.

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ARTICLE

Major Causes of Calf Morbidity and Mortality in Smallholder Dairy Farms in Shashemene Town, Ethiopia

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ABSTRACT

A cross-sectional study was conducted to determine the major causes of calf morbidity and mortality in smallholder dairy farms and associated potential risk factors in Shashemene. A total of 187 calves from 46 farms were included in the present study. The overall crude morbidity and crude mortality rates were 27.8% and 6.4%, respectively. The most frequent disease syndrome was diarrhea with incidence rate of 28(15%) followed by pneumonia 8(4.3%), Gastrointestinal tract (GIT) disorder 8(4.3%) and septicemia 5(2.7%). In addition skin lesion, navel ill and unidentified cases were encountered. The main causes of death were diarrhea 6(3.2%), Septicemia 2(1.1%), GIT disorder 2(1.1%), pneumonia 1(0.5%) and others 1(0.5%). The most important risk factors associated with morbidity and mortality were housing hygiene, floor condition and calf size in farm. Out of 187 calves examined for GIT parasites; 63(33.3%) were positive for nematode eggs. Prevalence of helminthes parasite increased with increasing age, showing higher prevalence ($P<0.05$) in calves above 2 months than in calves below 2 months of age. Besides, majority of the calves, 48(25.7%) were found positive for coccidian oocyst. In general; diarrhea, pneumonia and septicemia were the major causes of calf morbidity and mortality. Interms of risk factors housing hygiene, floor condition, calf size in the farms, age and breed were identified major role players. Therefore, identifying major causes and improving management practices and breed should be given to emphasis by advisory of smallholder dairy farms.

1. Introduction

In Sub-Saharan African countries, livestock plays a crucial role both in national economies and the livelihood of rural communities [1]. It provides drought power, milk, and meat, input for crop production and soil fertility and raw material for industry. The livestock sector contributes 13-16% of total agricultural GDP in Ethiopia [2].

Despite the huge number of cattle and their economic importance, the productivity is low due to the constraints of disease, nutrition, poor management, lack of marketing facilities and opportunity, inadequate animal health services, uncoordinated development programs between various levels of government institutions and/ or non-government organizations and poor performance of indigenous breeds. These constraints result in poor reproductive performance of dairy cattle [3]. Consequently, national milk production remains among the lowest in the world even by African standard [4]. However, there is a slow and gradual

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overall growth in milk production in Africa due to cross breeding programs that are being introduced in many tropical countries to increase milk production [5].

Diseases have numerous negative impacts on productivity and fertility of herds i.e. losses due to mortality and morbidity, loss of weight, depressed growth, poor fertility performance, decrease physical power and the likes [6]. This results from complex interaction of the management practice, environment, infectious agent and the calf itself. Major causes of calf diseases and death were diarrhoea, pneumonia, joint problems, umbilical diseases, trauma, congenital abnormalities, nutritional deficiencies, dystocia and other infections [7-9]. Calf losses were significantly reduced by introducing new techniques of management including on time colostrum feeding, housing, feeding and nutrition [10].

Several factors affect the health and vigor of the calves immediately after birth [11].The poor immune system and lack of previous exposure to infection and poor management make new born calves susceptible to infectious diseases [12]. Proper nutrition is fundamental for calf growth and for the general profitability of calf rearing enterprise. In young stock, a good nutritional strategy optimizes rumen development and growth while minimizing stress and disease. Livestock housing conditions greatly affect health and productivity [13]. Cleanliness of the barn influences calf health, as calves housed in unclean barns are at higher risk of diseases than calves housed in clean barns [9].

The mode of passive transfer in neonates varies with the type of placentation and in the case of neonatal calves; it is based on an immediate postpartum ingestion of antibody rich colostrum [14]. The age of the calf is the most important factor affecting morbidity and mortality, approximately 75% of the mortality in dairy animals less than one year of age occurs in the first month of their life [15].

Failure of passive transfer in heifer calves is linked with decreased rate and efficiency of growth and decreased first and second lactation milk production [16]. In developing parts of the world including Ethiopia there is a growing trend in the development of dairy farming which is becoming an important source of income particularly for small holder farmers. However, this cannot be realized without the application of effective calf health and management practices as the future of any dairy farming production depends on the successful program of raising replacement animals (calves). With the above background, the objectives of the present study were:

- To assess the major causes of morbidity and mortality in calves
- To identify risk factors associated with calf morbidity and mortality in smallholder dairy farms in Shashemene

2. Materials and Methods

2.1 Study Area

The study was conducted in Shashemene town, West Arsi Zone, Oromia Regional State, which is located distance of 250 km south east of the capital Addis Ababa at latitude of 7° 11'33'' north and a longitude of 38° 35'33'' east. The area lies within the Rift Valley, with an altitude ranging from 1700 to 2600 metres above sea level (masl). Its annual rainfall ranges 700 to 950 mm while annual temperature range is 12-27°C. The livestock population in zone includes cattle (3,629,900), sheep (694,213), goats (322,332), horse (227,784), donkeys (165,367), mules (8,953) and camels (57). It is also known by production of teff, barley, wheat, maize, sorghum, potato, sweet potato, cabbage, spinach and onion. Annual crops are predominant and rain fed agriculture is mainly practiced using draught power.

2.2 Study Design

Both cross-sectional and longitudinal prospective observational studies were undertaken in six months. The sampling units (calves) were identified individually and monitored throughout the study period.

2.3 Data Collection

Data was collected through questionnaire survey, clinical and laboratory examinations for parasite from study populations. It was collected from 46 purposely selected dairy farms based on the farm size and willingness of the farm owners to participate in the study. Accordingly, a total of 187 calves' from 46 farms were considered.

2.3.1 Cross-sectional Study Based on Questionnaire

The owners and / or attendants of the included dairy farms were interviewed using structured and open ended questionnaires. The contents of the questionnaire were demographic information, farm size, feeding habits and management of the livestock farms, calf age, housing of the animals, disease occurrence, calf death, and sex of calves.

2.3.2 Longitudinal Study

Monitoring of dairy farms for calf morbidity and mortality was carried out for 6 months. For the purpose of this study, calves of age less than six months were considered. Morbidity as any sickness that has recognizable clinical manifestation, and mortality as death of calves after birth to 6 months of age were used during the study period. For the monitoring, all calves in the selected farms at the

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beginning of the follow up period and individual records were prepared. The calves were withdrawn from the follow up when they completed their 6 months of age.

Subsequently, a regular visit was made every three weeks to observe and record calf morbidity, mortality and possible causes. The main activities accomplished during the regular visits were clinical examination of calves for any health problem; observation on different calf management aspects like cleanness of the calf house and feeding practices; and collecting information from calf attendants about occurrence of calf health problem incidents between the visits and recording of the history of the calf health problem that would enable the investigator suppose the possible cause and thus assist diagnosis.

Calf morbidities encountered during the monitoring period were categorized following disease conditions/syndromes based on their clinical signs:

Diarrhoea: Any conditions characterized by passing of lose or watery feces with increased frequency, which could or could not be accompanied by other systemic signs like dehydration, decreased appetite or fever.

Pneumonia: When frequent coughing observed with or without respiratory discharges and fever.

Septicemic condition: Any condition characterized by depression, anorexia and fever without any distinct involvement of specific body system.

Navel ill (omphalitis): Swelling of umbilical cord which is painful when palpated and with or without abscess formation

Joint ill (arthritis): Enlargement of joints usually with abscess formation in any one or all limbs, which could or could not be preceded by other disease condition.

2.3.3 Fecal Sample Collection

A fresh fecal sample was collected from the rectum of each calf using sterile disposable gloves. The sample was placed in a labeled clean glass bottle container and was transported to the parasitology laboratory on the same day and was kept at 4°C in a refrigerator until processing within 48 hours of arrival. At the time of sampling, the name of the farm owner, date of sampling, age, sex, breed, tag number (if present) was recorded for each calf on a recording format and examined the infection rate of Coccidia and internal parasites by using flotation technique at the Parasitology Laboratory, School of Veterinary Medicine, Hawassa University.

2.4 Data Analysis

The collected were fed into Microsoft excel spread sheet program, coded, edited and saved until analysis. Data analysis was undertaken using statistical program for social science version 20.0 (SPSS) software. During data analysis, descriptive analysis and chi-square test were employed. A p-value ≤ 0.05 was considered significant in the analysis.

3. Results

3.1 Morbidity and Mortality

The study revealed that diarrhea was the most frequently observed clinical disorder (28 cases out of 187 calves) followed by GIT disturbance, pneumonia and septicemia (Table 1).

3.2 Risk Factors Associated with Incidence of Calf Morbidity and Mortality

Out of 46 farms visited, 24 (72.3%) morbidity and 13 (100%) mortality were recorded in farms with poor hygienic condition (P=0.000). Considering floor type, mor-

Table 1. Summary of diseases/syndromes that caused morbidity and mortality in dairy calves

Health Problems/syndrome	Morbidity case	Morbidity (%)	Mortality case	Crude Mortality (%)
Septicemia	5	2.7	2	1.1
Diarrhea	28	15	6	3.2
GIT Disturbance*	8	4.3	2	1.1
Pneumonia	8	4.3	1	0.5
Other*t	3	1.6	1	0.5
Total	52	27.8	12	6.4

GIT Disturbance*include bloat, indigestion and any pain symptoms from GIT

Other* include navel ill, skin lesion, unidentified

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bidity and mortality record was 6(18.2%) and 1(7.7%), respectively in the concrete farms (Table 2).

Generally, housing hygiene, floor condition and calf size in the farm seem to be the major factors for diseases incidences in the present study. Hence, calves house in soil floor were more often at risk than calves housed in the concrete floor. Similarly, calf size in farm and housing hygiene has been significantly associated (P <0.05) with dairy calf morbidity and mortality.

3.3 Prevalence of Gastrointestinal Nematodes and Coccidian Oocyst

In addition to other health problems, parasitic infection was the most prevalent in investigated smallholder dairy farms. Out of 187 examined calves, 4(6.3%) and 9 (18.8%) calves aged less than 1month were positive for nematode parasites and positive for coccidian oocyst, respectively (Table 3).

Considering breed as potential risk factor, 22 (34.9%) local, 34(54%) exotic and 7(11.1%) cross breeds were positive for nematode parasites. Breed of calves with significant effect on the occurrence of gastrointestinal nematodes and coccidian oocyst (Table 4).

Based on sex, 18(37.5%) male and 30(62.5%) female calves were found infected with coccidian oocyst (Table 5).

4. Discussion

The study showed that 6.4 (n=12) mortality and 27.8% (n=52) morbidity cases were recorded. In this study, the mortality rate found for 6 months has considerably agreed with the mortality rates reported for similar period by different studies in Ethiopia [17]. However, it was lower than the 12% mean calf mortality rate in smallholder dairy production in Sub-Saharan Africa [18] and from western world which were reported in the ranges of 9 to 13 % for Europe and similar to 6.3% for USA [15].

On the other hand, the present finding was much lower than previous report (25%) by [19] in Ethiopia. On the other hand, low prevalence of 3.4% mortality was reported by [20] from Abernossa Ranch, whereas, [9] reported relatively

Table 2. Potential risk factors associated with calf morbidity and mortality at farm level

	Morbidity				Mortality			
Factors coded	No of farm	Affected no (%)	χ^2-value	P-value	No of farm	Affected no (%)	χ^2-value	P-value
Education status 0=non-educated 1=primary 2=sec and above	11 30 5	6(18.2) 22(66.7) 5(15.1)	3.61	0.164	11 30 5	3(23.1) 7(53.8) 3(23.1)	2.849	0.241
House hygiene 0=poor 1=clean	24 22	24(72.7) 9(27.3)	19.769	0.000	24 22	13(100) 0(0)	16.611	0.000
Floor condition: 0=soil 1=concrete	31 15	27(81.8) 6(18.2)	11.060	0.001	31 15	12(92.3) 1(7.7)	5.119	0.024
Calf size in farm 0=less than 5 1= greater than 5	22 24	12(36.4) 21(63.6)	6.148	0.013	22 24	2(15.4) 11(84.6)	7.643	0.006
Sex: 0=female 1=male	22 24	14(42.4) 19(57.6)	1.366	0.243	22 24	3(23.1) 10(76.9)	4.448	0.035

Table 3. Prevalence of GIT nematodes and coccidian oocyst within different age groups

Helminthes eggs					Coccidia Oocyst			
Calf age	No of examine	Positive (%)	χ^2-value	P-value	No of examine	Positive	χ^2-value	P-value
< 1month 1-2 month 3-4 month > 4 month	73 41 39 34	4(6.3%) 21(33.3%) 20(31.7%) 18(28.6%)	42.688	0.000	73 41 39 34	9(18.8%) 6(12.5%) 20(41.7%) 13(27.1%)	25.649	0.000

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Table 4. Prevalence of GIT nematodes and coccidian oocyst within breed

Helminthes eggs					Coccidia Oocyst			
Breed	No of examined	Positive (%)	χ^2-value	P-value	No of examined	Positive	χ^2-value	P-value
local exotic cross	49 101 37	22(34.9) 34(54%) 7(11.1%)	6.369	0.041	49 101 37	19(39.6%) 22(45.8%) 7(14.6%)	6.095	0.047

Table 5. Prevalence of gastrointestinal nematodes and coccidian oocyst within sex

Helminthes eggs					Coccidia Oocyst			
Calf sex	No of examines	Positive (%)	χ^2-value	P-value	No of examines	Positive (%)	χ^2-value	P-value
Male female	81 106	25(39.7%) 38(60.3%)	0.511	0.475	81 106	18(37.5%) 30(62.5%)	6.889	0.346

higher overall crude mortality of 18% compared to the present findings.

Concerning the morbidity and mortality of calves, most previous reports from Ethiopia were based on studies in research stations and state farms with large herd sizes and usually holding high exotic blood level animals, apparently these were associated with increased risk of calf disease occurrence [9]. In the present study, the number of calves per farm was small and the farmers can easily monitor calves and take measures to avoid calf health problems improve management and different methods used in diagnosis. Some authors reported calf morbidity based on producer diagnosis and treatments while others depended on veterinarian diagnosis [9]. This could be one of reasons to find relatively lower mortality rate than those mentioned above farms.

In the present investigation, calf diarrhea was found to be the predominant calf health problem with incidence rate of 15% followed by pneumonia and GIT disturbance (4.3%). Diarrhea was also the leading cause of mortality in the study herds. This finding is in agreement with the findings of [9] who reported calf diarrhea and pneumonia the predominant calf health problems in dairy calves at Ada'a district of Oromia region. However, the present finding was higher for diarrhea and pneumonia as compared to [13] who recorded a prevalence of 10% and 0.7% for diarrhea and pneumonia respectively. On the other hand, there were studies which found pneumonia as the leading cause of calf mortality [21].These differences could be emanated from the difference in management and other factors such as; housing hygiene, ventilation, environment, age, season, herd size and other related factors. Furthermore, analysis of the potential risk factors was done for calf diarrhea and age of the calf, condition of birth and cleanness of the calf house were the factors. This was due to inadequate passive transfer of colostral immunity. Such calves either would lack vigor to suckle on time or will fail to absorb even if they managed to suckle. Calves from prolonged labor develop respiratory acidosis, which interferes with absorption of colostral immunoglobulin [22].

Epidemiological investigation of nematodes in livestock using suitable and cost effective diagnostic methods was found to be important. In this study 33.3% were positive for nematode eggs and 25.7% were found positive for coccidian oocyst. This result was lower than (58.00%) prevalence [23] and 54% [24] in Haramaya University. This difference is may be due to less contact with other animals, different management system or due to increase in awareness of the farmer to treat their animals with antihelmentic drugs. But the prevalence of gastrointestinal parasites in the current study is higher than 11% [25]. This difference may occur due different area and management.

Helminthes parasite prevalence was observed to increase with increasing age and showing a significantly higher prevalence ($P < 0.05$) in calves above 2 months than in calves below 2 months. This was agreement with [26] reported that GIT parasite burden and diversity increased with age and at weaning and ends of first year of life, calves acquired the parasite spectrum similar to that of adult cattle. This could be due to the fact that as age increases, calves were given fresh grass as supplemental feed. Additionally, there was mixing of calves of different age groups. Also there was close contact with adult animals. This could be possible means of acquiring parasitic infections. In majority of smallholder dairy farms, calves were commonly open grazed or tethered on natural pastures [13]. The impact of parasitic burden should be taken into account in the veterinary health care to dairy calves.

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In the present study the risk factors were tested for their association with crude mortality and crude morbidity in smallholder farms. Among risk factors assessed; housing hygiene was found to be significantly associated with the incidence of disease problems having at (P=0.000). This significant association with disease problems found in present study was in agreement with other reports [27,21] who documented the existence of significant association between higher risk of morbidity and dirtiness of calf barn. Similarly, a significant association of age at first colostrum feeding with calf morbidity was reported different researchers, [9] and higher risk of morbidity in late fed-(after 6 hours) was related to failure of passive transfer of colostral immunity during this period [28]. Similarly, floor condition was significantly associated at (P=0.024) this present study was agreement with [13].

Other risk factor for health problems was higher in male calves (17.1%) than female calves (14.1%). This finding agrees with [13] finding who reported higher health problems in male calves than females particularly during the first months of their age. This could be due to less attention and management care given to the male calves as their role in the farms was considered not profitable in this study. So, it is important to know that the feeding and the general management, of male calves needs to be improved for animal welfare reasons as well as for more profitable utilization of beef from these calves for consumption. However there is also another reason that should be taken in to account that is male calves have less absorption ability of serum immunoglobulin's than female calves and they could become more immune deficient than female calves.

5. Conclusions and Recommendations

The calf morbidity and mortality rates found in this study were higher than economically tolerable and that can be achieved through good management. Given the fact that the study farms raise their own replacement stock and have small herd size, higher rates calf morbidity and mortality will be great hindrance to improve productivity of dairy production through selection. Calf diarrhea and pneumonia were the predominant calf health problems of the farms involved in this study. Among the potential risk factors evaluated for their association with the occurrence of calf health problems; risk factors associated with diseases occurrences and death indicating, calf housing hygiene, floor conditions, farm size and sex as potential risk factors.

Based on the above conclusion the following recommendations are forwarded:

- Greater attention should be given to risk factors associated with disease occurrences and death indicating such as; hygienic conditions and optimum time of colostrum feeding to minimize calf health problems and hence their mortality.
- More researches should be conducted to identify the causative agent of the major health problems identified in this research as this is crucial in formulating effective preventive and control strategies like use of vaccination or other methods.
- Extension services need to focus on awareness creation among dairy farm owners about good calf management's practices and their roles in productivity of dairy farming investments.

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REVIEW

A Review of Research Directions and Research Methods of Farmland Weeds

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ABSTRACT

Farmland weeds are an important part of farmland ecosystems. Research on farmland weeds is one of the major research fields in agricultural ecology. It is of great significance for achieving high yield, high quality and high efficiency in agriculture. In recent years, research on farmland weeds has focused on investigation of weed communities, research on weed seed banks, and research on weed control. These three research directions complement each other. Among them, the investigation work of weed communities and the research of weed seed banks are helpful for us to grasp the occurrence of farmland weeds more accurately and provide references for the control of farmland weeds. This article summarizes the research directions of farmland weeds in recent years (weed community investigation, weed seed bank, weed control) and the research methods used, provide reference value for the follow-up research work of farmland weeds, and provide theoretical support for promoting the development of rural ecological industry and building beautiful villages.

1. Introduction

Farmland weeds refer to plants growing in farmland that are harmful to the main food crops, generally non-cultivated wild plants or plants that are useless to humans, mainly herbaceous plants. This concept is relative. For example, dandelion is not a weed when it grows in a field where the main medicinal plant is grown; but when it grows in a corn field, it becomes a weed. The biological characteristics of field weeds are as follows: multiple propagation methods, strong reproduction and regeneration, the life cycle of weeds is generally shorter than that of crops, seeds fall with maturity, strong resistance to stress, and high photosynthesis efficiency. The main hazards of farmland weeds are: competing with crops for nutrients, water, sunlight and space, obstructing field ventilation and light transmission, increasing local climate temperature, and some are intermediate hosts of pests and diseases, promoting the occurrence of pests [1]; Parasitic weeds directly absorb nutrients from crops, thereby reducing crop yield and quality [2-3]. Therefore, the research on farmland weeds is of great significance to agricultural production. This article mainly discusses the research directions and ecological research methods of farmland weeds in recent years from three aspects: weed community survey, weed seed bank, and weed control.

2. Weed Community Survey and its Research Methods

2.1 Investigation of Farmland Weed Communities

Farmland weed community survey is to investigate the occurrence of weeds (species, distribution, density, dominance, etc.) in farmland. Through investigation, we can

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grasp the occurrence of farmland weeds. The above work can not only accumulate data for weed prediction, but also help to detect exotic weeds in time, prevent biological invasion, and provide a certain theoretical basis for scientific and effective weed control. In recent years, surveys of weed communities have found that artificial measures (agronomic measures such as fertilization and irrigation) and natural factors (season, light, temperature, water, etc.) will affect the structure of weed communities [4]. Among them, the seasonal and temporal and spatial succession of weed communities have attracted much attention [5].

2.2 Research Methods of Farmland Weed Community Investigation

(1) Sampling method, sampling amount, sampling time

Weeds in farmland are distributed randomly. In order to make sampling more representative, sampling method is very important. The sampling method of farmland weed community survey is mostly based on the size and shape of farmland or experimental plots, and appropriate sampling methods are adopted. Most of them are small-support multiple-point methods, among which "W" sampling and five-point sampling are the most commonly used.

Sampling volume refers to the size of the sample square, which is also determined by the conditions of the test site, most of the sample squares are 1m×1m, 50cm×50cm [6-8].

The sampling time is slightly different according to the research object and the research content. Some samples are taken before the weeds bloom, some are based on the growth period of the main crops, and some are taken every certain number of days (for example, 25 days) throughout the growth period until the harvest period. Sometimes sampling is done during specific periods, such as before and after raising geese [7-8].

(2) Data analysis method

The basic data density, abundance, abundance, and dominance are calculated using calculation formulas. Species diversity is expressed by different indexes: Berger-Parker abundance (Pi), Shannon evenness index (J) and Shannon-Wiener diversity index (H), Simpson dominant concentration (C), Sorensen community similarity coefficient (V)), the abundance of species (S) represents [6,9-10].

3. Research on Weed Seed Bank and its Research Methods

3.1 Farmland Weed Seed Bank

The litter found in the above ground of the farmland and all the weed seeds that survive in the soil are collectively referred to as the soil weed seed bank. The weed seeds in the soil do not meet the germination conditions of some seeds due to various reasons such as temperature and moisture. Therefore, they exist in the soil in the form of a seed bank, forming a soil weed seed bank [11]. The study of weed seed banks can clarify the succession of weed communities, which is of great significance for the prediction and control of weeds [12]. In recent years, the dynamics of weed seed banks under different agronomic measures, different natural conditions and different soil physical and chemical properties have been studied [13-14].

3.2 Research Methods of Farmland Weed Seed Bank

(1) Sampling method, sampling amount, sampling time

The distribution of seeds in the soil is extremely uneven in the horizontal and vertical directions. In order to obtain samples with higher accuracy, the sampling method is the basis of the experiment. There are three most commonly used sampling methods, the random method, the transect method, and the small support multiple point method [15]. The random method of sampling may make the sample square too single; the small support multiple point method is more cumbersome in actual operation, and it is also more difficult to implement. The sample line method is the most commonly used method among the three methods. This method is not only easy to operate, but also representative of sampling. Therefore, the sample line method is often used in the experiment.

The sample size of the sample square refers to two aspects: the size of the sampling area and the size of the sampling depth. At present, there has been no definite standard for the size of the sampling volume. For the sampling volume, there are three methods that are often used: a large number of small sample methods, a small number of large sample methods, and a sub-sample method of sub-unit samples within a large unit. The large-quantity sample method has the highest reliability among the three sampling methods. There are many specifications for the sampling area. The most commonly used specifications are 1m×1m, 50cm×50cm. In addition, there are 100cm×50cm, 10cm×10cm, 20cm×20cm and other specifications. In actual operation, it is determined according to the specific needs of the experiment and the characteristics of the community. The sampling depth is generally 10cm, which can be divided into 3 layers [16-17], 0~2, 2~4, 4~10cm, and some also adopt the layering method of 0~2, 2~5, 5~10cm. Part of the experiment needs to continue sampling from deeper soil layers (10-15cm, 15-20cm) [13,18-19], and there will only be a very small amount of active seeds in the deeper soil.

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Sampling time is very important, because it is related to the effect of the experiment and affects the result of the experiment. The sampling time is different mainly depending on whether to study the long-term soil seed bank or the instantaneous soil seed bank. The largest soil seed bank sampling time should be October.

(2) Identification method of seed bank

After the samples are retrieved, the species composition and density of the soil seed bank must be clarified, and the species identification and activity determination of the seeds must be carried out [11]. There are generally two methods for species identification, physical separation and seed germination.

There are two main physical separation methods: floating concentration method and mesh screening method. The effect of the floating concentration method and the mesh screening method [20] is not obvious, it is very difficult to separate the seeds, and the separated seeds may be viable, may die, or may be in the process of decay, so it is necessary to identify their viability, the process is also more difficult [11].

The seed germination method [18] is a method of cultivating the treated substrate soil and observing after the seed is retrieved. In the process of seed identification, the experimenters found that the seed germination method can save the step of identifying vigor, and the identification of seedlings is much easier than the direct identification of seeds [11]. Therefore, more than 90% of the identification methods use the seed germination method [15,21]. However, the germination conditions required for different seeds are different, so the types and numbers of seeds that may be obtained by the germination method are lower than the actual situation [11].

The two identification methods have their own advantages and disadvantages, and can complement each other. Therefore, in current practical applications, direct separation and seed germination methods are combined.

4. Weed Control Research and its Research Methods

4.1 Farmland Weed Control

Farmland weed control is to prevent and control the occurrence of field weeds through chemical, physical, biological, and integrated control methods. Farmland weeds have seriously endangered the high-yield, high-efficiency, and high-quality production of crops, and research on weed control is imperative. Although there are various weed control methods, with the development of the time, people have higher and higher requirements for food safety. Therefore, the research on weed control must keep pace with the time. At the end of the last century, the widespread use of chemical herbicides brought a series of environmental and safety issues [22]. Therefore, people began to study methods such as biological control, ecological control and integrated control, as far as possible to effectively control weeds while reducing environmental hazards [23-24].

4.2 Research Methods of Farmland Weed Control

(1) Classification of control methods

The current control methods of weeds are mainly divided into seven types: artificial weeding, mechanical weeding, physical weeding, plant quarantine, chemical weeding, biological weeding and integrated control. Manual weeding and mechanical weeding [25] are relatively primitive weeding methods, which mainly rely on manpower, animal power or mechanical traction plus farm tools to weeding, which are time-consuming and labor-intensive, and are not highly efficient. They are not suitable for intensive planting and intercropping. Physical weeding [25-27] mainly uses water, light, heat and other physical factors to weed, such as fire, flooding, and high-temperature weeding with plastic mulch. These methods may pollute the environment. Chemical weeding [28-30] is a more common method used in recent decades, with quick results and high efficiency, but the problem of pesticide residues is more serious, which not only affects food safety, but may also cause harm to other crops. Plant quarantine is a preventive measure to prevent the long-distance spread and invasion of exotic weeds. Biological weed controls [31-32]. Use insects, livestock, pathogenic microorganisms [32] and competitive replacement plants and their metabolites to control weeds, such as raising fish and ducks in rice fields, or raising geese in corn fields. Grass, this method is ecologically friendly and has a long-lasting effect, but the research is difficult and progress is slow. Comprehensive control [33] is to control weeds in combination with farming methods and various control measures, such as biological control plus straw mulching to control weeds. This method is more flexible in application and effective, but it is difficult to implement.

(2) Identification method of control effect

The control effect identification is mainly divided into two aspects, one is the safety investigation, and the other is the weeding effect investigation [34-39]. Safety investigation mainly adopts morphological observation method combined with laboratory analysis method for identification. The weeding effect is mainly to observe the field weeds every day after the application of the medicine to record the symptoms and death rates of different weeds. The sampling method usually adopts the method of small

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support and multiple points to calculate the control effect and fresh quality control effect of the plant.

5. Conclusions

The direct or indirect damage of farmland weeds to field crops has aroused people's interest in his research. However, with the deepening of research and the increasing requirements of people for environmental quality and food safety, the research on weed control has shifted from a single, inefficient, and environmentally unfriendly to efficient, ecological, lasting, and Comprehensive. Weed investigation and seed bank identification have laid a solid theoretical foundation for weed control and provided data and theoretical basis for weed control. At present, the ecological research methods adopted by the Farmland Weeds Research Institute are relatively simple, and breakthroughs and innovations are urgently needed.

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