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Significance of Cryopreservation Biotechnology for Protection of Aquatic Species

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Abstract

Cryopreservation is a method of long term storage of living cells at very low temperature mostly at the temperature of liquid nitrogen that is -196ºC. These cells are stored in those conditions in which their capabilities of movement, regeneration and reproduction should not disturb. This process is very helpful for the fish farming as preserved sperm, oocytes can be used for the off season fertilization of fish species. Cryopreservation is helpful for conservation of specific genetic traits and to extant endangered species. By cryobanking transportation of gemplasm from one farm to another farm is also become easy. In this process some chemicals are used as cryoprotectant agents like DMSO (dimethyl sulfoxide). In this review we describe both advantages and disadvantages of cryopreservation.

Keywords: Cryopreservation, Conservation, Dimethyl sulfoxide, Fertilization, Germplasm

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INTRODUCTION

Cryopreservation is defined as the long time storage of Individual living cells and biological tissues at very low temperatures, like the temperature of liquid nitrogen, usually at -196^{o}C (Bakhach, 2009). At this temperature, the cellular activities are temporarily prevented and cells can be genetically stable for a long time until needed. This procedure is very important for biomedical, clinical, species conservation and biotechnology research areas. It is a best method for preserving living tissues for long time because it's a cheap method as compared to other procedures.

Cryoinjury is the most important area of research for checking the response of cell changes according to inner and outer environment (Mazur, 1984). It also considered the properties of freezing and defrosting. Important parameters which involve in these research areas are diffusion, osmosis, Cryoprotectants, cooling and thawing process.

Cryopreservation method comprises conversion of cell maintenance media to culture media which have cryopreservation agent, like dimethyl sulfoxide (DMSO). Then Cells are cooled at temperature of -80°C in specific cooling container. After cooling cells are transferred to very low temperature storage of below -135°C. Liquid nitrogen is commonly used for this extreme low temperature.

Cryopreservation has many applied uses in fisheries and aquaculture. They are:

1. Wider transfer of gametes from one point to another point
2. Male progeny fish numbers reduced
3. Provide more time for progeny availability
4. large number of families should be conserved through Selective propagation
5. genetic resources preservation

Fish population is in alarming condition due to water pollution and overfishing. Endangered species can be preserved by cryopreservation of aquatic germplasm, and by fish farming. By these strategies genetically important characteristics can be conserved and saved from loss occur through diseases and natural disasters.

Many fish species has been preserved completely by cryopreservation of semen for propagation of many wild and domestic species. Researchers did many efforts from more than last three decades for cryopreservation of fish embryos but still they are unsuccessful (Streit et al., 2014). Successful cryopreservation of gametes, eggs, and embryos will provide a new way of completely limitless production of more vigorous and healthy generations of fish species as needed (Godoy, 2013). Genetic biodiversity of aquatic resources can be maintained by saving the Genomes of endangered species (Rana, 1995).

Cryopreservation of sperm from aquatic species

According to IUCN 5,161 aquatic species are in endangered condition and these can be recovering by using the cryopreservation methods in farming of naturally present species (IUCN Red List, 2015). Researchers are focusing on aquatic animals species for the purpose of life maintenance in controlled condition and for checking the effect of environmental pollution for future maintenance. This environmental pollution become a great risk for Killer whales (Orcinus orca) and dangerous for movement, production and strength of sperm. As a result it can create the infertility in Killer whales.

This problem was recovered by directional solidification technology and by using cryprotectant agents and glycerol (Robeck et al., 2011). This method also used for cryobanking of gametes to maintain the population of sea aquariums.

Androgenesis

Cryopreservation also used for the purpose of changing in chromosome set by stopping activity of the oocyte genome through irradiation or stop fertilization by using cold, heat or pressure shock at the first stage of mitotic division. This complete process of inactivation is called Androgenesis (Dunham, 2004; Komen & Thorgaard, 2007). This procedure is helpful for the recovery of specific species which sperms were cryopreserved by fertilizing with eggs of relevant species. This technique was successfully applied on rainbow trout (Babiak et al., 2002; Scheerer et al., 1991), sturgeon species (Grunina et al., 2006), and between fertilization of common carp and goldfish (Bercsényi et al., 1998).

Germplasm Cryobanking of aquatic species

Cryobanking of fish germplasm involve many types of cells, like sperm, eggs, oocytes, embryos, somatic cells, spermatogonia and primordial germ cells. Endangered natural reservoirs of fish species also can be saved by using Germplasm cryopreservation. The first successful cryopreservation process was done on bull semen to save and reproduce the threatened species (Polge et al., 1949). In fish Aquaculture sperm is mostly common for the propagation and administration of related species involving cyprinids, silurids, salmonid (Magyary et al., 1996; Tsvetkova et al., 1996). Cryopreservation of embryos and oocytes in aquatic species is only successful for eastern oyster eggs (*Crassostrea virginica*) (Tervit et al., 2005), and for larvae of sea urchin and eastern oyster (Paniagua-Chavez & Tiersch, 2001; Adams et al., 2006).

Fish genome is small in size, so it is best model for studying the human genetic diseases (Barbazuk et al., 2000). More than 200 fish species sperm was successfully manage and cryopreserved from marine and fresh water (Kopeika et al., 2007; Tsai et al., 2010) including carp, salmonids, catfish, cichlids, medakas, white-fish, pike, milkfish, grouper, cod, and zebrafish (Scott & Baynes, 1980; Harvey & Ashwood-Smith 1982; Stoss & Donaldson 1983; Babiak et al., 1995; Suquet et al., 2000; Van et al., 2006; Bokor et al., 2007; Tsai et al., 2010). Frozen-thawed spermatozoa have more fertility and survival power than freshwater species (Drokin, 1993; Gwo, 2000).

Tissue collection and cryopreservation

Tissue culture is necessary for getting the more tissues before cryopreservation or it is also required for reproduction of fish. It is difficult to manage all samples collectively at the time of tissue collection so these are cryopreserved as soon as possible after harvesting of tissues (Moritz & Labbe, 2008). Fish sperms and somatic cells can be saved in cryobank by collecting them in straws and cryovials. Procedures of tissue collection, culturing them and cryopreservation have been designed for different aquatic species (Lakra et al., 2011), but their response can be varied from specie to specie (Chenais et al., 2014).

Pros and Cons of Cryopreservation in Fisheries Science

Biological material can be preserved for thousands of years without damage.

Total volume of sperm can be used without any wastage.

Off-season fertilization can be done by using preserved sperms.

Transportation of germplasm is easy for farming system as compared to transport of fish.

Conservation of genetic resources of specific required traits (Cabrita et al., 2010).

Conservation of genetic material of threatened species which become very important model specie in biomedical research (Tsai, 2003; Iwai et al., 2009).

Fish gametes can be preserved from both parents for maintenance of genetic biodiversity.

Fish embryo and oocytes cannot be cryopreserved because of damage by very low temperature (Tsai & Lin, C, 2012).

Cryopreservation Quality

For getting the best results of cryopreservation evaluation of every step is necessary. This process has different steps for the quality checking is following:

- Checking the movement of sperm after collection
- After putting in extender solution
- After storage at low temperature
- After addition of cryoprotectant
- After melting of sample
- Fish quality sperm can also be checked by using software "computer-assisted sperm analysis"
- Flow cytometry and comet assay also used for checking cell characteristics and DNA quality (Daly & Tiersch, 2011).

Cryoprotectants

Cryoprotectants used to prevent damage of cells from the crystallization and recrystallization process during storage at freezing temperature. Chemicals which used as cryoprotectants are following (Meryman, 1966).

- Methanol
- Dimethyl sulfoxide (DMSO)
- Sucrose

Evaluation strategies used in cryopreservation:

There are four main stages in the cryopreservation process including condition of fish at the time of collection, preparation, cryostorage and thaw conditions of sperm at the time of usage. All these steps are given in fig 1.

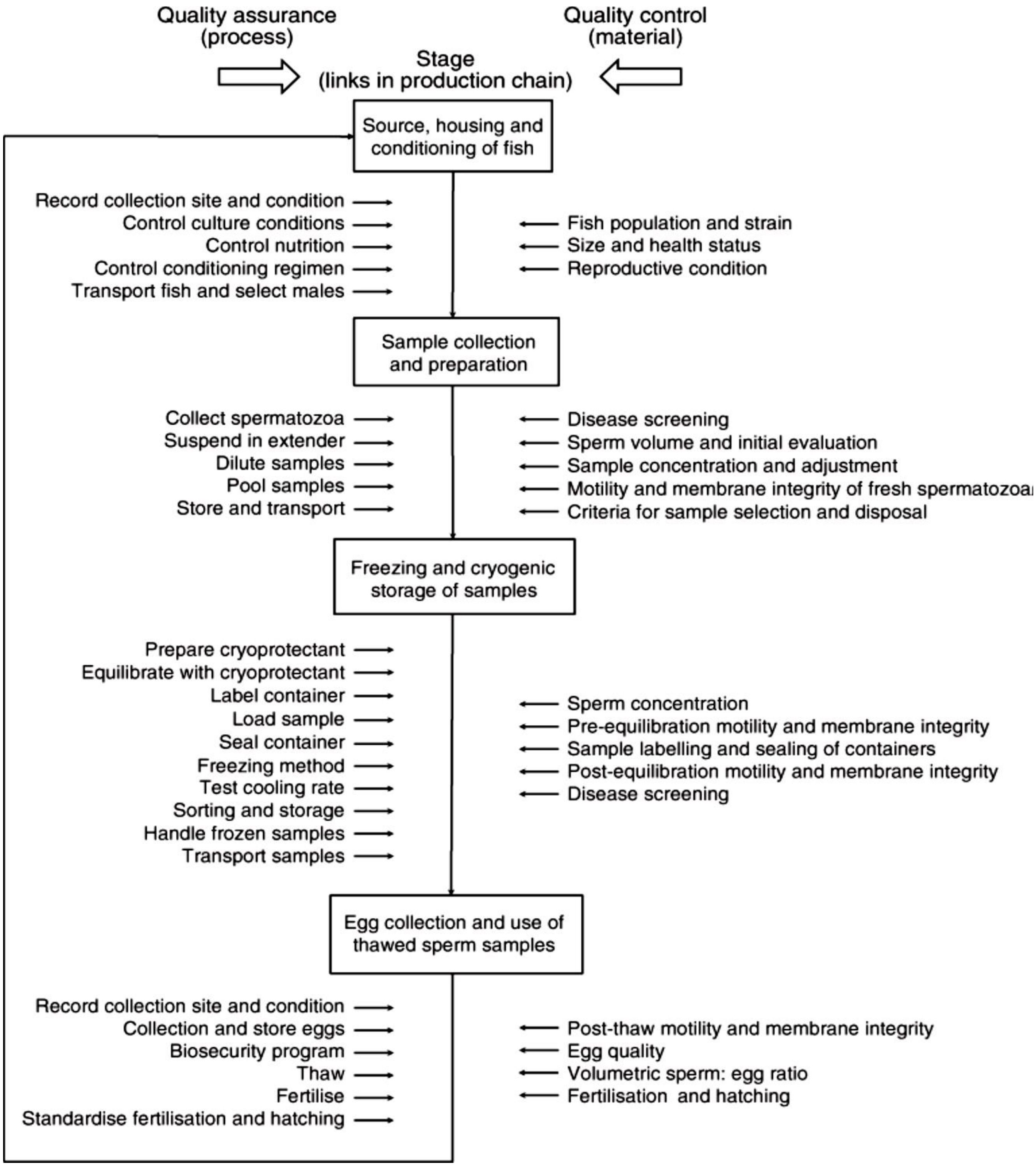

Figure 1. Key quality assurance (left) and quality control (right) activities that take place along the four main stages of the cryopreservation process (Torres et al., 2016).

Difficulties in Cryopreservation

Sometime cells are not able to use after cryopreservation due to damage of cell membrane (Kim et al., 2015; Chaytor et al., 2012). During cryopreservation two methods can create problem are slow-freezing and vitrification (Fahy et al., 1984). These processes can create crystallization, recrystallization and formation of glass solid instead of crystals inside and outside of the cell and causes the injury of cell even cryoprotectants also not enough to solve this problem (Fahy et al., 1984). Anti-freezing proteins are used to solve this problem by preventing the ice recrystallization, so it can improve the process of cryopreservation (Zilli et al., 2014).

New Trends and Future Works in the Area

Researchers are trying to find out solutions for the preservation of fish embryos and ovarian tissues. Genetic and behavioral changes of cells should be checked in Larvae and juveniles stages and even in adult form when they are exposed to cryo-solutions. Scientists are trying to find out new solutions for overcome the problems of cell damage produced by ice crystallization.

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Detecting the Chemical Changes of Sugar Beet by Using Remote Sensing Technology

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Abstract

The changes in spectral behavior of plants against chemical effects were investigated by using remote sensing and its terrestrial spectral data, in this study. Sugar beet plant was selected as test plants. The study area was split into 3 sections for the sugar beet plant and three different phosphorus fertilization were treated to these sections (300 kg P ha^{-1}, 150 kg P ha^{-1} and 0 kg P ha^{-1}). Terrestrial spectral measurements were carried out on the leaves of the sugar beets, after the development of them. The reflectance values obtained by terrestrial spectral measurement data were used as an end member in order to run spectral classification and Sentinel 2A satellite image was used for spectral classification. Vegetation indices also were produced in order to support the spectral classification results. As a result of the study, remote sensing and its terrestrial components' usability have been shown in order to prevent wrong fertilization, to increase product yield, to protect the health of the plant and soil.

Keywords: Spectroradiometer measurements, Spectral classification, Sugar beet

Research article
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INTRODUCTION

Remote sensing basically means that the information of an object is obtained without direct contact to that object. The science of remote sensing has also shown great improvement since the 1800s (Gibson, 2000). In addition, today there are many free satellite images available for remote sensing and it provides speed, practicality, and convenience in accessing the information (Gürsoy et. al., 2017; Gürsoy & Atun, 2019a; Canbaz et. al., 2018). Nowadays, the use of remote sensing has increased and the usage areas have varied with the developing technology. One of these areas is agricultural applications. Thanks to remote sensing, it has been possible to perform applications such as tracing, irrigation, fertilization, and product health quickly and effectively (Ramoelo et. al., 2015; He et al., 2016; Birdal et al., 2017).

There are many studies on agriculture by using remote sensing in today. In the study conducted by Özelkan et al. (2015), the vineyard areas in the Trakya region in Turkey were investigated by remote sensing and geographical information systems. In this context, using the remote sensing and GIS, the vineyard areas in the area of Trakya region, Tekirdağ and Tekirdağ Department of Viticulture Research Station were examined. The geographical location of the existing vineyard was determined by satellite image for this purpose. In addition, water stress and photosynthesis conditions of plants were investigated with the help of terrestrial hyperspectral remote sensing techniques and the most suitable areas for viticulture were evaluated in a GIS environment by considering various criteria.

The study carried out in 2017 by Gürsoy et al, it was treated various doses of cadmium and zinc to sugar beet plants grown in a greenhouse environment. Zinc was applied as 0 and 5.0 mg Zn / kg doses and cadmium doses were treated 0, 2.5, 5.0 and 10.0 mg Cd / kg (CuSO4). As a result of the study, the wavelength ranges in which the spectral signatures change in the electromagnetic spectrum according to the doses and the elements applied to the plants were determined.

The study conducted Yousfi et al. in 2016, wheat and bread wheat in different irrigation conditions of vegetation indices and canopy temperatures were compared to different methodological approaches. The plants were periodically observed for two years, the spectrophotometry of the plants was examined and the images were taken with traditional cameras. Canopy temperatures were measured between 12.00 and 14.00 at noon simultaneously with spectroradiometer measurements. The GA, GGA and NDVI vegetation indices were produced to investigate the status of plants. The GA and GGA vegetation indices were calculated by the images taken from the camera. NDVI index was calculated by reflectance obtained from spectroradiometer. As a result of the study, the vegetation indices obtained by traditional cameras (GA, GGA) showed a significant correlation with the NDVI calculated by the reflectance obtained by the spectroradiometer.

In this study, unlike the experiments conducted in the literature, plants treated differently doses of fertilization were classified by spectral classification algorithms by using remote sensing and its terrestrial spectral components. Subsequently, different vegetation indices were utilized in order to support the classification results and the relationships between these indices were examined. As a result, differences in the amount of fertilizer in plants could be detected by remote sensing and its terrestrial spectral components.

MATERIAL and METHODS

The study was conducted field conditions in Sivas city of Ulaş region where located in the middle of Turkey (Figure 1). The study was carried out in 2017. Sugar beet which is very important for the regional economy has been selected as the test plant.

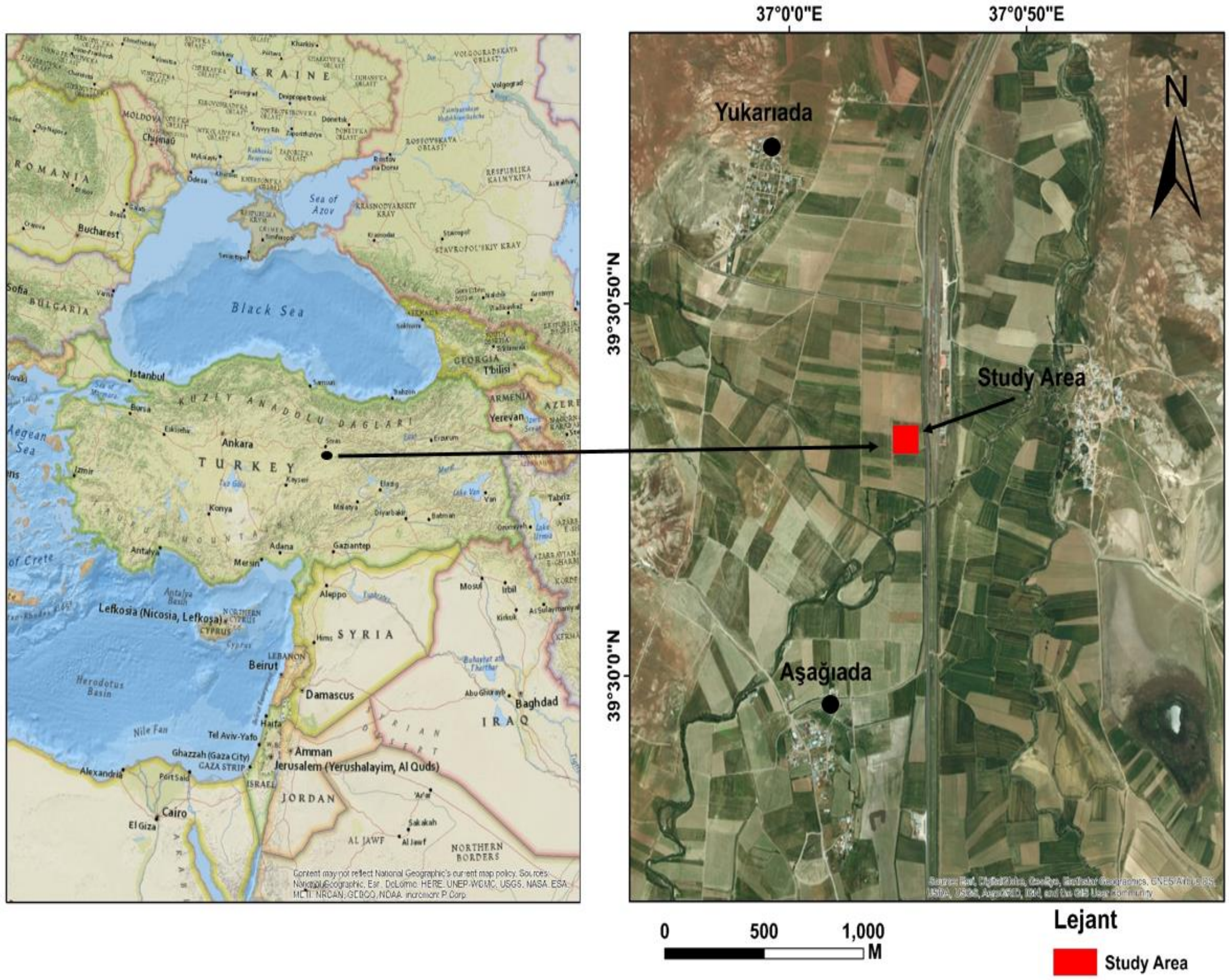

Figure 1. Study Area

Physical and chemical properties of soil structure were investigated before planting sugar beet seed (Table 1). The research was carried out in field conditions with randomized blocks as 3 replicates. The study area was divided into 3 zones and 300 kg P ha^{-1} and 150 kg P ha^{-1} phosphorus were applied to the north and middle of the region respectively. Phosphorus fertilizers weren't applied to the south of the study area. Phosphorus fertilizers were given as triple superphosphate with planting. Valentina type sugar beet seed was sown in the field after these operations.

Table 1. Physical and Chemical Properties of Soil Structure (Gürsoy & Atun, 2019b)

Soil Property	Depth (0-30 cm)
pH (H_2O)	7.42
Lime (%)	14.30
Salt (dS m^{-1})	0.41
Organic Matter (%)	1.30
Texture	CL
Total N (%)	0.10
Available P (kg ha^{-1})	53.50
Available K (kg ha^{-1})	948.10

After the plants mature, spectroradiometer measurements were performed in order to get reflectance values for each phosphorus group's sugar beets. The spectroradiometer measurements were made in order to obtain reference spectra to be used spectral classification. The measurements were carried out by Field Spec Pro 4 High - Res, which was able to measure between 350 and 2500 nm from ASD. Subsequently, these average reflectance values belonging to each phosphorus group were resampled to the band intervals of the Sentinel 2A satellite to obtain the end members to be used in the spectral classification (Table 2).

Table 2. Reflectance Resampled to Sentinel 2A Band Intervals

Wavelength (nanometer)	Mean 300 kg P ha^{-1} (micrometer)	Mean 1 50 kg P ha^{-1} (micrometer)	Mean 0 kg P ha^{-1} (micrometer)
443	0.040715	0.037593	0.019891
490	0.047850	0.045520	0.024314
560	0.095054	0.099328	0.055483
665	0.047529	0.043044	0.021635
705	0.136481	0.141598	0.083516
740	0.572003	0.604650	0.416171
783	0.730212	0.754632	0.532130
842	0.738143	0.760215	0.539149
865	0.740174	0.761540	0.541672
945	0.657524	0.683436	0.474532
1375	0.280079	0.281595	0.130788
1610	0.191399	0.186920	0.093105
2190	0.078668	0.069800	0.031734

It is necessary to make an atmospheric correction in order to reduce atmospheric, sensor and topography errors before making classification in satellite images (Canbaz et. al., 2017, Gürsoy & Kaya, 2016). Sentinel 2A, the satellite image used in the study, was provided free of charge from ESA. The image was prepared for classification by applying atmospheric correction. After the process of atmospheric correction, the resampled reflectance was used as an end member to run spectral classification.

Matched filtering, one of the most frequently used algorithm in classification has been chosen as a spectral classification algorithm. The matched filtering has been derived to remove the signal to noise ratio of a disturbed signal by noise. This algorithm is also used as the best method for detecting primary users of the transmitted signal is known (Harsanyi & Chang, 1994; Gürsoy & Atun, 2018; Gürsoy et. al., 2017).

Various vegetation indices were also used in order to support the result of the classification study. The indices were generated using spectral reflectance differences of the Sentinel 2A satellite. Vegetation indices used in the study were NDVI, CIgreen and CIrededge.

The most common vegetation index for determining plant status and vegetation is NDVI. In the NDVI index, the near infrared and red regions of the electromagnetic spectrum are used. The red and near-infrared region is a region sensitive to plants and dense vegetation (Rouse et. al., 1974; Welmann et. al., 2018; Gandhi et. al., 2015). It was produced to detect different phosphorus doses, in the scope of the study.

Green and near-infrared regions of the spectrum are used in CIgreen, which is called the green chlorophyll index (Clevers & Gitelson, 2013; Peng et. al., 2011). CIgreen was also used to display phosphorus fertilization at different doses in sugar beet.

The red region of the spectrum is utilized to generate the CIred-edge index used to estimate the amount of fertilizer and chlorophyll in plants (Clevers & Kooistra, 2012; Vina et. al., 2011). It was also utilized to monitor phosphorus fertilization at different doses in sugar beet plants.

RESULTS and DISCUSSION

As a result of the spectroradiometer measurements made in the leaves of sugar beet, the plants with the least reflectance were found to have no phosphorus applied plants. The sugar beet applied at 150 kg P ha^{-1} kg dose was the highest reflectance in most regions of the electromagnetic spectrum. In addition, increasing the application of phosphorus (300 kg P ha^{-1}) reduced reflection by comparison to 150 kg treated plants (Figure 2).

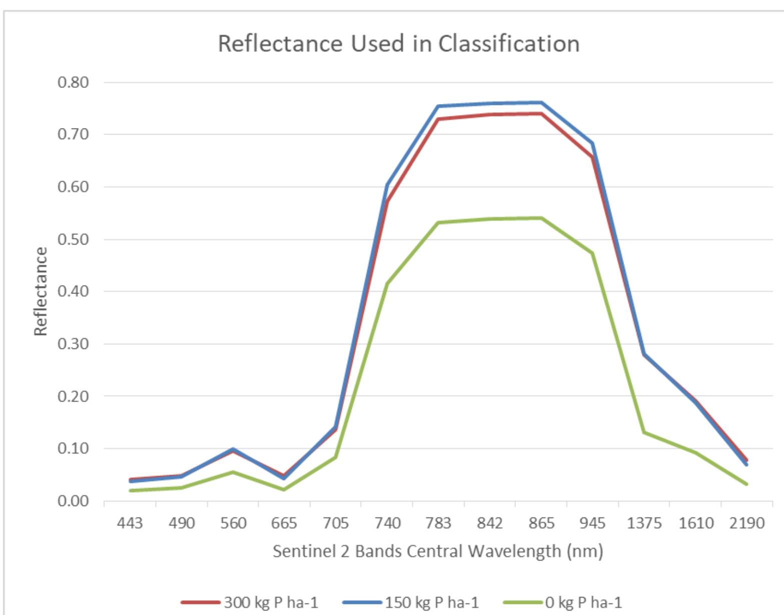

Figure 2. Mean Reflectance Values Belonging To Each Phosphorus Group

Spectral classification was performed by using the reflectance values obtained from the spectroradiometer. Sugar beet plants with different amounts of phosphorus applied were detected, with the spectral classification (Figure 3).

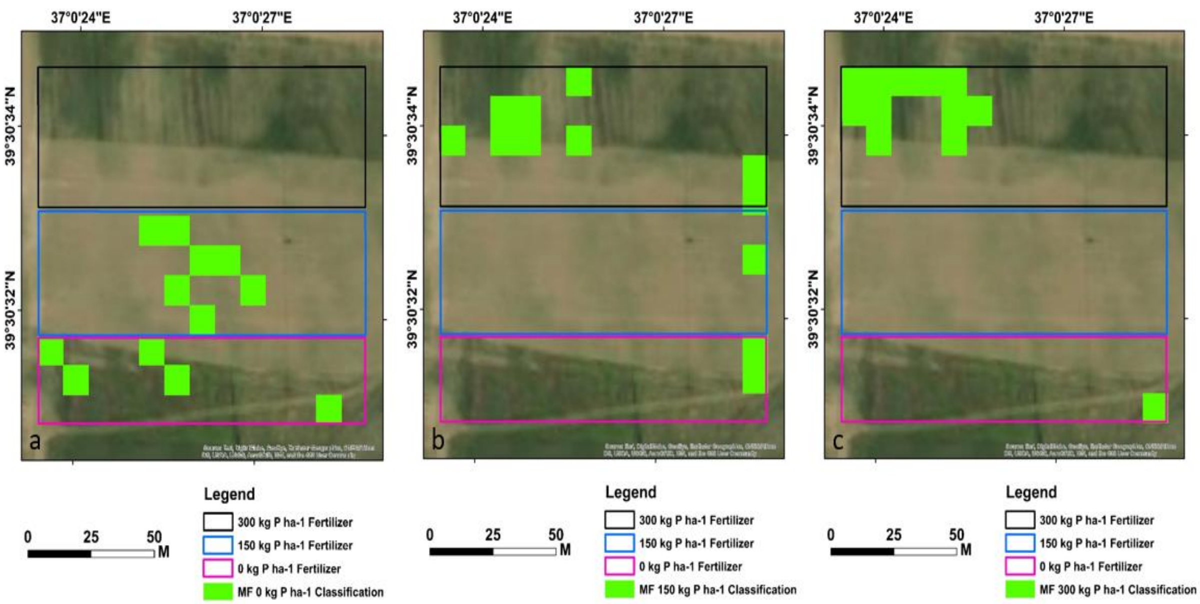

Figure 3. Spectral Classification Results of Matched Filtering. a) 0 kg P ha^{-1} kg Phosphorus Fertilizer Sugar Beets b) 150 kg P ha^{-1} kg Phosphorus Fertilizer Sugar Beets c) 300 kg P ha^{-1} kg Phosphorus Fertilizer Sugar Beets

As a result of the spectral classification, it is determined that some of the classified pixels are in non-own classes. The reason for this is that the farmer applied fertilizer to the entire area of the study field in the year prior to the start of the study. In addition, different amounts of phosphorus applied parcels are adjacent to each other in this study. Thus, phosphorus fertilizers applied in different amounts interacted with each other in the soil and the other control group also affected the sugar beet plants. This is another factor that negatively affects the outcome of the classification.

Vegetation index results showed that the index values of sugar beets that did not receive phosphorus were low. Thus, these plants could be easily distinguished from fertilized sugar beets plants. In addition, it is seen that the index values of the edge pixels of some areas where phosphorus fertilization was applied in the vegetation index maps were low. It was concluded that the phosphorus fertilizer did not penetrate sufficiently to the areas remaining at the endpoints of the study area and that the sugar beet plants were deprived of the fertilizer (Figure 4).

In addition, the correlation between vegetation indices was investigated. It was concluded that there was a high linear correlation between them (Figure 5).

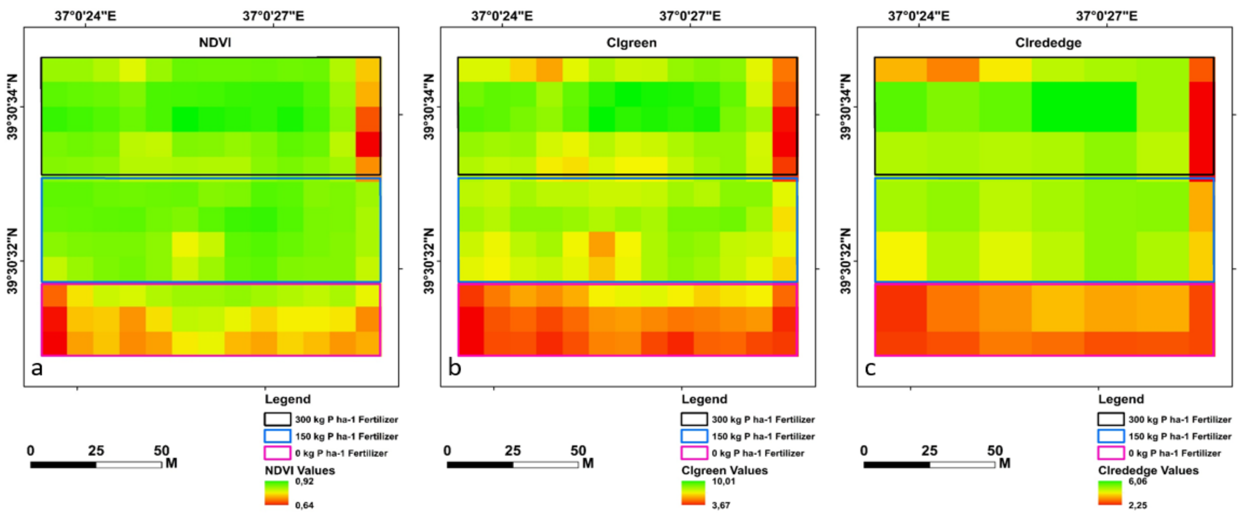

Figure 4. Vegetation Indices. a) NDVI Result b) CIgreen Result c) CIrededge Result

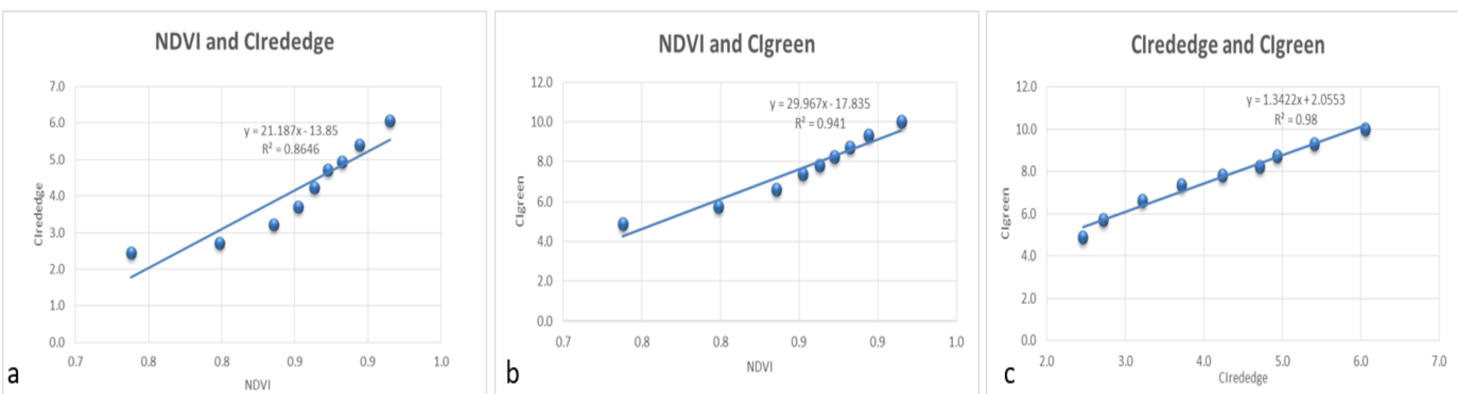

Figure 5. Correlations between Vegetation Indices. a) Correlation between NDVI and CIrededge b) Correlation between NDVI and CIgreen c) Correlation between CIrededge and CIgreen

CONCLUSIONS

As a result of the study, it has been shown that plants exposed to different amounts of fertilization doses could be detected by remote sensing and its terrestrial spectral components. It is thought that wrong fertilization could be prevented by applying the study to other agricultural lands. In addition, the effectiveness of Sentinel 2A in agricultural applications has also been demonstrated. However, it should be noted that the 10-meter spatial resolution of Sentinel 2A significantly affects the classification accuracy. It is thought that using a higher resolution satellite image or a multispectral aerial photograph will improve the accuracy. Besides, separating parcels with different amounts of fertilization, leaving more than one pixel in size, or carrying out the work in separate parcels will increase the accuracy of classification.

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Comparative Assessment of the Researcher-Managed and Farmer-Managed Onion (Allium cepa L.) Production in Sto. Domingo, Nueva Ecija, Philippines

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Abstract

A comparative assessment is a vital tool in the farmer's practice on their farm and compares the researcher's practice on how it varies in terms of its operation and productivity. It is also a good idea to assess it in a commercial scope of production. This study aimed to assess, compare, and give the farmers the recommended commercial onion production practice. This was possible through a survey conducted, assess, and compare the two management practices of growing onion crops by the researcher and the farmer-managed onion production. A survey of onion growing areas in Brgy. San Fransisco in Sto. Domingo, Nueva Ecija was done to determine the differences between the researcher-managed and farmer-managed in its farm management and operations. The survey results revealed that the researcher's technologies have done for a long time; therefore, it needs some verification to update the information. However, it is still useful to have a guide to improve the technology either on the farmers` side and to the researcher's end. Therefore, for successful adoption of the technology, it should be tested first in the specific locality before recommending it to the farmers, or the farmer should experiment on a small portion of their farm before doing it in a commercial plantation. The farmer's practiced also reveals some innovative way of doing farm activities practically and proven effective for productivity and income.

Keywords: Onion production, research, farmer's managed, net income

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INTRODUCTION

Bulb onion (Allium cepa L.), locally known as sibuyas, is probably the most indispensable culinary ingredient not only in the Philippines but probably in the world. It is a favorite seasoning, and its pungent aroma and sharp taste make it ideal for spicing up meat, salads, and vegetable dishes (https://businessdiary.com.ph/6051/onion-production-guide). It is also used to cure various physiological disorders such as cough, obesity, insomnia, hemorrhoid, and constipation. In 2019, the volume of onions produced in the Philippines was approximately 222.1 thousand metric tons. In 2018, the production value of onions in the country was about 6.7 billion Philippine pesos (Onion Production in the Philippines 2019). In Central Luzon, the top producer of red onion at 19.74 thousand metric tons accounted for 51.9 percent of the country's total production. MIMAROPA followed this with 42.4 percent, and Ilocos Region, 2.6 percent. However, the production of onion in Nueva Ecija, particularly in the municipality of Bongabon (the leading producer of onion in the Philippines and probably in Southeast Asia), is expected to increase following the introduction newer and pest-resistant varieties. Onion production fits very well in the rice farming system in selected regions of the country. These are usually grown after rice towards the dry season when water is not sufficient for another rice crop. Farmers utilize the rice straw from the previous cropping as mulching materials in allium production. They consider onion and garlic as good cash crops with high returns to investment, Lopez, and Anit (1994).

A survey and field visitation was done in Sto. Domingo being one of the onions producing areas in Nueva Ecija, to conduct a survey and focus group discussion (FGD) with the vegetable farmer leaders. The FGD group was led by a model farmer named Ging Gamboa, an Engineer who ventured into the vegetable farming business in Sto Domingo, Nueva Ecija. We interviewed two researchers from the Central Luzon State University, Science City of Munoz, Nueva Ecija, to verify their practice and ask the guide on the cultural management practices they developed for onion bulb production. A comparative assessment is an essential tool in knowing the condition of the farmer's practice in their farm and to compare the researcher's practice on how it varies in terms of its operation and management. This study aimed to assess, compare, and give the farmer's recommendations, the best practice of commercial onion production.

METHODOLOGY

The method used in the study was done by gathering ten onion farmer leaders through focus group discussion (FGD). All the information asked the farmers were guided with standard cultural management practices for onion production published by the onion researchers (Abon et al. 2015). The area was visited, and the farmers were interviewed and observed for their activities on the farm.

Figure 1. Area planted with onions one month after planting

Figure 2. Onions production using double rows planting

Figure 3. Onion plants and rice on the field

RESULTS and DISCUSSION

Table 1 present the result of the focus group discussion among the onion farmers in Sto. Domingo, Nueva Ecija, Philippines. The different cultural management practices between the researcher-managed and the farmer-managed onion production. We conducted an FGD with the farmer leader and some researchers in CLSU. We also interviewed a model and awardee farmer (Ging Gamboa) and got some reliable information. According to her, there are some practices recommended by the researchers that need to be verified. For example, the actual irrigation of the crops from planting up to harvesting during dry season cropping. It needs 13-16 times of irrigating the onion crop until harvest compared to the researcher's recommendation, which has only 5- to 8 times for clay loam soil and 8-10 times for sandy loam soil. According to (Ging Gamboa) the farmer, the practice of 5-10 times irrigation and the amount of fertilizer of 10 bags also lacks, which is impossible to produce high yield and onion quality. The technology is very location-specific that needs to be verified in a specific location before recommending it to the farmers. Mostly, some management changes from time to time, as the farmers observed in their respective farms. We also convinced the farmer's experience on how a crop is being grown in their respective farms compared to the researcher's itself because researchers only experimented once, twice, or trice compared to the farmers that did the farming for the whole life.

Also, the researcher's technologies have done for a long time; therefore, it needs some verification to update the technology's information. However, it is still useful to have a guide to improve the technology either on the farmers` side and to the researcher's end. Therefore, it must be tested first in the specific locality before recommending it to the farmers for successful adoption of the technology. The farmer should experiment on a small portion of the farm before doing it on a commercial plantation.

Table 1. Information gathered from the farmers comparing the results of the researcher's versus the farmer's practice

Particular Information	Researcher-Managed	Farmer-Managed
1. Importance of the crop to the farmers	Onion is one of the country's most important crops. Its prominence stems from its varied utilization and medicinal value, particularly in curing many physiological disorders such as hemorrhoids, constipation, and menstrual discomfort. It is also considered a potential aphrodisiac. In Nueva Ecija and Ilocos provinces, onion is a significant crop that provides a good income source among farmers.	There are two types of bulb onion grown in the Philippines, the white and the red onion. The white varieties grown for the traditional market are either the granex (flat) or the grano (round) type, short-day onions. The red varieties, on the other hand, are produced because of their long storage life. Strains of Red Creole and Red Pinoy are among the widespread varieties being grown. Bulb onions are grown in about 11,998 ha (2017), mainly in Central Luzon and the Ilocos Region. They are grown both for the local and export markets.
2. Recommended varieties used by the growers	Yellow Grannex Red Creole Red Pinoy	Hybrids Red Orient Superex Red Creole Cal 120 Red Pinoy Cal 202 BGS 95 (F1 hybrid) Liberty Capri Yellow Granex
3. Site Selection/Soil Type	The area should have dependable irrigation and transportation facilities. Soil texture suited for onion production is sandy clay or clay loam. River deltas are excellent in growing areas.	Site selection of onion production is the same between research and farmer's management. They observed that bulb onions grow well in friable and well-drained loam soil with good water holding capacity. Onion requires cooler weather during the early stages of growth and a dry atmosphere with moderately high temperature for bulb development & maturation for best growth and bulb quality. Planting can be done as early as October (red onions).
4. Growing Season 5. (the same)	The season of planting is the same between research, and farmers managed onion production. They are planted during the dry season when the water is not sufficient for rice requirements. It is grown from October to February and is generally planted after rice under Central Luzon in Nueva Ecija areas.	The season of planting is the same between research, and farmers managed onion production. They are planted during the dry season when the water is not sufficient for rice requirements. It is grown from October to February and is generally planted after rice under Central Luzon in Nueva Ecija areas.
6. Seedbed Preparation (the same)	The seedbed soil must be loose and friable. This is attained by covering the area with rice hull about 3cm thick and then burned. Plow and harrow the seedbed twice. Prepare seedbed with a dimension of 1 x 10cm and raise it to at least 15-20 cm from the ground. Sow 0.5kg of seeds per seedbed at ten seedbeds, enough for 1 hectare.	

7. Seedling Production	Mix ½ kg of seeds with ½ kg of fine soil to attain an equal distribution during sowing. Cover the seeds with a 1 cm thick rice hull. Water the seedbeds morning and afternoon for 20 days, and once-daily after that, using a sprinkler. Apply fertilizer by dissolving 50g urea per kerosene can water 14 days after emergence (DAE). Repeat the operation every two weeks. Spray insecticide when necessary during the seedling stage and water the seedbeds before pulling of seedlings.	A 1-ha production area requires ten cans (1kg/can) of seeds. A 300-500 m2 seedbed produces enough transplants for one ha. Prepare beds 1 m wide & incorporate animal manure and rice hull. Line sows 3-5 kg seeds in rows set across the bed 7-10 cm apart. Distribute seeds thinly and evenly cover the seeds lightly with compost and mulch with rice straw or grass clippings to maintain adequate soil moisture and protect the seedbed against direct sunlight and rain with nylon net removable plastic tunnels. Reduce watering and expose seedlings to full sunlight one week before transplanting.
8. Land preparation	There are three methods recommended by researchers for land preparation in onion production. 1.1 **Conventional land preparation**. Cut the rice stubbles and use them as mulch. Plow the field once and harrow twice to obtain good tilth. Cover the prepared land with mulch a week before transplanting. Construct desired trenches along the perimeter and at the center of the paddy. 1.2 **Zero tillage.** Cut the rice stubbles a week before transplanting and immediately mulch the area. Construct desired trenches along the perimeter and at the center of the paddy.	Land preparation is done one month before transplanting. The use of tractor-driven implement requires 1-2 plowing & harrowing operations. Some farmers also used carabao-drawn implements, especially those areas with less than 0.5 hectares.
9. Transplanting	Transplant one seedling per hill spaced 15cm x 15cm, 40-45days after emergence. Dibble the seedling 1cm deep. The space between rows will be provided as a canal for water irrigation.	Transplant seedlings 4-5 weeks after sowing gently uproot the seedlings to prevent root damage. Plant at a distance of 15 cm between rows & 3-5 cm between transplants can also be practiced. Use markers for proper spacing & to facilitate transplanting. After marking, use dibbles to make holes. Plant deep enough but not too profound. Care must be taken so as not to damage the basal portion of the plant. Place the white portion of the plant below the soil surface. Press the soil firmly around the basal portion. Irrigate the field before and after transplanting. We also observed some onion farmers followed a double row planting using in between rows/space for canal during water irrigation. However, the model farmer (Ging Gamboa) followed a flatbed method;

		she had a small box (kahon) 3m by 3m size planted with closed distance onion 3cm by 3cm. A small box was adopted to control water during irrigation and have evenly distributed water to the plants within the 'kahon' during irrigation.
10. Fertilizer Application	Chicken dung ten bags before planting, then two bags of urea and three bags applied 14 days after planting. Urea 2 bags and complete three bags applied at 50 days after planting.	In the absence of soil analysis, a 1-ha production area requires 8.5-11.5 bags of ammonium sulfate (21-0-0), 6.5-26.5 bags superphosphate (0-18-0), and 2-4 bags muriate of potash (0-0-60). Apply all of 0-18-0 & half of 21-0-0 & 0-0-60 as basal fertilizer. Side dressed the remaining 21-0-0 & 0-0-60 at 30, 45 & 60 days after transplanting. High nitrogen rates tend to shorten the storage life of onions. Combine herbicide application with hand weeding to produce a good quality crop.
11. Weeding and Cultivation	Weeding and cultivation are the same with research and farmer's managed. The weeding operation will start one month after transplanting. Repeat the operation as the need arises.	
12. Irrigation	Irrigate the field at various growth stages as follows: First : 3-5 days before transplanting or right after mulching. Second: two weeks after transplanting or after the first application of fertilizer Third: at the early bulbing stage (50 DAT). Fourth: at bulbing stage (60 DAT) Fifth: optional, depending on the plant condition and soil moisture status. Sandy loam soil requires 6-10 irrigation.	Bulb onions require adequate moisture for steady, continuous & desirable growth. Depending on soil types, irrigation varies between 3 & 5 days interval depending on the soil condition. Stop irrigation 2-3 weeks before harvest, or when 20-30% of the tops fold over. The last irrigation should be a light one. It needs 13-15 times for irrigation of onion from field transplanting until harvest.
13. Insect Pests and Diseases Control (the same)	Insect pests and disease control are more or less the same (Researcher-managed and Farmer-managed). They sprayed as soon as the pest appear and be repeated for ten days after or depending on infestation level. The rate of application will be followed by the manufacturer's recommendation (Table 2).	

Table 2. Pest management

Insect Pests/Diseases	Suggested Pesticides		Rate of application (tbsp/16 li water)	When and How to apply
	Common name	Product name		
A. Insect pests				
Cutworm, Armyworm	Cartap hydrochloride	Padan 50 SP	1.5 – 2.0	Spray any of these Insecticides as soon as insect pests appear.
	Profenofos			
	Lambacyhlothrin	Selectron 500 EC	3.0 – 5.0	
		Karate 2.5 EC	1.0 – 1.5	
	Lambacyhlothrin			
Leafminer, Thrips		Karate 2.5 EC	1.0 – 1.5	Repeat spraying at 10 days interval
	Thiamethoxan	Padan 50 SP	1.5 – 2.0	

		Trigard 75 WP Actara 25 WP	2.0-3.0	depending on level of insect infestation.
B. ***Diseases*** Purple blotch	Mancozeb Fluazinam Chlorothalonil Copper hydroxide	Dithane M-45 Frowncide 50 SC Daconil 75 WP Funguran-OH	4.0 – 6.0 2.0 – 3.0 4.0 -6.0 1.0 – 4.0	Start spraying when symptoms of disease appear and repeat at 7-14 days interval.
Root galls	Carbofuran	Furadan 5 G plus fresh chicken manure	1 bag + 2 tons/hectare	

Table 3. Post-harvest Handling and processing of onion bulbs

Particular Information	**Researcher-Managed**	**Farmer-Managed**
Post-harvest Handling	Trim the onion roots and leaves right after harvesting or one day after piling them under the sun. Use sharp knife or scythe and cut 4-6 cm from the bulb. Separate the small, medium, large bulb for proper sorting and marketing. Cure the bulb right after trimming by air drying at room temperature.	The bulbs will grade according to size & quality. Clean the bulbs by peeling off the outer peelings. Pack in jute or net sacks for storage and/or immediate disposal. Arrange in crates and store in a well ventilated place free from high moisture and exposure to the sun ready for transport to market.

Table 4. Cost and return analysis for 1hectare bulb type onion production. (comparing between farmer's and researcher's managed)

Quantity	**Quantity**	**Quantity**	**Unit**	**Rate/Unit**		**Value (P)**	
I. GROSS INCOME							
Researcher-managed	25,000		kg	20		**500,000**	
Farmer-managed	25,000		kg	20		**500,000**	
I. EXPENSES	**Managed by**			**Managed by**		**Managed by**	
1. LABOR	***Researcher***	***Farmer***	***the same***	***Researcher***	***Farmer***	***Researcher***	***Farmer***
Seedling production						TOTAL AMOUNT	
Seedbed preparation and sowing	4	3	MD	500	350	2000	1050
Watering/fertilizer appln	4	3	MD	500	350	2000	1050
Pulling	2	2	MD	500	350	1000	700
Land Preparation							
Plowing (once)	6	6	MD	500	350	3000	2100
Harrowing 2 times	5	4	MD	500	350	2500	1400
Cutting stubbles	10	10	MD	500	350	5000	3500

Construction of trenches	5	5	MD	500	350	2500	1750
Mulching	6	0	MD	500	350	3000	0
Planting	25	25	MD	500	350	12500	8750
Care of plants							
Weeding	20	20	MD	500	350	10000	7000
Controlling of insect pests	4	5	MD	500	350	2000	1750
Fertilizer application	5	5	MD	500	350	2500	1750
Irrigation	10	15	MD	500	350	5000	5250
Harvesting	25	25	MD	500	350	12500	8750
Trimming/curing/drying	5	5	MD	500	350	2500	1750
Sorting	5	5	MD	500	350	2500	1750
Hauling	2	2	MD	500	350	1000	700
Cleaning/sorting /packaging	10	10	MD	500	350	5000	3500
SUB-TOTAL						78,500	52,150

1.MATERIAL INPUTS							
Seeds	5	5	kg	1500	1500	7500	7500
Fertilizer							
Complete	6	6	bags	1500	1500	9000	9000
Urea	3	5	bags	1500	1500	4500	7500
Amm sulfate	0	3	bags	0	700	0	2100
Muriate of potash	0	3	bags	0	705	0	2115
Chemicals							
Karate	1	1	li	1500	1500	1500	1500
Selecron 500 EC	1	1	li	750	750	750	750
Padan 50 SP	1	1	kg	750	750	750	750
Dithane	1	1	box	450	450	450	450
Gasoline	35	35	li	60	60	2100	2100
Oil	8	8	li	200	200	1600	1600
Jute sacks	1000	1000	pcs	15	15	15000	15000
SUB-TOTAL						43150	50365
TOTAL ON LABOR & INPUTS						121,650	102,515
Overhead Expenses							
Research (Land charge [1/])						10,000	10,000
Interest on capital [2/]						17234	17234
TOTAL EXPENSES						148,884	129,749
NET INCOME per Hectare						351,116	370,251

[1/] Land charge is based on payment to Riceland, computed at 15 cavans/ha at 46kg/cavan at P15/kg

[2/] Capital is based on labor and inputs. Interest rate is 28 % per annum. Onion (Bulb type) production and marketing covers six months.

COST and RETURN ANALYSIS

The cost and return analysis was presented in Table 4. Comparing the two practices (researcher and farmer-managed), I noticed in the expenses on labor that there was a higher expenses incurred on the researcher's side because the rate of the laborer is much higher (P500.00) as compared in the farmer-managed of (P350/day) (Table 4).

However, for the inputs the farmer managed had a higher cost of inputs because the fertilizer requirements that they had adopted is higher than the researcher's practice. The farmers did not get soil analysis for laboratory to get the actual nutrient content of their soil before planting as compared to the researcher-managed area. Soil analysis is recommended to minimize loses or over application of fertilizer is controlled thus, fertilizer use efficiency will be achieved. Also the number of irrigation/watering is also higher as experienced by the farmer. Perhaps it will vary depending on the location, season, type of soil, variety used either (early or medium maturing).

According to the farmer that we interviewed it needs 13-16 times of irrigating the onion crop until harvest as compared to researcher's manage which has only 5- to 8 times and sandy loam soil needs 8-10 times. According to (Ging Gamboa) the farmer, the practice of 5-10 times irrigation as well the amount of fertilizer of 10 bags is also lacking which is impossible to produce high yield and quality onion. However, comparing the yields produce, they have the same kg produced per hectare. The basis for our computation on the yield is this: 1 tenth of a hectare (according to her, 1 pound or one can of seeds equivalent to 1/10 of a hectare. This area produced more or less 100 bags at 25 kg per bag, equivalent to 2500 kg per 1/10 area. If we convert it to hectare, we multiply it to 10, equivalent to 25,000 kg per hectare comparable to the research-managed farm. Based on the cost and return analysis (Table 4.) the yield obtained under the farmers` practice are comparable. However, the total cost of production is higher under researchers` management due to the higher daily wage given to the workers under the standard minimum wage law given by the workers.

IMPLICATIONS

Researcher's technologies have done for a long time; therefore, it needs some verification to update the information. However, it is still useful to have a guide as a basis for improving the technology either on the farmers` side and to the researcher's end. Therefore, for successful adoption of the technology, the technology must be tested first in the specific locality before recommending it to the farmers. The farmer should do the experiment on a small portion of the farm before doing it on a commercial plantation.

RECOMMENDATIONS

Based on our results of the study/observation in the farmer area, some recommendations can be shared with the farmers.

1. The fertilizer used by farmers is either higher or lower than the actual requirements. So, there's a need to analyze the soil nutrient status of the farmer's area so that fertilizer use efficiency is maximized. To do this the local government unit must help or subsidize the cost.
2. The distance of planting will also be studied as the density will affect competition with growth factors such as water, light, nutrients, and space.

3. The program of planting and crop rotation is encouraged to minimize build-ups of pests and diseases in the area; also, the soil's organic content be improved by using leguminous crops.
4. Adopt integrated pest management to minimize the use of harmful chemical pesticides, which is very harmful to the environment and animals and human beings.
5. For successful adoption of the technology, it is essential that it be tested first in the specific locality before recommending it to the farmers. The farmer should experiment with a small portion of the farm before doing it on a commercial plantation.
6. If possible, the Department of Agriculture (DA) will assist not only on the technology but also on the financial aspects, especially those farmers who have no enough money to provide during crop production.
7. The government will also consider the concern of the farmers, especially during the marketing of their produce.

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Advantages of Using the Biofertilizers in Ukrainian Agroecosystems

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Abstract

Amid growing problems of excessive application of chemical fertilizers, biofertilizers hold the potential to increase farmers' current agricultural productivity, while at the same time contributing to the soil's ability to produce more in the future. This article is part of a larger study conducted by the Université de Montréal in Ukraine with the support of Mitacs and Earth Alive Clean Technologies. The responses of user farmers and non-user farmers of biofertilizers, manufacturers or suppliers of biofertilizers, government officers and research scientists are captured to build understandings of how microbial products (biofertilizers) prove to be advantageous when applied in food crops. The agronomic advantage of biofertilizers compared to conventional chemical fertilizers is well proved biologically and in economic terms. The farmers surveyed showed interests in using biofertilizers in the future, however, both manufacturing and supply of biofertilizers are inadequate compared to the demand of microbial biofertilizers in the country. Yet, the farmers are concerned for supply of quality products have better effectiveness, longer shelf life and lesser costs.

Keywords: Biofertilizers; Biologicals; Fertilizers; Farmers' Preference; Soil Health

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INTRODUCTION

To accomplish high productivity of crops and soil, the unsustainable application of chemical fertilizers and plant protection chemicals have resulted in steady declines in soil and crop productivities the world over. Hence, agricultural practices need to evolve to sustainably meet the growing global demand for food without irreversibly damaging the world's natural resources (especially soil) while maintaining food security. Investing in sustainable agriculture is one of the most effective ways to simultaneously achieve the Sustainable Development Goals (SDGs) related to poverty and hunger, nutrition and health, education, economic and social growth, peace and security, and preserving the world's environment (Earth Alive, 2017). Amid growing problems of excessive application of chemical fertilizers, biofertilizers hold the potential to increase farmers' current agricultural productivity, while at the same time contributing to the soil's ability to produce more in the future. Several countries, such as Canada, Argentina, South Africa, Australia, USA, India and Brazil, have embraced these technologies. The list of potential commercial biofertilizer products that promise increased yield for the farmer continues to grow (Simiyu *et al.*, 2013).

A biofertilizer is a substance containing living microorganisms that are applied to seed, plant surfaces, or soil, and that colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Weyens *et al.*, 2009; Xiang *et al.*, 2012). Some common agents in biofertilizers include *Rhizobium*, *Azotobacter*, *Azospirillum*, Phosphorus solubilizing bacteria (PSB) and *Mycorrhizae*. The microbial biofertilizers have been developed to recover the soil biology and sustainability of agroecosystems. The biofertilizers contribute to the soil's ability to produce more in the future (Arjjumend *et al*., 2017). The benefits of biofertilizers have been cited as cost-effective, providing up to 25-30% of chemical fertilizer equivalent of nitrogen, providing phosphorous and potassium, increasing water absorption and keeping soil biologically active (Arjjumend, Konstantia and Warrren, 2020). The agronomic potential of plant–microbial symbioses proceeds from the analysis of their ecological impacts, which have been best studied for N-fixing (Franche, Lindstrom and Elmerich, 2009). In the soil or rhizosphere, biofertilizers generate plant nutrients such as nitrogen and phosphorous through their activities or make them available to the plants (Rajendra, Singh and Sharma, 1998).

The biofertilizers market is segmented by microorganisms into rhizobium, azotobacter, azospirillum, blue-green algae, phosphate solubilizing bacteria, mycorrhiza, and other microorganisms, by technology type into carrier enriched biofertilizers, liquid biofertilizers, and other technology types, by application into seed treatment and soil treatment, and by crop type into cereals, legumes, fruits and vegetables, plantations, and others (Arjjumend, Konstantia and Warrren, 2020). Ukraine has limited production of biofertilizer products. As the Ukrainian economy generally declined beginning in 1991, many production units were shut down, and have not been restored (Stefanovska, Pidlisnyuk and Kaya, 2006). The existing poor status of biofertilizer production and distribution, which is largely government-sponsored, indicates that the country has huge gaps between demand and supply. In Ukraine, the majority of plant nutrients, including biofertilizers and organic fertilizers, are imported, especially from China.

This article is an outcome of a larger study conducted between September 2017 and February 2020 by the authors from the Faculté de droit, Université de Montréal with the financial support from Mitacs and Earth Alive Clean Technologies. Field data collection support was provided by Department of Environmental Law, Yaroslav Mudriy National Law University of Ukraine and by several community workers in their individual capacities. The present paper focuses on advantages of using biofertilizers vis-à-vis chemical fertilizers in Ukraine. Four different groups of respondents were surveyed between April 2018 and March 2019 using methods of semi-structured interviews, structured interviews, informal discussions, and observation. The responses of user farmers and non-user farmers of biofertilizers, manufacturers or suppliers of biofertilizers, and scientists are reviewed to build cases of how microbial products (biologicals) prove to be advantageous when applied in field crops. The agronomic advantage of biofertilizers compared to conventional chemical fertilizers is biologically and economically well proven. The respondent farmers have shown their preference of biofertilizers over chemical fertilizers and have expressed willingness to adopt biofertilizers to revive their soil biology and health along with better crop yields.

MATERIALS and METHODS

The present study was conducted in Ukraine to understand scientific advantages of using biofertilizers. Several types of respondents were interviewed and observations were made in the field, apart from reviewing the pertinent literature.

Sampling and Sample Techniques

Different four respondent groups were chosen to conduct the study: Group 1 – research and development (R&D) Scientists; Group 2 – Manufacturers and Suppliers; Group 3 – User & Non-User Farmers; and Group 4 – Government Officers. Group 1 involves respondents from R&D of biofertilizers and scientists conducting research on microbial agents. These scientists were important for the study because they had explained the microbiology, biotechnology, agrochemistry of the microbial biofertilizers. Group 2 respondents include those from the manufacturing, trade and supply chain of biologicals and agrochemicals. Group 3 respondents are the farmers/cultivators/growers using or not using the biofertilizers. These farmers are direct stakeholders of this study on biofertilizers. In absence of biologicals, they may be suffering from adverse effects of chemical fertilizers. Alternatively, in event of using biologicals in their farming practices, these respondents will have experiences and opinions about various aspects of biofertilizers. Group 4 respondents included government officers involved in policy/law implementation/enforcement, some of which was informally shared by the officers, as they cannot share such information in writing or formally.

Table 1 contains the total sample size of each of the respondent groups. Names of Ukrainian oblasts are also mentioned in Table 1 for all respondent groups. In Table 2, distribution of surveyed farmers or growers is highlighted. All the proposed participants (respondents) were first contacted through telephone and/or email in order to make an appointment. Following the pre-appointments, the participants were physically visited and interviewed or interacted with.

To augment data from each respondent group, various sampling techniques were used, as indicated in Table 1. All the farmers were divided into two major distinct categories: non-users of biologicals and users of biologicals. The composition of sampling of these farmers is illustrated in Table 2.

Table 1. All the farmers were divided into two major distinct categories: non-users of biologicals and users of biologicals.

Respondent Group	*Sample Size*	*Names of Oblasts*	*Sampling Method*	*Research Method*
G.1 R&D Scientists	11	Lviv, Kiev, Ivano-Frankivsk, Kharkiv, Chernihiv	Expert, Snowball	Informal discussion; Semi-structured interview
G.2 Manufacturers and Suppliers	8	Kharkiv region	Snowball, Purposive	Semi-structured interview; Structured interview
G.3 User & Non-User Farmers	36	Ivano-Frankivsk, Kharkiv, Sumy, Luhansk	Stratified random	Semi-structured interview; Structured interview; Observation
G.4 Government Officers	8	Lviv, Kiev, Ivano-Frankivsk, Kharkiv	Purposive, Expert	Informal discussion; Semi-structured interview

Table 2. Composition of Group 3 Respondents (Farmers)

Category of Farmers	*Kharkiv*	*Sumy*	*Ivano-Frankivsk*	*Luhansk*	*Total*
Non-Users of Biologicals	3	3	3	3	12
Users of Biologicals	6	6	6	6	24
Total	9	9	9	9	36

Methods of Data Collection

As mentioned in Table 1, different data collection methods were used to augment data from different respondent groups. For instance, information from Group 1 respondents (R&D scientists) was augmented using informal discussions and semi-structured interviews through applying questions as listed in Appendix 1. On the other hand, manufacturers/suppliers (Group 2 respondents) gave their responses in accordance with the questions as listed in Appendix 2.

The data gathering methods used were semi-structured and structured interviews (Table 1). The farmers (Group 3 respondents) were surveyed by employing structured interview, semi-structured interview and observation methods (Table 1). The questions for non-users of biologicals among Group 3 respondents are listed in Table 3, whereas the questions for users of biologicals among Group 3 respondents are listed in Table 4. Similarly, Group 4 respondents (government officers) were interacted with using informal discussion and semi-structured interviews (Table 1) for the questions listed in Appendix 3.

Certificat D'approbation Éthique (Ethical Approval Certificate) and its Compliance

The Multi-Faculty Committee on Research Ethics (*Comité plurifacultaire d'éthique de la recherche - CPER)* of Université de Montréal issued Ethical Approval Certificate (no. CPER-17-114-P) to the study project. During the field data collection from all four respondent groups, the conditions of the Ethics Certificate were fulfilled and complied with. In compliance of the Ethical Certificate, the Consent Form was presented to each of the individual respondents in Ukrainian. Depending on participant preference, the appropriate Consent Form was used and signed by both the respondent and field researcher. Before conducting the interview or discussion with the respondents/participants, each individual was told the objectives of the research through an Information Sheet containing what was expected from respondent, the benefit of sharing information, confidentiality details, and the participant's right to withdraw. After adequate explanations about the research and freely given consent of the respondent/participant, the desired information was augmented from the respondent/participant.

RESULTS

The information gathered from all the respondents has been analyzed and presented to build cases of how microbial products (biologicals) prove to be advantageous when applied in field crops. Sampling of 12 farmers (3 farmers in each of 4 oblasts) using chemical fertilizers was done in Ukraine and their responses were recorded on several parameters (Table 3). The questions were chiefly regarding the disadvantages of using chemical fertilizers and the impacts they observed on their agroecosystems and human health and domestic animals from chemical fertilizers used. Likewise, 24 farmers (3 farmers using biofertilizers and 3 using biopesticides or using both in each of 4 oblasts) in Ukraine were interviewed and their answers were recorded in Table 4.

1. Soil performance under chemical fertilizers

The respondent farmers using chemical fertilizers were asked for their views on how chemical fertilizers affect the soil, plants, ecosystem and human health (Table 3). Most of these farmers gave favorable views about chemical fertilizers by stating that the chemicals improve production as the plants need nutrition and crops cannot be grown without nutrition (Table 3). Respondent scientists and officers argued that mineral fertilizers replenish the availability of nutrients in soil and maintain fertility of soil. The suppliers/manufacturers articulated that the impact of chemical fertilizers on soil depends on the quantum of chemicals being used. According to farmers, if chemical fertilizer is used in the right proportion in accordance with moisture, it is harmless to soil (Table 3).

However, other respondent farmers narrated how chemical fertilizers deteriorate the conditions of the soil. These respondents observed that, after the introduction of mineral fertilizers, the intensity of the natural conversion of atmospheric nitrogen to the compounds that can be assimilated by plants is reduced (Table 3). The mineral salt solutions are harmful to soil microorganisms that form a layer on the fertile soil, and hence the formation of humus slows down (Table 3).

Another question posed to the respondent farmers was “how does the soil get affected after application of chemical fertilizers?” (Table 3). Ukrainian farmers using chemicals advocated in favour of the fertilizers, saying that the soil restores deficient nutrients once fertilizers are applied and that only excesses of mineral fertilizers cause harmful effects on soil (Table 3). These respondent farmers noted that they use chemicals in right quantities, hence negative effects are not visible (Table 3). According to them, soil is not affected if chemical fertilizer is applied wisely in appropriate quantity as the correct dosage of fertilizers minimize the ecological footprint on the soil (Table 3). However, some respondent farmers using chemical fertilizers shared their experiences that chemical fertilizers can increase the radioactive lead Pb (^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb), which causes accumulation of heavy metals in soil and plant bodies (Table 3). The influence of chemical fertilizers on atmospheric air and water is mainly due to excessive nitrogen release. Apparently, mineral fertilizers have a negative impact on plants and on the quality of products, as well as on organisms that use it, the farmers claimed (Table 3).

2. Health and ecological risks from chemical fertilizers

In Ukraine’s four oblasts, respondent farmers using chemical fertilizers listed the common health effects of chemical fertilizers, especially on children and women (Table 3), including gastrointestinal problems, poisoning, vomiting, cancer (if residues persist), phlegm of the upper respiratory tract, rhinitis, laryngitis, bronchitis, and pneumoconiosis (Table 3). The respondent scientists explained that the enzyme system is poorly developed in children, making nitrates more dangerous for them, especially as nitrates and nitrites are carcinogens. Moreover, nitrozoamines, which have hepatotoxic properties, cause hepatitis. Some suppliers and surveyed farmers using chemical fertilizers highlighted that nitrites lead to chronic intoxication of the body, weaken the immune system, reduce mental and physical capacity, exhibit mutagenic and embryotoxic properties (Table 3). The respondent farmers using chemical fertilizers explained the ecological effects of chemical fertilizers (Table 3). They replied that chemicals take path in the human food chain. The mineral fertilizers accelerate leaching of calcium, magnesium, zinc and copper, from the soil, which affects the processes of photosynthesis and reduces the resistance of plants to diseases (Table 3). Mineral fertilizers lead to reducing soil porosity and granular aggregates and, finally, to acidification of the soil (Table 3).

Regarding the health effects of chemical fertilizers, Ukrainian farmers using biofertilizers and biopesticides suggested a list of associated sicknesses, such as asthma, skin diseases, gastrointestinal problems, toxicity among children, and miscarriages of pregnant women (Table 4). Some respondent farmers explained that mineral fertilizers are used everywhere in Ukraine and that no health issue is observed if fertilizer is used in appropriate quantity (Table 4). However, scientists, officers and other farmers explained that many chemical elements enter plants through biological processes, and that they are transformed into toxic elements. Nitrogenous fertilizers pose the greatest danger to humans and agroecosystems (Table 4).

Nitrates are especially dangerous for infants, because their enzyme base is imperfect, and recovery of methemoglobin into hemoglobin is slow (Table 4).

The question “Do you think that biofertilizers are safer compared to chemical fertilizers?” was addressed by farmers using biofertilizers and biopesticides (Table 4), who affirmed this observation. The respondent farmers reiterated that biofertilizers do not cause harm to the soil or plants (Table 4). Several respondent farmers also reported that biofertilizers remove ions of heavy metals from soil and clean the contaminated soil (Table 4).

The respondent farmers then described the comparative ecological advantage of biofertilizers, including that they are relatively safer to ecosystems as they trigger oxidation of soil (Table 4). Some of the respondents said that biofertilizers contribute to the neutralization of salts of heavy metals. These respondents compared chemical fertilizers by stating that chemicals store in soil and plant body, hence the mineral fertilizers need to be used as per strict technical prescriptions if used along with biofertilizers (Table 4).

3. Soil performance under biofertilizers

Respondent Ukrainian farmers using biofertilizers in crops were asked how the biofertilizers benefit the soil, plants, ecosystem and human health (Table 4). In the respondents' views, biofertilizers do not harm humans, plants or ecosystems. According to the surveyed government officers, biofertilizers benefit and enrich the soil as fertility increases. According to the farmers interviewed, biofertilizers stimulate plant growth and mobilize the minerals (e.g. N, Fl) to become accessible to plants and nourish soil (Table 4). The respondent manufacturers and scientists expressed their views that the chemicalization process of soil reduces because the biofertilizers are safer and have no negative impact on soil. Biofertilizers are also reported to increase plant and soil immunity while improving quality of produce (Table 4). The respondent farmers shared their observations that resistance to various diseases and to climatic variability increases following the application of microbial biofertilizers (Table 4). The farmers and government officers also explained how microorganisms deliver functions in the soil. They described that atmospheric nitrogen is fixed by microbes and transferred to plants, as microbes also synthesize a wide range of substances in soil (Table 4). According to respondent scientists, humus is increased several times because microbes of biofertilizers positively impact the enzymatic activity in the soil. Finally, the farmers indicated that biofertilizers solve salinity problems in the soil (Table 4).

The question of how the attributes of the soil change once biofertilizers are used was answered by the surveyed farmers using biofertilizers and biopesticides (Table 4). The respondent farmers expressed their views that the bacteria of biofertilizers stimulate root growth and solubilize the nutrients or minerals like phosphorus, which the plants easily digest. Plant root systems enlarge and are nourished because the microbes fix nutrients to make them accessible to plant roots (Table 4). The biofertilizers increase soil temperature by 2-5^{o}C which enhances root formation and germination of seeds. Fruiting, blooming, germination, and root formation are supported by the bacteria that feed on root secretions and release growth metabolites (Table 4). The rational use of biofertilizers contributes to obtaining environmentally friendly products, the accumulation of humus, reducing soil fatigue, improving soil structure and fertility (Table 4). According to the surveyed farmers using them, due to their biological properties, biofertilizers are absorbed by plants at a rate of almost 100 per cent, while the content of nitrates in farm produce remains minimal (Table 4).

The manufacturers/suppliers said that with prolonged use and strict application of biofertilizers, soil can improve. Farmers also stated that the bacteria feed on secretions of the root system in rhizosphere (Table 4). The respondent farmers using biofertilizers and respondent scientists articulated that biofertilizers work on a synergistic basis or on antagonism principles and, as a result, the fermentation process makes leaves and fruits of plants inedible to the pathogenic microbes.

Finally, plants becomes more resistant to pathogens, drought and frost (Table 4). The farmers disclosed an important fact that heavy metal ions are reduced from the acidic soil if microbial biofertilizers are applied (Table 4).

The same respondent farmers using biofertilizers in agriculture explained how soil becomes softer after the application of biofertilizers (Table 4). They replied that soil improves on application of biofertilizers because bacteria change the soil structure, texture, profile, fertility and productivity. The biofertilizers increase soil fertility, improve yield and quality of cultivated crops, and enhance humus formation (Table 4). These farmers also indicated that nitrogen, potassium and phosphorus are easily accessible to plants when biofertilizers are applied. Simultaneously, soil becomes resistant to fungal diseases, drought and other pathogens as biofertilizers reduce negative impacts of chemicals on soil fertility and reduce the residues by 60% (Table 4). Farmers and scientists highlighted that bacteria of the biofertilizers renew microbiocenosis of the soil, restoring the microenvironment balance of the soil. Using biofertilizers, soil becomes black, a favorable environment for growing vegetables (Table 4). A respondent farmer reiterated that biofertilizers are not efficient unless used with the chemical fertilizers (Table 4). This hints that mineral fertilizers and biofertilizers needs to be used simultaneously to get better results.

Table 3. Responses of Control Farmers/Growers (Non-Users of biofertilizers)

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
1. Soil performance under chemicals				
1.1. Do you think that chemical fertilizers affect the soil, plants, ecosystem and human health?	• Chemicals improve production • Chemical fertilizers are essential • Yes. All people talk about it	• Plants need nutrition. If chemical fertilizer is used in right proportion in accordance of moisture, it is harmless to soil. • Crops cannot be grown without chemical fertilizers	• Mineral fertilizers replenish the availability of nutrients in soil • Impact of fertilizers on soil depends on the quantum of chemicals being used • Fertilizers maintain fertility of soil	• After the introduction of mineral fertilizers, the intensity of the natural conversion of atmospheric nitrogen to the compounds that can assimilate plants is reduced. Mineral salt solutions are harmful to microorganisms that form the fertile soil layer; thus, the formation of humus is slowing down.
1.2. How does the soil get affected after application of chemical fertilizers?	• Soil is not affected if chemical fertilizer is applied wisely	• We use chemicals in right quantities. Hence negative	• Soil restores deficient nutrients once fertilizers are applied	• The fertilizers can increase the radioactive Pb which causes accumulation of heavy metals. The

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
	in appropriate quantity • Fertilizers are added more with no negative impact	effects are not visible • Excess of mineral fertilizers cause harmful effects on soil.	• Right doses of fertilizers minimize the ecological footprint on soil	influence of fertilizers on atmospheric air, water is mainly due to nitrogen formation. Mineral fertilizers have a negative impact on plants and on the quality of products, as well as on organisms that use it.
2. Investment & economic risks				
2.1. How much do/did you spend on buying chemical fertilizers and pesticides?	• UAH 6000 per ha • UAH 6000 per ha	• UAH 4500 per ha • UAH 4000 per ha	• UAH 4000 per ha • UAH 3000 per ha • UAH 4500 per ha	
2.2. Can you calculate the economic or investment risks of crop cultivation under chemicals if the crop fails due to nutrients' deficit, disease, pests, nematodes, insects, etc.?	• Huge sum	• A lot. Costs of labour, diesel, fertilizers, pesticides, tax, warehouse, transport, seed, traction, rent, etc.	• Costs of labour, equipments, repair works, diesel, fertilizers, pesticides, tax, warehouse, transport, seed, traction, rent, etc.	
3. Health and ecological risks				
3.1. What are the common health effects of chemical fertilizers? Specially on children and women.	• Gastrointestinal problems	• Excess cause poisoning, vomiting • Persisting residues can cause cancer	• Poisoning	• Phlegm of the upper respiratory tract, rhinitis, laryngitis, bronchitis, pneumoconiosis, etc.

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
				• In children, the enzyme system is poorly developed and nitrates for them are more dangerous. • Nitrates and nitrites are carcinogens. • Nitrozoamines, which have hepatotoxic properties, also cause hepatitis. • Nitrites lead to chronic intoxication of the body, weaken the immune system, reduce mental and physical capacity, exhibit mutagenic and embryotoxic properties.
3.2. Can you explain the ecological effects of chemical fertilizers?			• Chemicals take path in food chain	• Mineral fertilizers provoke leaching from the soil of calcium, magnesium, zinc, copper, manganese, etc. • Leaching affects the processes of photosynthesis, reduces the resistance of plants to diseases. • Mineral fertilizers lead to reducing soil porosity and granular aggregates. • Acidification of the soil.

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
4. Other qualitative information				
4.1. What is your preferred fertilizer?	• Ammonium Nitrate • Organic manure (not much available now because livestock farms are shutting down)	• Ammonium Nitrate • NPK • Organic fertilizers (livestock disappearing)	• Ammonium Nitrate • Nanjj Master • Complex fertilizer • Organic fertilizer	• Organic fertilizer
4.2. Do you want to use biofertilizers?	• No • Biofertilizers are ineffective in temperate non-irrigated zone	• They are ineffective • No • Expensive	• Expensive • No	• Yes
4.3. What drives you to use biofertilizers in future?	• Biofertilizer neither effective nor economic • Biofertilizers are ineffective	• They are expensive and ineffective	• Not effective	• They are not harmful
4.4.Which company/brand biofertilizer(s) do you like to use?				
5.Additional Questions				
5.1. Do you prefer locally made products or foreign products?	• Local • Both	• Local	• Local	• Local
5.2. Would you be willing to pay more for a foreign product than for a local product?	• Only if it is more effective	• No • Yes, if it is effective	• No	• Yes, if quality product
5.3. Scale 1-10: How willing are you to try a new/innovative product?	• 9 • 7 • 6	• 5 • 5	• 3 • 3 • 2	• 10

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
5.4. Which local or international organic certification do you trust?				• Organic

4. Soil-water regime under biofertilizers

Only a few farmers using biofertilizers gave a precise answer to the question "how many irrigations were required for a crop (e.g. wheat) grown without biofertilizer(s) usage?" (Table 4). Some farmers said that watering varies from 3250 m^3/ha to 4760 m^3/ha water on the fields, while other farmers responded that it needs to be 3 times a year. Corn, for instance, needs 70-80% moisture in the soil (Table 4). Some farmers replied that irrigation is not available in Ukraine and farmers depend on rains and weather. These farmers affirmed that biofertilizers reduce irrigation needs by 2 irrigations for a crop (e.g. wheat). Rain was said to be the main source of growing crops by the farmers, however, these farmers reiterated that moisture is built up in soil when biofertilizers are applied, as biofertilizers provide natural water permeability of the fertile layer of soil (Table 4).

How biofertilizers help in increasing the longevity of moisture in the soil after usage of biofertilizer(s) was explained by the respondent farmers (Table 4). The Ukrainian farmers using biofertilizers in their fields responded that moisture remains for longer in the soil and 40-70% of water is kept in rhizosphere once biofertilizers are applied (Table 4). They hinted that soil agglomerations are formed by bacterial activity in the soil making phosphates easily accessible to plants (Table 4). According to the respondent scientists and suppliers, biofertilizers synthesize biologically active substances by dissolving, for example, silicate and other substances including nitrogen, potassium and phosphorus. It humidifies soil layers while maintaining air and water permeability of soil layer (at least 60 cm deep). The farmers also reported that the coefficient of water consumption in crops such as sunflower is 450-570 (Table 4). The government officers stated that bacteria dissolve phosphorus in soil and increase the salt index level that regulates pH of the soil. It all supports plant growth.

The respondent farmers have explained how biofertilizers increase the water holding capacity of soil (Table 4). They revealed that biofertilizers help keep moisture in soil and transform microelements to be easily digestible by plants. Water needs are reduced considerably, the farmers reiterated (Table 4). The suppliers explained that biofertilizers work for 3-5 years longer than conventional mineral fertilizers. Biofertilizers also contribute to the aeration of the soil, water retention, filtration ability, and rate of cation exchange in the soil (Table 4). According to the respondent farmers using biofertilizers, bacteria recycle and dissolve intractable phosphorus in soil and make it accessible to the plants. Moreover, resistance to leaching of nutrients from the soil is built up if biofertilizers are added to the soil (Table 4). Two farmers stated that 80% of organic fertilizers wash out of the soil, whereas 15% of biofertilizers also wash out of the soil (Table 4). This reflects an understanding that microbial biofertilizers have far more durability and sustainability.

The respondent farmers have described how increased moisture content enhances nutrition intake by the plant roots (Table 4). They narrated that the bacteria of biofertilizers mobilize the accumulated phosphorus for the plant root, thereby increasing the fertility of soil and transforming nutrients to be easily absorbed by soil (Table 4). In words of respondent scientists and manufacturers/suppliers, certain bacteria strain dissolve ammonia, amino-silicate and release potassium and hard nitrogen. As a result, quality and size of grain (I & II grades) and straw improve. Potassium (30%) contained by bacteria is used by plants after death of bacteria if the biofertilizers are applied in crops/soil.

5. Comparative yield & characteristics of produce

The respondent Ukrainian farmers gave their feedback about the effect of biofertilizers on qualitative change in crop production following the use of biofertilizers. To the question "how do you measure the (comparative) crop productivities accruing after usage of biofertilizer(s)?", the farmers responded that they observed increase in yields and quality production of crops they grow (Table 4). A farmer pointed out that this increased yield and production is approximately 10% after using biofertilizers (Table 4). One respondent farmer reported this increase by 6.11 ton/ha of corn (Table 4). Some respondent farmers stated that they did not calculate the benefits accruing from using biofertilizers, while others opined that the size of the harvest depends on the density of productive stalk and mass of grain from one ear, and that biofertilizers boost all that (Table 4).

The traits of farm produce, such as taste, color, quantity, and shelf-life, may also change when using biofertilizers. Accordingly, the respondent farmers were asked "how is the farm produce (grains, fruits, tubers) different when biofertilizer(s) used?" (Table 4). According to these respondents, biofertilizers result in beneficial impacts on farm produce as the plants grow better in a number of aspects (Table 4). For example, use of *Bacillus amyloliquefaciens* increase yield by 10%. Likewise, *Actinomycetes* inhibit the growth of pathogens and stubble (Table 4). In fact, bacteria help the plants produce higher growth by mobilizing the vitamins, carotenes, proteins and increasing qualitative indicators of plants (Table 4). These farmers also confirmed that plant products get saturated color and better quality once biofertilizers are applied (Table 4).

Table 4. Responses of Farmers/Growers (Users of Biofertilizers)

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
1.Soil performance under biologicals				
1.1 Do you think that **biofertilizers** benefit the soil, plants, ecosystem and human health? In what way?	• Yes. They do not harm to human or plants or ecosystem. • Biofertilizers benefit the earth • Chemicalization of soil reduces • Biofertilizers are safer	• They increase plant immunity and yield quality • Air nitrogen is fixed by microbes and availed to plants • Quality of yield improves	• They make plant more resistant • Biofertilizers have no negative impact on soil • Microbes synthesize wide range of substances in soil and help plants	• Plant nutrition • Resistance to various diseases • Rresistance to unfavorable soil and climatic conditions. • They help to form healthy and strong plants

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
	• Soil fertility increases • They enrich soil with minerals and protect soil • Minerals (e.g. N, Fl) become accessible to plants • Inoculants are used	• Nutrients are made accessible to plants • Beneficial for soil • They increase soil immunity and minerals • They impact positively the enzymatic activity • They protect and nourish soil and plant	• Humus is increased several times • Immunity of the soil is increased • Soil fertility increases	• They solve salinity of the soil • They improve the properties of the soil • They transform, revive the exhausted earth, rocky, sandy, contaminated soil • They stimulate plant growth
1.2 May you describe the changed attributes of the soil once biofertilizers are used?	• Bacteria stimulate the root growth and solubilize the nutrients like phosphorus, which the plants easily digest. Pathogens are expelled out. • Root system enlarges • Plant becomes more resistant to drought and frost • They work on synergistic basis or on antagonism principles • Soil becomes more nutritious • They fix nutrients to make them accessible to plants	• With prolonged use and strict application methods, soil can improve • In rhizosphere, the bacteria feed on secretions of root system • Pathogens do not develop • Fermentation process makes leaves and fruits of plants inedible to the pathogenic microbes • They increase soil temperature by 2-5°C which enhances root formation and germination • Biofertilizers make minerals	• Nutrients are absorbed in the soil in presence of bacteria • Roots are nourished and supported • Plant growth is stimulated • No harmful effects on plants and soil • Heavy metal ions are reduced from the acidic soil • Fruiting, blooming, germination are supported • They are not toxic •	• The rational use of bio-fertilizers contributes to obtaining environmentally friendly products, the accumulation of humus, reducing soil fatigue, improving soil structure and fertility • Biofertilizers, due to their biological properties, are absorbed by plants by almost 100%, while the content of nitrates in products is minimal

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
		accessible to plants • Bacteria feed on root secretions and release growth metabolites		
1.3 Has the soil become softer after application of biofertilizers? If yes, can you explain the reasons behind this?	• Yes. Soil improves on application of biofertilizers. • Biofertilizers are not efficient unless used with the chemical fertilizers • Soil becomes resistant to fungal diseases and drought • Soil indicators improve and fertility increases • Biofertilizers reduce negative impacts of chemicals on soil fertility and reduce the residues by 60% • Soil becomes stronger	• Bacterial change the soil structure • Bacteria colonize the soil and prevent pathogens • Soil becomes more nutritious • Bacteria renew microbiocenosis of the soil • Bacteria contribute to the productivity and fertility of soil	• Biopesticides are not used because they are less effective • In drought, bacteria do not work properly • Resistance of plants to disease and pests increases • Microenvironment balance of the soil is restored • Root system is supported • Humus formation is enhanced	• Yes • Soil becomes black soil, a favorable environment for growing vegetables • It increases soil fertility, improves yield and quality of cultivated crops • They do not change the composition of the soil and are safe for the environment and humans • Organic fertilizers are easily digested by crops. Nitrogen, potassium and phosphorus, in the composition of biofertilizers, are in an easily accessible form for plants

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
2. Soil-water regime under biologicals (especially biofertilizers)				
2.1 How many irrigations were required for a crop (e.g. wheat) grown <u>without</u> biofertilizer(s) usage? Crop-wise data	• Sprinkler watering. No count available • Drought resistant grains	• No irrigation	• It depends on weather conditions • No irrigation • Corn, for instance, needs 70-80% moisture. Level of moisture in soil depends on weather conditions. • Watering varies from 3250-4760 m^3/ha on the fields	• Rainfed agriculture • Irrigation 3 times a year
2.2 How many irrigations are required for a crop (e.g. wheat) grown <u>with</u> biofertilizer(s) usage? Crop-wise data	• Weather dependent • Rains dependent. 0-100 cm moisture in 2016 • Biofertilizers reduce irrigation needs by 2 times at least		• Moisture is built up when biofertilizers are applied • Biofertilizers provide natural water permeability of the fertile layer of soil • Watering 2-3 times less • 2 less watering	• 2 irrigations
2.3 Can you tell about the <u>longevity of moisture</u> in the soil before and after usage of biofertilizer(s)? If possible, crop-wise data	• Coefficient of water consumption in sunflower is 450-570		• Moisture remains for longer • Bacterial dissolve phosphorus in soil and increase salt index level that regulates pH	

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
2.4 How do biofertilizers help the soil in summer and dry season?	• Phosphates become solubilized • Soil agglomerations are formed by bacterial activity • Biofertilizers synthesize biologically active substances	• Accumulation of phosphorus is easily accessible to plants • 40-70% water is kept in root area	• Bacteria dissolve silicate and other substances including nitrogen, potassium and phosphorus • Microbes make a humidified layer on soil • Air and water permeability of soil layer is maintained (at least 60 cm deep)	• Biofertilizers retain moisture more
2.5 Can you explain how biofertilizers increase water holding capacity of soil?	• Biofertilizers help keep moisture in soil and they transform microelements into easily digestible to plants • Water needs are reduced considerably	• Bacteria need moisture, which is built in the soil	• Bacteria recycle and dissolve phosphorus in soil and make accessible to the plants • Bacterial fix the intractable phosphorus	• Resistance to leaching of nutrients from the soil • 80% of organic fertilizers are washed out of the soil • 15% of biofertilizers are washed out of the soil • Biofertilizer on the field will work for 3-5 years longer than conventional fertilizers • Biofertilizer contributes to the improvement of aeration of soil,

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
				water retention and filtration ability, increases the rate of cation exchange
2.6 May you describe how increased moisture content enhances nutrition intake by the plant roots?	• Biofertilizers increase fertility of soil and transform nutrients to be absorbed easily by soil • Soil fertility increases • Correlation of grain and straw matters • Quality and size of grain improve. Grains of I & II grade are produced	• Bacteria mobilize the accumulated phosphorus for the plant roots	• Moisture increases where microbes work • Certain bacteria strain dissolve ammonia, aminosilicate releasing potassium and hard nitrogen. 30% of potassium in ash of bacteria. • Potassium is used by plants after death of bacteria. • Minerals are also accumulated in soil.	
3. Comparative yield & characteristics of produce				
3.1 How do you measure the (comparative) crop productivities accruing after usage of biofertilizer(s)?	• Ammonium nitrate (34.4%) – 600 UAH/50 kg • Humate LF20, microelements 20l – 1550 UAH	• Size of the harvest depends on the density of productive stalk and a mass of grain from one ear • Seeds are treated with inoculants • Biofertilizer-caused profits are not calculated	• Pre-sowing treatment of seeds • Quality of crops improve • Productivity of winter wheat increases by 10% • 6.11 ton/ha of corn	

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
3.2 How is the farm produce (grains, fruits, tubers) different when biofertilizer(s) used? [taste, color, quantity, shelf-life, etc.]	• Organic products without nitrates • Treatment of seeds • Use of Bacillus amyloliquefaciens increase yield by 10%	• Stubble destruction • Thickness of production is measured • Actinomycetes inhibit the growth of pathogens	• Bacteria help the plants produce higher growth • They mobilize vitamins, carotenes, proteins and increase qualitative indicators of plants • Plants product get saturated color and better quality • Quality of product is improved • No impact on gustatory traits of corn	
4.Comparative investment & economic risks				
4.1 How much do/did you spend on buying chemical fertilizers and pesticides?	• UAH 130 per kg for processing of seed cereals • 2-3 times more • UAH 7500/ha • UAH 8500/ha	• UAH 8500-10000 per ha • 350 kg fertilizer per ha • 6800-10000 kg ammonium nitrate per ha • UAH 7000-9000 • Ammonium nitrate – UAH 6800 per ton • Unical – 314.8 UAH per litre • Total – UAH 7500 per ha	• UAH 5000-6000 per ha • UAH 8000 per ha • UAH 8000-9000 per ha • UAH 5000 per ha • UAH 8000 per ha	
4.2 How much do/did you spend on buying biofertilizers	• 1 kg per 5 ton seeds • Biofertilizers cost more than mineral fertilizers	• UAH 2000 • PMK – U – 1395 UAH/canister	• UAH 4000 per ha	

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
and biopesticides?	• Organic fertilizers no more available due to declining livestock	• Biospore – 1317.5 UAH per canister • Humate LF20 – 1550 UAH/ canister		
4.3 Can you calculate the economic or investment risks of crop cultivation under chemicals if the crop fails due to nutrients' deficit, disease, pests, nematodes, insects, etc.?	• Efficiency of biofertilizer directly depends on usage methods • Use of biofertilizers needs systematic and constant application	• When biologicals are used systematically and properly, the yield and production are higher • Dry soil lead to economic loss		
4.4 What investment or economic risks are involved if the crops grown by using biologicals?	• Biologicals are less effective. They need very careful usage methods • Biologicals do not work in dry soil. Hence inoculants are used	• Bacterial products do not work effectively if not used side by side mineral fertilizers and organic fertilizers		
4.5 Comparison of risks between both situations	• Any fertilizer needs proper and careful application methodology	• Bacteria may not survive for longer. Short shelf life is a risk.		
5. Comparative health and ecological risks				
5.1 What are the common health effects of	• Asthma among children	• Chemical fertilizers are necessary to	• Mineral fertilizers are used	• Many chemical elements enter the plant through

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
chemical fertilizers? Examples	• Skin diseases	grow cereal crops. Yet, they need to be used wisely. • Gastrointestinal problems • Toxins in children	everywhere in Ukraine • No health issue if fertilizer is used in appropriate quantity	biological processes • They are transformed into toxic elements • Nitrogenous fertilizers pose the greatest danger to humans • Nitrates are especially dangerous for infants, because their enzyme base is imperfect, and recovery of methemoglobin into hemoglobin is slow • Pregnant women have miscarriages
5.2 Do you think that biofertilizers are safer compared to chemical fertilizers?	• Impacts of chemicals reducing • Yes	• Yes • Farmers use mineral fertilizers recklessly	• Yes • They do not cause harm • They remove ions of heavy metals from soil	• They do not harm the soil
5.3 What is comparative ecological advantage of biofertilizers?	• Biofertilizers are relatively safe to ecosystems • Chemicals store in soil and plant body	• Bacterial form humus in the soil from available organic matter	• Mineral fertilizers need to be used as per technical prescriptions • They contribute to neutralization of salts of heavy metals • Biofertilizers trigger soil oxidation.	• To fertilize a certain plot, less mineral fertilizers are required

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
6.Other qualitative information about farmer's preferences				
6.1 What is preferred fertilizer?	• Ammonium nitrate • Unical			• Any fertilizer for soil replenishment
6.2 Is biofertilizer preferred over chemical fertilizer? Why?	• Both have pros and cons • Biofertilizers are preferred. But they are expensive and they give results after using 2-3 years of application. • Root system of plants is developed and immunity is enhanced	• Yes • Safe • Yes. They develop root system and increase immunity	• Soil is humidified • No chemical formation • Yes • Check degradation of soil	• Improvement of soil quality
6.3 Are chemical fertilizers and biofertilizer(s) used simultaneously?	• Yes • Effective if used simultaneously	• They work better if used together • Yes	• Yes	
6.4 What are perceived or recorded advantages of using biofertilizers?	• Biofertilizers are expensive • Soil fertility and immunity increased • Quality of soil and produce improve • Amount of chemicals is reduced after using biofertilizers	• Quality of wheat grade – 1 improves	• Yield increase • Quality improvement • Nitrogen and phosphorus sequestration	• High biological activity to susceptible species of pests • Manifest in the death of pests in subsequent phases of development • Selectivity of action • Safety for entomophagus and pollinating insects

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
				• Resistance to insects and pathogens • Resistance to biopreparations • Lack of phytotoxicity and effects on taste • Low waiting time • No risk of toxicity accumulation in the environment
6.5 What drives you to spend on biofertilizers?	• Biofertilizers reduce the impact of chemicals on soil, plants and human health • Stress resistance of plants increased • Better yields of sunflower	• They improve the quality of produce • Wheat yield increases by 80%	• Plants are strengthened • Resistance of plants is improved • Increase of yields • Qualitative products are obtained	• Yes, • Increasing the yield of agricultural products • Protecting the soil from harmful substances
6.6 Which company/brand biofertilizer(s) do you use or like to use?	• Agritema	• Baikal EM-1 • Ecolife Odessa • BIOLAND • Enzyme Agro • Bayer • Life Force Ukraine	• Life Force Ukraine • Humate K • PMK	• Biostimulator SVIT BINFIELD AGRO TECHNOLOGY
7.Additional Questions				
7.1 Do you prefer locally made products or foreign products (biofertilizers or biopesticides)?	• Local • Foreign	• Both • Local	• Both • Local	• Local

Questions	*Kharkiv*	*Luhansk*	*Sumi*	*Ivano-Frankivsk*
7.2 Would you be willing to pay more for a foreign product than for a local product?	• It depends on economic benefits • French products	• If effective, we can pay high price for foreign products too • We are satisfied with products of Life Force	• Local products have problems • Foreign product should be affordable and effective • Constant problems	• Yes • No
7.3 Scale 1-10: How willing are you to try a new/innovative product?	• 8 • 10 • 8 • 7 • 9 • 10	• 9 • 8 • 7 • 8 • 5 • 6	• 6 • 6 • 7 • 7 • 8 • 6	• 5 • 10 • 2 • 10
7.4 Which local or international organic certification do you trust?	• Both	• Local	• International	• ECO Control • EU Organic Bio
7.5 What soil amendment products do you currently use?	• Humate, N, K	• Biocomplex BTU • Agritema • Bayer • Humate, K, Na	• Enzim State Enterprise, BTU-Center Private Enterprise	
7.6 Are you experiencing problems with impoverished soil?	• No	• Soil in Ukraine is losing fertility very fast • Destruction of stubble • Soil fertility is decreasing	• Destruction of stubble	• Yes constantly

6. Comparative investment and economic risks

The respondent Ukrainian user farmers of chemical fertilizers were asked how much they spend on chemical fertilizers and pesticides (Table 3). Seven farmers gave the rough estimate of expenditures of an average UAH 457.15 per hectare (Table 3). From among 24 respondent farmers in Ukraine who use biofertilizers and biopesticides, 11 farmers gave figures of their expenditure on chemical fertilizers and pesticides. Their spending ranged from UAH 5000 to UAH 9250 per annum per hectare (with an average of UAH 7504 per annum per hectare) on chemicals (Table 4).

Some respondent farmers provided information slightly different than the question posed yet still informative. For instance, one respondent farmer said that UAH 130 were spent on processing seeds, while other farmers stated that 350 kg of chemical fertilizer was required (Table 4) and that 8400 kg ammonium nitrate per ha was needed. Similarly, one respondent farmer stated that the cost of unical was UAH 314.8 per litre, but did not provide the quantity used (Table 4). However, another respondent farmer suggested that chemical fertilizers cost 2-3 times more than biofertilizers or organic fertilizers (Table 4).

The respondent Ukrainian farmers using biofertilizers and biopesticides did not properly describe their expenditure on buying the biofertilizers and biopesticides (Table 4). Several respondent farmers said that biofertilizers cost more than mineral fertilizers, which is absolutely incorrect. It has been established that the per unit price of biofertilizer is quite higher than that of chemical fertilizer, but, expenditure per unit area of land is far less. One respondent farmer could not differentiate between biofertilizer and organic fertilizer, and hence said that organic fertilizers are no longer available due to declining livestock in Ukraine (Table 4). Another respondent farmer stated the price of biospore (UAH 1317.5 per canister), another stated the price of PMK–U (UAH 1395 per canister) and yet another stated the price of humate LF20 (UAH 1550 per canister). However, two respondent farmers indicated that UAH 2000 and 4000 per hectare per annum expenditure are needed to purchase biofertilizers and biopesticides, respectively (Table 4). This amount comes to an average of UAH 3000 per hectare per annum. Comparing the average spending on biologicals, this expenditure of UAH 3000 per annum on biofertilizers/biopesticides (Table 4) is far less than the respondent farmers' average expenditure of UAH 7504 on chemical fertilizers and pesticides.

Surveyed Ukrainian farmers using chemical fertilizers provided no exact calculation of the economic or investment risks of crop cultivation with chemicals if the crop fails due to nutrients' deficit, disease, pests, nematodes, or insects. (Table 3). The respondents replied using concepts such as 'huge sum and a lot' and referred to a number of costs, such as labour, diesel, fertilizers, pesticides, tax, warehouse, transport, seed, traction, rent, equipments, repair works, and fertilizers (Table 3). Like users of chemical fertilizers, the users of biofertilizers and biopesticides were also asked the question, "can you calculate the economic or investment risks of crop cultivation under chemicals if the crop fails due to nutrients' deficit, disease, pests, nematodes, insects, etc.?" The respondent Ukrainian farmers stated that the efficiency of biofertilizer directly depends on usage methods and usage needs systematic and constant application (Table 4). They also stated that, when biologicals are used systematically and properly, the yield and production are higher (Table 4).

The question "what investment or economic risks are involved if the crops are grown by using biologicals?" was answered by the respondent farmers using biofertilizers and biopesticides. The respondents opined that biologicals are less effective and do not work in dry soil (Table 4), hence inoculants are used by farmers. Several farmers further stated that bacterial products do not work effectively if not used side by side with mineral and organic fertilizers because they require very careful usage methods (Table 4). Moreover, they presented their views that bacteria may not survive for longer as its shelf life is short, which is risky (Table 4).

7. Farmers' preferences for fertilizers and biofertilizers

The respondent farmers who were users of chemicals fertilizers were asked for their preferences of using fertilizers and their potential preferences should biofertilizers be offered to them (Table 3). Similarly, respondent users of biofertilizers also expressed their preferences (Table 4). Usage of chemicals in crops indicates that most of the nutrients are nitrogen, phosphorus and potash. Ammonium nitrate, unical and complex fertilizer are reported as major sources of nitrogen (Table 3; Table 4). Micronutrients and calcium or magnesium attained least priority. However, organic manure and organic fertilizer are two reported sources of humus content for the soil (Table 3). According to government officers, however, not much humus is available in Ukraine now because livestock farms are shutting down and livestock are disappearing fast.

Through the question, "do you want to use biofertilizers?", the willingness of respondent farmers to use biofertilizers was understood. With the exception of 1-2 respondent farmers, respondents failed to demonstrate a firm willingness to use biofertilizers. Some respondents argued that biofertilizers are ineffective in temperate and non-irrigated zones, while others simply stated it was too expensive to use (Table 3). What would drive them to use biofertilizers in the future also generated negative responses by Ukrainian farmers using chemical fertilizers (Table 3). Their answers were the same – biofertilizers are neither effective nor economic. However, several respondent farmers argued that biofertilizers are not harmful and can be beneficial (Table 3).

The reasons for preferring biofertilizers over chemical fertilizers were explored with the respondent farmers using biofertilizers (Table 4). They responded that the root system of plants is developed, and immunity is enhanced, once biofertilizers are used (Table 4), and that the biofertilizers check the degradation of soil and improve quality of soil as well as plants (Table 4). Chemicalization of the soil does not take place. However, one respondent farmer expressed the view that both chemical fertilizer and biofertilizer are expensive and they give results after using 2-3 years of application (Table 4). The respondent farmers also confirmed that they use chemical fertilizers and biofertilizer(s) simultaneously (Table 4). Biofertilizers give effective results if used simultaneously (Table 4).

The respondent Ukrainian farmers using biofertilizers disclosed the perceived or recorded advantages of using biofertilizers (Table 4). According to the respondent farmers, soil fertility/quality and plant immunity/yield increased with improved quality of wheat grade-I (Table 4). They also reported that the amount of chemicals needed is reduced after using biofertilizers, which promote nitrogen and phosphorus sequestration. Moreover, plant protection functions are also delivered by biofertilizers, which trigger high biological activity to susceptible species of pests (Table 4). This manifests in the death of pests in subsequent phases of development, while ensuring safety for entomophagus and pollinating insects. After all, biofertilizers build resistance to insects and pathogens with lack of phytotoxicity and no risk of toxicity accumulation in the environment (Table 4).

The factors which drive respondent user farmers to purchase biofertilizers include their being economically cheaper, poison free, and ecologically safe. The farmers using biofertilizers suggested that plants are strengthened with increased resistance through using biofertilizers. Moreover, biofertilizers reduce the impact of chemicals on soil, plants and human health (Table 4). These respondent farmers stated that crops, like sunflower, produce better yields (80% increase) and better quality of grains, fruits and tubers, and forage (Table 4).

The surveyed farmers using biofertilizers provided the names of some manufacturers of biofertilizers which they prefer, including Agritema, Baikal EM-1, Ecolife Odessa, BIOLAND, Enzyme Agro, Bayer, Life Force Ukraine, Humate K, PMK, Biostimulator and SVIT Binfield Agro Technology (Table 4).

Potential preferences of respondent farmers regarding the use of local or foreign products (biofertilizers) were identified through interview questions. Most of the respondent farmers showed preferences for using local biofertilizers (Table 3). Only a few respondent farmers preferred both local and foreign made products (Table 3). Similarly, respondent user farmers of biofertilizers gave their preferences as to both local and international products (Table 4). However, many respondent farmers have shown no preference to pay more for a foreign product rather than for a local product (Table 3). Yet, majority of respondent farmers stated that they could pay more for foreign products if they are relatively more effective and their quality is better (Table 3). In the same fashion, respondent farmers using biofertilizers were asked the question, “would you be willing to pay more for a foreign product than for a local product?” There was a mixed response on this issue. The majority of respondent farmers using biofertilizers showed willingness to use a foreign product (Table 4), although many of them stated that this willingness was conditional. They expressed that preference for biofertilizers depends on economic benefits, effectiveness, affordability, and other qualitative traits (Table 4). One respondent farmer refused to accept foreign products due to satisfaction with products of Life Force company (Table 4).

The respondent farmers’ willingness scale to try a new/innovative product was probed as well. Out of 12 surveyed farmers, 9 farmers opted to share their willingness on a total 10-point scale (Table 3), with the average of 5.55 out of 10-point scale (Table 3). It is significant that more than half of the respondent farmers have a willingness to use biofertilizers in the future. Likewise, all 21 respondent farmers from the 4 different oblasts of Ukraine shared their willingness to try a new/innovative product on 10-point scale (Table 4). Their average score on this scale was 7.3 (Table 4). This score is higher than the respondent farmers using only chemical fertilizers, which may be because the users of biofertilizers have already adopted new products and innovations and thus are more willing to try another set of innovations.

As certification and standards are key to the acceptance and preference of biofertilizers, respondent farmers using chemical fertilizers were surveyed, but they did not provide responses (Table 3). The same was true of respondent farmers using biofertilizers (Table 4). Together, they have equal trust in both kinds of certifications and standards. They noted the names of the two trusted certifications – ECO Control (Ukrainian) and EU Organic Bio (international) (Table 4). Respondent Ukrainian users of biofertilizers informed that they exclusively use soil amendment products such as Humate, Biocomplex BTU, Agritema products, Bayer products, K, Na, and Enzim (Table 4). The respondent farmers using biofertilizers shared their experiences concerning problems they are facing with impoverished soil (Table 4). Some respondent farmers answered negatively, while others stated that soil in Ukraine is losing fertility very fast and they are constantly facing difficulties (Table 4).

DISCUSSION

1. Soil performance under chemical fertilizers

Chemical fertilizers affect soil, plants, ecosystems and human health. When using chemical fertilizers, the soil becomes drought-prone, water-deficit, hard, compact, water-scarce, infertile, polluted and less productive. After the introduction of mineral fertilizers, the intensity of the natural conversion of atmospheric nitrogen to the compounds that can be assimilated by plants is reduced. The mineral salt solutions are harmful to soil microorganisms that form a layer on the fertile soil, and hence the formation of humus slows down. Chemical fertilizers can increase the radioactive lead (^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb), which causes accumulation of heavy metals in soil and plant bodies. A few respondent Ukrainian farmers stated that the impact of chemical fertilizers on soil depends on the quantum of chemicals being used and that only excess of mineral fertilizers cause harmful effects on soil.

2. Health and ecological risks from chemical fertilizers

The common diseases that can be attributed to usage of chemical fertilizers are: skin diseases, kidney problems, respiratory diseases, indigestion, memory loss, lung ailments, mental and physical weakness, menstrual disorders, loss of immunity, loss of work efficiency, eyesight weakness, gastrointestinal problems, poisoning, vomiting, cancer (if residues persist), phlegm of the upper respiratory tract, rhinitis, laryngitis, bronchitis, pneumoconiosis, hepatitis, chronic intoxication of the body, asthma, weakened immune system, miscarriages of pregnant women, and mutagenic and embryotoxic effects. Mineral fertilizers accelerate leaching of calcium, magnesium, zinc, copper, and manganese from the soil. Leaching affects the processes of photosynthesis and reduces the resistance of plants to diseases. Mineral fertilizers lead to reducing soil porosity and granular aggregates, and finally leads to acidification of the soil. Nitrogenous fertilizers pose the greatest danger to humans and agroecosystems. Nitrates are especially dangerous for infants, because their enzyme base is imperfect, and recovery of methemoglobin into hemoglobin is slow. Biofertilizers, on the other hand, are safer compared to chemical fertilizers. Biofertilizers do not pollute water and air and keep the environment clean as they trigger oxidation of soil. Biofertilizers remove ions of heavy metals from soil and clean the contaminated soil.

3. Soil performance under biofertilizers

Biofertilizers are confirmed to improve the soil texture and profile, while enhancing soil fertility. Another significant advantage of using biofertilizers is that they are toxin-free, non-poisonous, harmless to soil, environment friendly, and disease resistant. Biofertilizers are also claimed to support plants and human health, reducing carbon footprints, while helping plants grow better and more safely. The microbes of biofertilizers solubilize nutrients (micronutrients too) of the soil and make them available to plant roots. Another aspect of microbes acting in the soil is their ability to enhance soil’s water retention capacity, enabling the soil to retain moisture in which nutrients dissolve and become available to plants. Biofertilizers increase soil temperature by 2-5^{o}C which enhances root formation and germination of seeds. Fruiting, blooming, germination, and root formation are supported by the bacteria that feed on root secretions and release growth metabolites.

The bacteria feed on secretions of root system in rhizosphere. Some biofertilizers have additional strength to defy enemy insects and pests, thereby reducing the use of plant protection chemicals. Biofertilizers are also reported as increasing plant and soil immunity while improving quality of produce. Biofertilizers work on a synergistic basis or on antagonism principles and, as a result, fermentation process makes leaves and fruits of plants inedible to the pathogenic microbes. Finally, plants becomes more resistant to pathogens, drought and frost. As a result, soil becomes resistant to fungal diseases, drought and other pathogens since biofertilizers reduce negative impacts of chemicals on soil fertility and reduce the residues by 60%. The respondent farmers also indicated that biofertilizers solve salinity problems in the soil.

4. Soil-water regime under biofertilizers

Biofertilizers reduce irrigation needs by 2 times at least for a crop (e.g. wheat) grown with biofertilizer(s) usage. The moisture is built up in soil when biofertilizers are applied, as the biofertilizers provide natural water permeability of the fertile layer of soil. Moisture remains for longer in the soil and 40-70% of water is kept in rhizosphere once biofertilizers are applied. Biofertilizers synthesize biologically active substances by dissolving, for example, silicate and other substances including nitrogen, potassium and phosphorus. They humidify soil layers and maintain air and water permeability of soil layer (at least 60 cm deep). Biofertilizers transform microelements to become easily digestible by plants and also contribute to the aeration of the soil, water retention, filtration ability, rate of cation exchange in the soil. Moreover, humus that causes plant growth is formed, aiding in resistance to drought and water holding capacity of the soil. Consequently, moisture solubilizes nutrients and enhances uptake by plant roots and hence nutrients intake is facilitated by moisture. Therefore, the effect of dry spell is minimized. Some farmers stated that the bacteria dissolve phosphorus in soil and increase salt index level that regulates pH of the soil. This all supports plant growth. The bacteria recycle and dissolve intractable phosphorus in soil and make it accessible to the plants. Certain bacteria strain dissolve ammonia, amino-silicate and release potassium and hard nitrogen. As a result, quality and size of grain (I & II grades) and straw improve.

5. Comparative yield & characteristics of produce

There is a reported 10-15% increase in yield and production after using biofertilizers. For example, the use of *Bacillus amyloliquefaciens* increases yield by 10%. The tubers, grains and fruits have better taste, size, quality, production, shelf-life, and color after biofertilizers are used. Noticeably, the size of the harvest depends on the density of productive stalk and mass of grain from one ear, and biofertilizers boost all these entities. Likewise, *Actinomycetes* inhibit the growth of pathogens and stubble. In fact, bacteria help the plants produce higher growth by mobilizing the vitamins, carotenes, proteins and increasing qualitative indicators of plants. The respondent farmers also confirmed that plant products get saturated color and better quality once biofertilizers are applied.

6. Comparative investment and economic risks

Expenditures per unit area of land on buying chemical pesticides/fertilizers and biofertilizers/biopesticides were compared. Ukrainian farmers stated that it costs more than 2-3 times the price of chemical fertilizers/pesticides when compared to biofertilizers or organic fertilizers and biopesticides. In Ukraine, the average spending on biologicals was UAH 3000 per annum versus average spending of UAH 7504 on chemical fertilizers and pesticides. An investment or economic risk if the crops grown by using biologicals exists. When the risk of the losses was quite high (60-70%) with the chemically grown crops, the risk of losses reduces to average 33% if crops grown by using biologicals. Therefore, risks reduce considerably if biologicals are used.

7. Farmers' preferences for fertilizers and biofertilizers

Nitrogen, phosphorus and potash are the main nutrients used in crops. Micronutrients and calcium or magnesium attained least priority. Common fertilizers include NPK (nitrogen, phosphorus, potassium), calcium nitrate, DAP (diammonium phosphate), MoP (molybdenum phosphate), ammonium nitrate, unical and complex fertilizer. Among the micronutrients, only the molybdenum was found being used by some farmers. How are biofertilizers applied? The respondent farmers confirmed that they use chemical fertilizers and biofertilizer(s) simultaneously. What drives respondent user farmers to purchase biofertilizers? Some advantages of using biofertilizers were stated to be production sustainability, input cost reduction, cheaper prices, ecologically safe, organic status, health and safety.

The respondent farmers' average willingness to adopt biofertilizers was measured. The respondent Ukrainian non-user of biofertilizers showed an average willingness of 5.55 out of 10-point scale (nearly 55%). On the other hand, the average willingness score of users of biofertilizers is 7.3 (i.e. 73%). This reflects that users of biofertilizers express greater willingness to adopt biofertilizers, yet the willingness of non-users of biofertilizers is not less. These respondent farmers showed preferences for using both local and foreign made biofertilizers. Moreover, they also trust both local and international organic certification.

CONCLUSION

A biofertilizer contains living microorganisms that are applied to seed, plant surfaces, or soil, and that colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Some common agents in biofertilizers include *Rhizobium*, *Azotobacter*, *Azospirillum*, phosphorus solubilizing bacteria (PSB) and *Mycorrhizae*. The agronomic advantage of biofertilizers compared to conventional chemical fertilizers is well proved biologically and in economic terms. The biofertilizers are safer ecologically and in context of public health. The biofertilizer is broad spectrum efficient inoculum tested to boost production, soil biology and agroecosystem sustainability. In the study, two important economic angles are highlighted by the respondents: 1) reduced risks of crop failure if using the biofertilizers; and 2) comparatively lesser inputs and investment are needed to grow crops if biofertilizers are added. Such economic and scientific advantages of using biofertilizers ultimately mobilize the respondent farmers preferring biofertilizers over the chemical fertilizers.

A problem lies with the production and supply of biofertilizers in Ukraine. Both the production and distribution are inadequate compared to the demand for microbial biofertilizers. However, a dozen companies are operational in Ukraine trading and supplying biofertilizers and other soil nutrients. The farmers using biofertilizers prefer using the microbial products, with certain reservations about quality of products, effectiveness and shelf life of microorganisms. The findings of this study revealed the scientific and practical advantages of using biofertilizers, however, studies need to be pursued to understand reasons of such trade gaps and slow growth of biofertilizers in agriculture sector of Ukraine.

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Appendix 1. Questions for Scientists/Academics

- *Scientific features of biologicals being manufactured*
  - Composition or ingredients of biologicals
  - Physico-chemical properties or characteristics of biologicals
  - Fertility or Epidemiological functions
  - Efficacy or efficiency of biologicals
  - Toxicological information
  - Shelf-life of the biological product
- *Characteristics of biologicals*
  - How can biofertilizer be distinguished from chemical fertilizer?
  - What are the general characteristics of biofertilizers?
  - How do biofertilizers function when they are applied onto soil or plants?
  - What are ecological functions of biofertilizers?
- *Comparative advantage of using biologicals*
  - Are biofertilizers economic compared to chemical fertilizers?
  - Can you give any calculation of the costs of both?
  - How are biofertilizers advantageous to chemical fertilizers?
  - What are ecological advantaged of biofertilizers?
  - Biosafety and hazardousness related issues: which is better?
  - What area advantages related to soil biology?
  - How will the use of biofertilizers solve environmental problems?

Appendix 2. Manufacturers, suppliers, importers and traders of microbial biofertilizers

Questions	*Responses – Ukraine*
What kinds of biologicals in what quantities with what effectiveness are being used by farmers?	
Categories of biofertilizers manufactured or <u>supplied/traded</u>	• Microbes-based
Any efficacy or efficiency tests/data of such biofertilizers?	• Field trials result 42% increase of the yield of wheat. • For all products stated tests were conducted. 10-30% increase in efficiency.

Appendix 3. Questions for Government Officers

Status of Existing Microbial Biotechnologies and Natural Compound Technologies of Biofertilizers & Biopesticides

- What kinds of biologicals in what quantities with what effectiveness are being used by farmers?
  - Categories of existing biofertilizers
  - What's basis of this classification/categorization?
  - Any list of category-wise (registered) biofertilizers?
  - What recommended quantities of these different biofertilizers are applied for which crops?
  - Any efficacy or efficiency data of such biofertilizers?

Enhancing the Yield and Profitability of Peanut (*Arachis hypogaea* L.) to Application of Different Organic Foliar Fertilizers

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Abstract

One strategy to produce enough, healthy, and safer products is to apply the best practices by using locally produced organic bio-fertilizer as nutrients for the crops. This study aimed to evaluate the effects, determine the appropriate, and assess the profitability of using locally produced organic foliar fertilizers on peanut production. The treatments designated as follows: T_1 - Control (no application), T_2- Power grow 100 ml/16li H_2O, T_3 - Vermi tea 100 ml/16li H_2O, T_4 - Poultry litter tea100 ml/16li H_2O, and T_5 - Wood vinegar 100 ml/16li H_2O. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Each replication was divided into five (5) treatment plots measuring twelve (12) m^2 separated by 1 m alleyways between replications and treatment plots to facilitate farm operations and data gathering. The treatment plants were sprayed with foliar fertilizer six times at weekly intervals, starting two weeks up to the pick of the peanut plants' last flowering. Results showed that peanut plants flowered early when applied with poultry litter tea. Likewise, highest leaf area index (LAI) and weight of 1,000 seeds (g) when applied with Power grow foliar fertilizer. Application of poultry litter tea, power grow and wood vinegar obtained the highest seed yield of 1.31-1.470 t ha^{-1} and achieved the highest grain yield tha^{-1}. Thus, gave the high gross margin of PhP36,723-48,965.00 ha^{-1} among the treatments. In terms of pest incidence, no serious presence of insects and diseases were noted; thus, a high to moderate resistance rating was obtained in all treatment plants.

Keywords: Best practices, local organic produced, sustainable, productivity and income

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) is also named groundnut, which belongs to the family Leguminosae that produces underground fruits called pods (Aboelill et al., 2012). The Philippines is consumed as boiled peanut, peanut oil, peanut butter, roasted peanuts, peanut bars, and candies. Groundnuts are considered a vital source of nutrients, calories, minerals, and antioxidants, vitamins essential for optimum health. It is one of the legumes considered as an excellent intercrop to corn, sorghum, sugarcane. Planting peanut help enrich the soil nutrients due to its ability to fix atmospheric nitrogen. Peanut, as a legume, needs only a small amount of N because of its ability to fix nitrogen from the atmosphere (Jordan et al., 2017). Organic substances can be used as fertilizer because it contains essential nutrients like nitrogen, phosphorus, potassium, calcium, iron, manganese, zinc, copper, magnesium, and protein substances that stimulate plant metabolism. Organic fertilizers are an excellent substitute for inorganic fertilizer in crops that require less nutrients for their growth and development. The use of organic foliar fertilizer is beneficial. It contains microorganisms such as bacteria that hastens organic materials' mineralization and makes it available to plants through the foliar spray (Yansong et al., 2009).

Foliar application of nutrients is a feasible, economically viable, and environmentally friendly approach to nutrient management. It is often the most effective and economical way to correct plant nutrient deficiencies at critical growth stages. Reports indicated that foliar application promoted root absorption of the same nutrient or other nutrients by improving root growth and increasing nutrients' uptake (Meena et al., 2007). The foliar application also overcomes the physiological disturbances caused by adverse soil conditions that hamper mobility and nutrient absorption. Foliar spraying of N, Mn, Cu, and B on several crops indicated beneficial effects.

Kalinova, et al. (2014) indicated that foliar application of 1% KCl obtained the best results in groundnuts. Manure tea as foliar fertilizer corrects the plant's deficiencies because the nutrients enter the plant through the stomata and cuticle. Foliar application of fertilizer is an effective way of correcting soil nutrient deficiency when plants cannot absorb directly from the soil (Jordan et al., 2017). The foliar application provides a quicker response and more effective for some nutrients like NPK than soil-applied fertilizer (Brandenburg, et al., 2019). Foliar feeding is often the most effective and economical way to correct plant nutrient deficiencies. It has become an established procedure in crop production to increase yield and improve the product's quality. Since there is a need to look for cheap and ecologically safe plant growth enhancers as a supplement to inorganic fertilizer for peanut production, Power grows, vermi tea, poultry litter tea, and wood vinegar can be used for this purpose. Hence, this study was conducted to evaluate the effects of different organic foliar fertilizers on peanut growth and yield.

MATERIALS and METHODS

Experimental Area, Design, and Soil Sampling

An area of 226.0 m^2 Umingan clay loam soil (FAO, 2016) is located at the Agronomy Experimental Area College of Agriculture and Food Science, Visayas State University, Baybay City, Leyte. The experimental area has a GPS coordinates of $10^o44' 59.8668''$ N, $124^o47' 38.1264''$ E. This was plowed and harrowed twice using a tractor-drawn implement at weekly intervals.

These were done to allow the weeds to decompose, pulverize the soil, level the field, and provide time for weed seeds to germinate and incorporate them into the soil. Furrows were constructed at a distance of 0.5 m apart.

Soil samples were collected randomly from the experimental area before plowing. These were composited, air-dried, pulverized, sieved (2 mm wire mesh) and submitted to the Central Analytical Service Laboratory (CASL), PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte. The soil samples were analyzed to determine the soil pH Potentiometric method (1:2.5 soil water ratio), % organic matter (Modified Walkley-Black method), total N by (micro Kjeldal method), extractable P, and exchangeable K (ammonium acetate extraction method). For the final soil analysis, three samples were collected from each treatment plot after peanut harvest. Collected soil samples were air-dried, composited, and processed to determine the same soil parameters mentioned above. The experiment was laid out in an RCBD (Randomized Complete Block Design) with three replications. Each replication was divided into five treatment plots, measuring 3 m × 4 m with 1 m alleyways between replications and 0.50 m between treatment plots to facilitate farm operations and data gathering. The different treatments are as follows: T_1- Control (no application), T_2 -100ml/16li H_2O Power Grow, T_3 - 100ml/16li H_2O Vermi tea, T_4 -100ml/16li H_2O Poultry litter tea, T_5 -100ml/16li H_2O Wood vinegar.

Organic Foliar Fertilizer Preparation

Vermicast was purchased at the Eco FARMI, and Poultry litter at the Department of Animal Science, both from Visayas State University, Baybay City, Leyte. While Wood vinegar was procured at Balinsasayao Research Station, Balinsasayao, Abuyog, Leyte. Vermitea, and Poultry litter tea were prepared through fermentation for three (3) weeks. The mixture of 1:1 ratio was prepared by mixing 1 liter of unchlorinated water and 1 kg of Vermicast in a clean bucket, covered with cheesecloth to prevent insects and other organisms' entry while allowing air circulation inside of the bucket and was mixed thoroughly and was fermented for 3 weeks. The mixture was then filtered, and the filtrates were placed in clean containers and stored under ambient conditions. (Krawczyk, 2018). All organic foliar fertilizer samples were collected and brought to the Central Analytical Service Laboratory (CASL), PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte for the analysis of NPK contents.

Organic Foliar Fertilizer Application

Spraying of foliar fertilizers (100 ml of fermented organic foliar fertilizers per 16 liters of water) was done six (6) times at weekly intervals starting two (2) weeks after sowing (DAS) up to the peak of the last flowering of peanut plants.

Spraying of organic foliar fertilizers was done when the wind is expected, and an enclosure was provided around the treatment plants to avoid contamination of other treatments.

Harvesting was done when 90% of the plants reached maturity. The pods became firm at this stage, and the crop exhibited yellowing to brown of matured leaves. One row on each side and two end hills served as border plants leaving two border rows in each treatment plot. Extra care was observed to minimize the damage of pods. After this, peanut pods were handpicked, washed, and sundried to attain a moisture content of 14% using a moisture meter.

Data Gath

For agronomic characteristics: days from sowing to flowering, days from sowing to maturity, plant height (cm) Leaf area index (LAI). LAI was computed using the formula:

$$\text{LAI} = \frac{\text{Total leaf area (TLA)}}{\text{Ground area } (2{,}500 \text{ cm}^2)}$$

Whose: TLA = $\sum (L \times W \times 0.552)$

Fresh herbage weight (t ha^{-1}) was gathered and converted to tons per hectare using the formula:

$$\text{Herbage yield } (\text{t ha}^{-1}) = \frac{\text{Plot herbage yield (kg)}}{\text{Harvestable area } (7.2 \text{ m}^2)} \text{ x } \frac{10{,}000 \text{ m}^2 \text{ ha}^{-1}}{1{,}000 \text{ kg t}^{-1}}$$

For yield and yield components: number of pods per plant, number of seeds per pod, weight (g) of 1,000 seeds, dry pod yield (t ha^{-1}), total seed yield (t ha^{-1}), and harvest index (H.I.).

$$\text{Harvest Index (H.I.)} = \frac{\text{Dry weight of seeds (g) 3 sample plants}}{\text{Dry herbage yield (g)+Dry weight of seeds (g)}}$$

Cost and return analysis: Gross Income = Pod Yield (kg ha^{-1}) x Current Market Price kg^{-1} of Peanut

Gross Margin = Gross Income – Total Variable Cost

Climatic data such as total monthly rainfall (mm), average daily minimum and maximum temperatures (°C), and relative humidity (%) throughout the conduct of the experiment were obtained from the records of the Philippine Atmospheric, Geographical and Astronomical Service Administration (PAGASA) Station, Visayas State University, Visca, Baybay City, Leyte. Data were computed, and analysis of variance (ANOVA) was done using the Statistical Tool for Agricultural Research (STAR). A comparison of means was made using Tukey's Test.

RESULTS and DISCUSSION

Table 1 shows the total monthly rainfall (mm), average daily minimum and maximum temperatures (˚C) and relative humidity (%) throughout the study obtained from the Philippine Geophysical, Astronomical, Services, Administration (PAGASA) Station, Visayas State, University, Visca, Baybay City, Leyte, the Philippines from May to August 2019.

The total weekly rainfall (mm) recorded throughout the study ranges from 80-116 mm with a total rainfall of 410.22 mm. AVRDC, (2006) mentioned that the water requirement of the peanut plant for its normal growth and development is about 500-600 mm per cropping season.

In this study, the amount of rainfall is insufficient; hence, the plants were watered every morning and late afternoon during the early stage of the crop to meet the water requirement needed by the peanut plants. The average daily minimum and maximum temperature, and the % R.H. recorded ranged from 25.49-32.83 ˚C and 77%, respectively. The temperature requirement ranges from 25 to 33ºC, and % R.H. is 75-85% (AVRDC, 2006). Thus, the temperature (^{0}C) and % R.H. were at an optimum level; thus, flowering and pod filling processes of crops were favorable resulted in high total grain yield (tha^{-1}) except on the plant not applied with any fertilizer as the control plants.

Table 1. Climatic data obtained from the PAGASA Station of VSU, Visca, Baybay City, Leyte

Period (Monthly)	Total Rainfall (mm)	Temperature (°C)		Relative Humidity (%)
		Minimum	Maximum	
May	80.95	25.52	34.23	78.00
June	116.21	26.43	32.76	80.00
July	115.46	25.43	31.57	75.00
August	97.60	24.60	32.76	76.00
Total	410.22	-	-	-
Mean	-	25.49	32.83	77.00

Organic Foliar Fertilizer analysis

The nutrient content analysis of the organic foliar fertilizer used in the study is presented in Table 2. These locally and commercially produced organic foliar fertilizer varies on the macronutrient contents. Hence, the result's efficiency was also varied as observed and discussed in the agronomic and yield components parameters (Table 4 and 5).

Table 2. Analysis result of the nutrient content of the different locally and commercially produced organic foliar fertilizers

Foliar Fertilizer	Total N	Available P ($mgkg^{-1}$)	Exchangeable K ($me100g^{-1}$)
Power grows	2.35	1.44	1.75
Vermi tea	0.90	0.72	1.47
Poultry litter tea	1.26	0.83	0.99
Wood vinegar	0.80	0.71	0.98

Soil Properties

Initial soil analysis taken from the experimental area showed that the soil had a pH of 6.20 with 1.351 % organic matter (O.M.), 0.081 % total N, 1.694 mg kg^{-1} available P and 0.641 me 100 g^{-1} exchangeable K (Table 3). The result indicated that the soil was slightly acidic, with a meager amount of organic matter, very low in total nitrogen, low in available phosphorus, and a high amount of exchangeable K (Landon, 1991).

The results showed that the soil's pH, organic matter, and total N were increased while available P, and exchangeable K decreased for the final soil analysis. The increase in soil pH relative to the initial soil analysis could be due to the release of organic substance and basic cations upon decomposition of some plant herbage and residues from the previous cropping. The decrease in available P and exchangeable K at final soil analysis is due to the consumption of the crop for pod and seed development as well as the losses due to leaching thereby, decreasing the nutrients described above, (Marschner, 1997).

Table 3. Soil test results before planting and after harvest of peanut using different organic foliar fertilizers

Treatment	Soil pH (1:2:5)	O.M. (%)	Total N	Available P ($mgkg^{-1}$)	Exchangeable K ($me100g^{-1}$)
Initial	6.00	1.34	0.081	1.694	0.641
Final					
T_1- Control	6.45	1.455	0.077	1.649	0.550
T_2- Power grow	6.68	1.383	0.099	1.526	0.512
T_3- Vermi tea	6.58	1.420	0.083	1.649	0.538
T_4- Poultry litter tea	6.31	1.416	0.086	1.597	0.623
T_5-Wood vinegar	6.42	1.643	0.108	1.289	0.635
Mean	6.49	1.443	0.091	1.850	0.618

Agronomic Characteristics

Table 4 shows the agronomic characteristics of peanut as influenced by the application of different organic foliar fertilizers. Analysis of variance revealed that the only number of days from planting to flowering and leaf area index (LAI) differed significantly and not on the other growth parameters. Peanut treated with poultry litter tea flowered significantly early than plants applied with Power grow, Vermi tea, Wood vinegar and the control. According (Jordan et al. (2017), poultry tea provides a higher amount of N nutrients (2.35-1.44-1.75 N, P_2O_5, K_2O kg ha^{-1}, Table 2), which enhanced the early flowering of the peanut plants. Moreover, plants treated with Power grow had a broader leaf area index of (1.14) than other treatment plants. Power grow to have higher N content (Table 2) than the other foliar fertilizers, which stimulates root development and improves leaf development. Lalog, (2011) mentioned that Power grow a certified organic foliar fertilizer that rich in macronutrients, micronutrients, and humic acid. It is environment friendly, helps the growth of various crops and vegetables while improving the quality of soil, and increases crop growth and yield.

Table 4. Agronomic characteristics of different organic foliar fertilizers on the growth and yield of peanut

Treatment	Number of days from Sowing to		Plant Height (cm)	Leaf Area Index	Fresh Herbage Yield (tha^{-1})
	Flowering	Maturity			
T_1- Control	31.00c	99.00	115.47	0.40c	13.46
T_2- Power grow	28.00b	98.00	122.57	1.34a	14.76
T_3- Vermi tea	28.67b	98.00	114.47	0.56d	15.28
T_4- Poultry litter tea	27.00a	99.00	110.43	1.04b	14.00
T_5-Wood vinegar	29.33bc	99.00	114.50	0.52c	12.07
Mean	28.80	98.62	115.49	0.70	13.91
C. V. %	2. 61	0.34	6.33	9.39	9.17

Means within the same column followed by common letters and without letter designations are not significantly different at the 5% level, HSD test

Yield and Yield Components and Harvest Index

Yield, yield components, and harvest index of peanut as influenced by applying different organic foliar fertilizer are presented in Table 5. Analysis of variance revealed that weight (g) of 1,000 seeds, the weight of dry pods and seed yields (tha^{-1}) differ significantly among treatment plants. Plants applied with Power grow obtained significantly heavier weights of 1,000 seeds of 590.47g, dry pod (2.07 t ha^{-1}), and seed yield (1.35 t ha^{-1}) comparable to plants sprayed with poultry litter tea and wood vinegar as foliar fertilizers. On the other hand, plants with Vermi tea got the lowest 1,000 seed weight with 495.93g, comparable to the plants not sprayed with any foliar fertilizer as control plants of 471.23g. This result can be attributed to the positive effect of Power grow to stimulate fruiting and produce larger with quality of harvested fruits. It also enhanced the quality and quantity of fruits, thus, increases the harvest yield. Studies show that using Power grow foliar fertilizer is the quick absorption of nutrients, thus, addressing nutrient deficiency very quickly. Likewise, Lalog (2011) explained further that Power grows by increasing photosynthetic activity in the leaves, stimulating the need for water by the leaves. Thus, there is an increase in water uptake by the plants' vascular system, which increases the quantity and quality of crop yield. On the other hand, the application of diluted chicken manure tea as soil drenched combined with beneficial and effective microorganisms could be used as a substitute with inorganic fertilizers. Likewise, Wood vinegar also improves plant metabolism and contributes to higher fruit production. It also Strengthen the process of photosynthesis and increases the content of chlorophyll of the plants. Hence, it increases yield production of the crops (Mungkunkamchao, et al., 2013).

Table 5. Yield, yield components, and harvest index of peanut using different organic foliar fertilizers

Treatment	No. of $Pods^{-1}$	No. of $Seeds^{-1}$	Weight of 1000 seeds (g)	Dry Pod Yield (tha^{-1})	Seed Yield (tha^{-1})	Shelling Percentage (%)	Harvest Index (H.I.)
T_1- Control	12.23	2.12	471.23c	1.49b	0.87c	59.65	0.67
T_2- Power grow	12.80	2.29	590.47a	2.07a	1.35a	65.05	0.56
T_3- Vermi tea	12.47	2.24	495.93bc	1.64b	1.18b	72.27	0.59
T_4- Poultry litter tea	13.00	2.17	574.37a	2.10a	1.47a	69.77	0.74
T_5- Wood vinegar	12.57	2.07	547.73ab	2.01a	1.31a	64.78	0.65
Mean	12.61	2.18	515.95	1.86	1.38	60.30	0.64
C.V. %	8.37	7.80	6.60	16.37	18.23	12.61	18.44

The same column, followed by a common letter and without letter designations, is not significantly different at 5% level, HSD.

Incidence of Insect Pest and Diseases to Peanut

The incidence of insect pests and diseases to peanut plants is presented in Table 6. Treatment plants showed high resistance to insect pests and moderately resistant to *cercospora* leaf spot diseases. They produce a reasonable higher yield in all treatment plots. Moreover, based on peanut plants' reaction (variety NSIC Pn_{18}) to insect pests and diseases, this variety is recommended to the farmers because it is high to moderately resistant to pests.

In effect, they can minimize the cost of pesticides. These results confirm the statement of Brandenburg, et al. (2019), it is important to test the resistance of the crop to pests and diseases before recommending it to the farmers and other interested clientele.

Table 6. Incidence of insect pests and diseases of peanut (NSIC Pn_{18}) variety applied with organic foliar fertilizers

Treatment	Insect Pests Damage	Reaction	Disease (CLS)	Reaction
T_1- Control	1.40	highly resistant	2.33	moderately resistant
T_2- Power grow	1.70	highly resistant	1.67	moderately resistant
T_3- Vermi tea	2.30	moderately resistant	1.23	moderately resistant
T_4- Poultry litter tea	2.20	moderately resistant	2.07	moderately resistant
T_5-Wood vinegar	2.30	moderately resistant	2.20	moderately resistant

Rating Scale for insect pest and diseases (NCT, 2017)

Damage Index	**Insects Leaf Damage (%)**	**Reaction**	**Damage Index**	**Range of Average Scale for Diseases**	**Description**
1	1-20	Highly resistant			
2	21-40	Moderately resistant	1	1.00	Highly resistant
3	1-60	Moderately susceptible	2	1.01-2.49	Moderately resistant
4	61-80	Susceptible	3	2.50-3.49	Intermediate resistant
5	80-100	Highly susceptible	4	3.50-4.49	Moderately susceptible
			5	4.50-5.00	Highly susceptible

Cost and Return Analysis

Cost and return analysis of peanut production as influenced by different organic foliar fertilizers is presented in Table 7. Plants applied with poultry litter tea obtained the highest gross margin of PhP 48,695.00 ha^{-1}, followed by plants applied with Power grow at PhP37,910.00 ha^{-1}, Wood vinegar at PhP36,723.00 ha^{-1}, and Vermi tea at PhP34,206.00 ha^{-1}. While control plants gave the lowest gross margin of PhP18,750.00 ha^{-1}. Variation in the treatments' gross margin was due to the differences in seed yield and cost of production, specifically on the cost of organic foliar fertilizers.

Table 7. Cost and return analysis ha^{-1} of different organic foliar fertilizers on the growth and yield of peanut

Treatment	Seed Yield (kg ha^{-1})	Gross Income (PhP)	Total Variable Cost (PhP)	Gross margin (PhP)
T_1- Control	0870c	43,500.00	24,750.00	18,750.00
T_2- Power Grow	1,350a	67,500.00	29,590.00	37,910.00
T_3- Vermitea	1,180b	59,000.00	24,794.00	34,206.00
T_4- Poultry tea	1,470a	73,500.00	24,805.00	48,695.00
T_5-Wood Vinegar	1,310a	65,500.00	28,777.00	36,723.00

*Calculation of gross income is based on the current price of dried peanut @Php50 kg

CONCLUSION

1. Plants with commercially produced (Power grow) foliar fertilizers achieved the highest LAI value and weight (g) of 1,000 seeds. While plants applied with Poultry litter, tea flowered the peanut plants early. Likewise, locally available organic foliar fertilizers (Poultry litter tea and Wood vinegar) can compete with commercial organic foliar fertilizers (Power grow) in enhancing the total pod and seed yields (t ha^{-1}).
2. In terms of total seed yield (tha^{-1}), poultry litter tea and Wood vinegar tea obtained higher yields comparable to commercially produced organic foliar fertilizer (Power grow).
3. Poultry litter tea obtained the highest gross margin of PhP48,695.00 ha^{-1} followed by Power grow of PhP37,910.00 ha^{-1}, Wood vinegar PhP36,723.00 ha^{-1} and Vermi tea with PhP34,206.00 ha^{-1}. The lowest was observed in the control plants with a gross margin of PhP 18,750.00 ha^{-1} only.

RECOMMENDATION

1. Poultry litter tea at the rate of 100ml per 16li of water can be recommended for peanut production as an organic foliar fertilizer.
2. It is also recommended that the results obtained from this study be tested in other locations of different soil types and agro-climatic conditions with the inclusion of the recommended rate of inorganic fertilizer of 30-30-30 kg ha^{-1} N, P_2O, and K_2O.

Conflict of Interest

The authors would like to declare that there is no conflict of interest regarding this paper's publication. Hence, all authors are informed by the corresponding author before submission of this article for publication.

Authors' Contribution

This work was carried out in collaboration between the senior and junior authors. Both authors contributed to the conduct of the study up the final editing of the article before submission for publication.

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NPK Contents of Vermicast as Influenced by Varying Substrates

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Abstract

Vermicomposting has been practiced for many years by several researchers for its positive outcomes toward sustainable agriculture. This study was conducted to assess the N, P, K content of vermicast as influenced by different substrates. Approximately, four (4) samples in each substrate as initial sample and vermicast as final sample were collected in the study. Varying substrates include the use of cow manure, mudpress, banana peelings, some leguminous plants namely kudzu and kakawate. Substrates and vermicasts among all treatments range from slightly acidic to slightly alkaline condition. There were considerably decreased in terms of pH, total N, K from its initial sample (substrate) to its final sample (vermicast) except for total P. Thus, this could be attributed to the nature and properties of varying substrates fed to the earthworms.

Keywords: Vermicast, organic substrates, total N, P, K

Research article
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INTRODUCTION

In today's generation, organic fertilizer had gained more attention due to heavy doses of chemical fertilizers and pesticides are being used by the farmers to get a better yield of various crops. These chemical fertilizers and pesticides decreased soil fertility and caused health problems to the consumers. Due to adverse effects of chemical fertilizers, interest has been stimulated for the use of organic manures. The Philippine Organic Agriculture Act (RA 10068) was approved to promote and implement the practice of organic agriculture in the Philippines that will cumulatively condition and enrich the fertility of the soil, increase farm productivity, reduce pollution and destruction of the environment. Organic fertilizers are effective in improving soil fertility and agricultural production by providing essential elements (N, P, K). Nevertheless, effectiveness of organic fertilizer requires time but its effects are sustainable in the long run. The release of nutrients from organic fertilizer is gradual and as microorganisms in the soil breakdown and decomposes the organic matter and makes the nutrients available for plants (Mencide, 2011). Organic agriculture includes the practices of vermiculture and vermicomposting.

Basically, vermiculture is the science of breeding and raising earthworms. According to Entre Pinoys (2010), it defines the growing potential for waste reduction, fertilizer production, as well as an assortment of possible outcomes for the future use.

Vermicomposting is the process of producing organic fertilizer or the vermicompost derived from different substrates or biodegradable materials that are processed by earthworms. Composting with earthworms lessens the disposal of agricultural wastes and increases the benefits of high quality compost (Rogayan, 2010). Furthermore, vermicomposting is a simple biotechnological process of composting in which certain species of earthworms are used to enhance the process of waste conversion and produce a better product. The resulting product of vermicomposting is commonly known as 'vermicast'. Vermicast is an organic fertilizer which is of high quality and it is very useful in enriching the soil as soil conditioner. Moreover, vermicast which is high in microbial enzymes and plant growth regulators and is also fortified with pest repellence attributes (Vermi Co. 2001 as cited by Ranin, 2015). According to Vasanthi and Kumaraswamy (1999) vermicast contains essential nutrients essential for plant growth, thus minimizing the application of chemical fertilizers.

This study was conducted to assess the nutrient content (NPK) of vermicast produce by *E. eugeniae* when fed with different mixtures of substrates. This research also aims to identify the changes of nutrient content of the different substrates after the vermicast production.

MATERIALS and METHODS

Treatments and Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. T_1= 1:1:1 cow manure, mud press, and banana peelings; T_2= 1:1:1:1 cow manure, mud press, banana peelings, and rice straw; T_3= 1:1:1:1 cow manure, mud press, banana peelings, and kudzu; T_4= 1:1:1:1 cow manure, mud press, banana peelings, and kakawate.

Preparation of Organic Materials and Vermicomposting Process

The use of plastic containers was provided with wire holes at the bottom for drainage. The substrates such as kudzu, kakawate, rice straw, banana peelings, mudpress and cow manure were collected in the field. These materials were shredded and mixed into the dried and compounded cow manure.

Vermi worms used in the study were cultured and collected at Eco-FARMI, VSU, Baybay City, Leyte. These vermi worms are identified as 'African night crawler' or scientifically known as *Eudrilus eugeniae.* A total of 500 g of earthworms was introduced into each treatment. The containers were placed in a cool dark place. Water was applied over the container to prevent from drying. Casts were collected after 6 weeks after the introduction of the earthworms and nutrient content was analyzed for pH, N, P, and K.

Data Gathered

Physical properties of vermicompost

This was done by weighing 5 to 10 grams of freshly harvested vermicompost from each treatment. Samples were oven-dried at 70 degrees Celsius for 24 hours. Moisture content was calculated using the formula:

$$\%MC = (FW - ODW) / FW \times 100$$

Where:

MC= moisture content

FW= fresh weight of vermicompost (g)

ODW= overn-dry weight of vermicompost (g)

Chemical properties of vermicompost

Vermicast from each treatment was analysed for the following parameters: pH was determined using potentiometric method (PCARR,1980). Organic Matter (OM) was determined following the walkley-black method (Nelson and Sommers, 1982). Total Nitrogen (N) was derived using the equation:

$$\text{Total N } (\%) = \%\text{ OM} \times 0.05$$

Total Phosphorus (P) was determined by using the extract from total K analysis, 2 ml aliquot of the extract from each treatment was placed in test tubes and was added with mixed reagent and stand for one hour to develop the molybdenum blue color. The sample was measured using B-L spectronic 20 at 880 nm and computed using the formula:

$$\text{Total P } (\%) = ODS \times K \times (100/0.05) \times (1/1000) \times \text{dilution}$$

Where:

ODS	= optical density
K	= slope of standard curve
100	= dilution of digested sample
1/10000	= to express result in % basis

Total Potassium (K) was determined suing Aqua Regia method (Chen and Lena, 2001).

Statistical Analysis

Statistical analysis of all data was obtained using the statistical tool available (CROPSTAT ver. 7.2.3) Analysis of variance (ANOVA) technique was used to compare the nutrient content of the different treatment use. Treatment means was separated following the Fisher Protected Least Significant Difference (FPLSD) at 5% level of significance.

RESULTS and DISCUSSION

Chemical Characteristics of Vermicompost Soil pH

Soil pH is a basic soil chemical property that affects many chemical and biological activities in the soil. Soil reaction can be alternatively known as soil pH which means the degree of acidity and alkalinity in a soil. The pH of the soil expresses the activity of hydrogen ions (H^+) in the soil solution. Moreover, mineral nutrients to plants can be affected by soil pH as well as many soil processes (FAO, 2006).

In terms of pH (Figure 1), treatment 3 which is a combination of cow manure, mudpress, banana peelings, and kudzu showed the highest pH or more alkaline among the other substrates. However, the pH value of all the substrates ranges from 7.66-7.92 which indicates a slightly alkaline condition. On the other hand, the pH value of all the vermicasts ranges from 6.85-7.12 which indicate a slightly acidic to near neutral condition. Among the vermicasts produced from different substrates, treatment 1 which is a combination of cow manure, mudpress, and banana peelings showed the highest pH or near neutral condition. In overall, there were slightly decreased in pH from its initial sample (substrate) to its final sample (vermicast). This could be attributed to the nature and properties of the substrate being used.

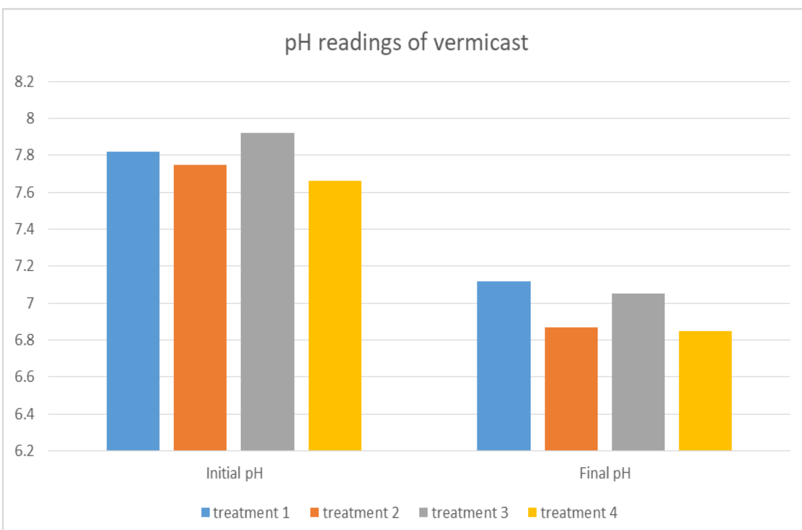

Figure 1. pH levels of vermicompost as influenced by varying substrates

Total Nitrogen

According to the results of the statistical analysis, the mean percent nitrogen of the four treatments of the initial samples was not significantly different from each other as shown in Figure 2. This means that the addition of leguminous plants to the substrate combination did not help increase the substrate's nitrogen content.

The final samples showed the same statistical analysis results with the initial samples. The treatments are also not significantly different from each other. When the initial samples (substrates) are compared to the final samples (vermicast), it can be seen that nitrogen content of the substrates decreased after it was converted into vermicast. Hand et al., (1988) has reported that nitrogen mineralization was greater in the presence of earthworms, and this mineral nitrogen retained in nitrate form. The reason for the lesser nitrogen content for the final samples might be due to the reason that the organic nitrogen was mineralized into nitrate form and might have leached or volatilized and some of the nitrogen was utilized by the worms for its growth and development.

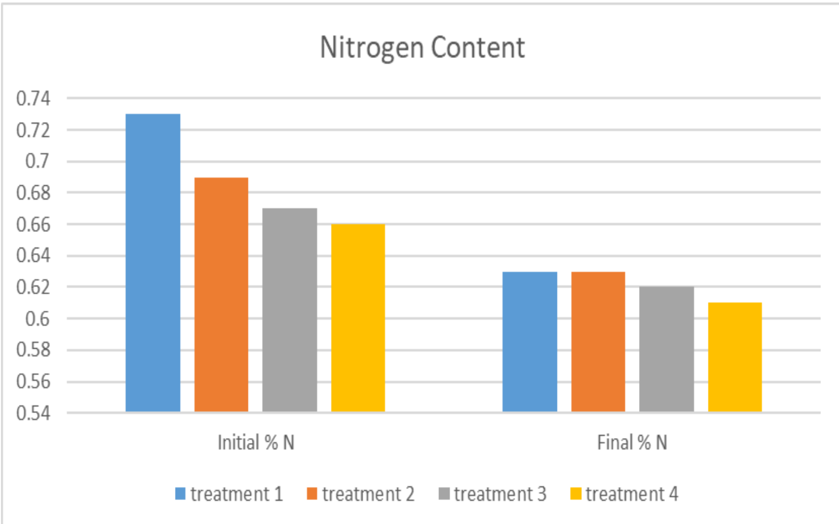

Figure 2. Total N (%) of vermicompost as influenced by varying substrates

Total Phosphorus

During the conduct of the study an initial sampling was implanted in order to measure the original levels of nutrients from the different substrates that will undergo vermicomposting. Readings from the results indicates that treatment 1 had the highest phosphorus content which was followed by treatment 4, treatment 2 and lastly from treatment 3 (Figure 3). Higher P readings of treatment 1 could be due to the higher cow manure and mud press content of the substrate. Ghosh et. al., (1998) reported that prior to vermicasting process, cow manure and mud press contain 1659.5 ppm mineral P and 2193.7 ppm mineral P, respectively. In addition, the organic P content in cow manure meAfter the vermicomposting process it was observed that there is a drastic decrease of P content of treatment 1 while the other treatments considerably increased in P content, with treatment 3 as the highest. Lazcano et al., (2008) reported that the process of vermicomposting resulted to a large decrease of available P.

The decrease of P of treatment 1 could be due to in growth and multiplication rate of the earthworms in the organic wastes, which resulted in a differential pattern of uptake of the nutrient for their body synthesis which caused a lesser release of the remaining P (Ghosh et al., 1998).

Leguminous plants such as kakawate have P levels that ranges from 0.19 to 0.25 based on the findings of Budelman (1989). Moreover, Kudzu appears to be largely dependent on mycorrhizal relationships. Plants from Alabama were found to develop 70% root colonization with mycorrhizal fungi, although only 10% of root tissues showed arbuscule development (Greipsson and DiTommaso, 2006). Inoculation of vesicular arbuscular mycorrhizal species resulted in higher tropical kudzu yields and greater magnesium and phosphorus uptake (Dodd et al. 1990). With these findings, it implies that both these leguminous plant species may contain high amounts of P. Increased P levels of treatments 3 and 4 may have been caused by the action of earthworms, which released higher amounts of phosphorus from the organic form and, at the same time, reduced fixation in different inorganically bound forms. Such effects of earthworms in mineralizing wide ranges of organic materials with the help of various bacteria and enzymes in the intestine has been described in detail by Edward and Lofty (1972). Mansell et al. (1981) showed that plant litter contained more available P after ingestion by earthworms and they attributed this increase to physical breakdown of the plant material by the worms. Satchell and Martin (1984) found an increase of 25% in total P of paper-waste sludge, after worm activity.

They attributed this increase in Total P to direct action of worm gut enzymes and indirectly by stimulation of the microflora. According to Lee (1992) the passage of organic residue through the gut of earthworm to the plant the released of phosphorus in available form is performed partly by earthworm gut phosphatases and further released of phosphorus might be attribute to phosphorus solubilizing microorganism present in worm cast.

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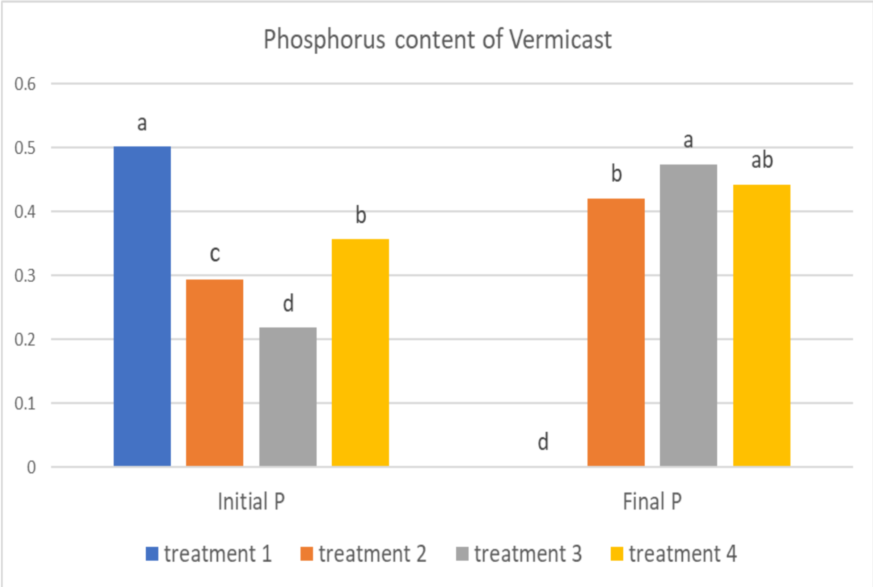

Figure 3. Total P (%) of vermicompost as influenced by varying substrates

Mansell et al. (1981) showed that plant litter contained more available P after ingestion by earthworms and they attributed this increase to physical breakdown of the plant material by the worms. Satchell and Martin (1984) found an increase of 25% in total P of paper-waste sludge, after worm activity. They attributed this increase in Total P to direct action of worm gut enzymes and indirectly by stimulation of the microflora. According to Lee (1992) the passage of organic residue through the gut of earthworm to the plant the released of phosphorus in available form is performed partly by earthworm gut phosphatases and further released of phosphorus might be attribute to phosphorus solubilizing microorganism present in worm cast.

Total Potassium

The results indicated that there is statistically significant difference on treatment 4 compared to all treatments on both initial and final having a significant difference on total potassium analysis on the different vermicast as influenced by different substrates fed to the earthworm (Figure 4). The significant increase in potassium was also confirmated with the study of Basker et. al (1992) their study indicated that exchangeable K content increased significantly due to earthworm activity however extractable K did not change significantly, the statistically insignificant change in extractable K was expected since earthworms cannot increase the total amount of nutrients in the soil but can make them more available, and they may increase the rate of nutrients cycling.

The result of the current study indicated that the treatment 4 can increased the potassium content of the cast on the other hand treatment 1 & 3 is comparable to treatment during final analysis was observed having a value of 1.00 & 0.99 respectively while treatment 2 shows inferior results.

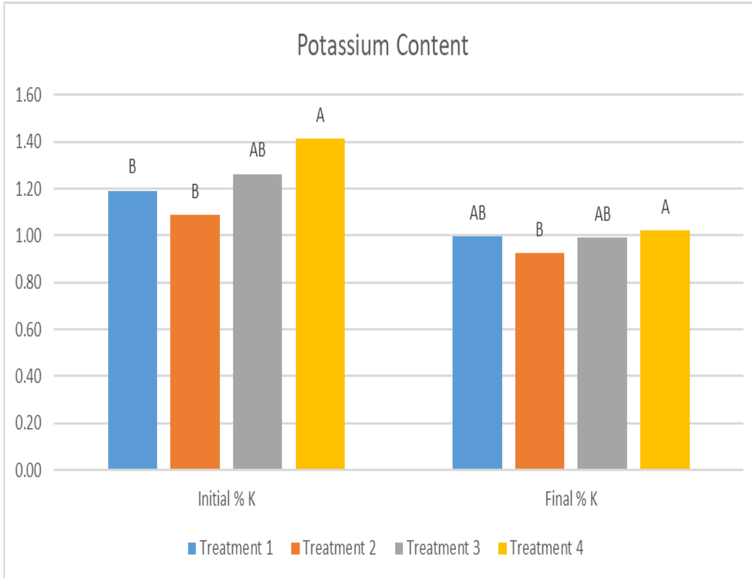

Figure 4. Total K (%) of vermicompost as influenced by varying substrates

CONCLUSIONS

Vermicompost can produce high quality organic fertilizers which are much better compared to other commercial fertilizers sold in the market. In addition, vermicomposting is a good strategy to reduce the intensive use of inorganic fertilizers, improve overall status of the soil, and increase crop yield and productivity. Based on the results of the study, the different substrates (initial sample) as well as the vermicasts (final sample) showed differences in terms of pH, total N, total P, and total K. Therefore, the following conclusions can be drawn:

1. Substrates and vermicasts among all treatments range from slightly acidic to slightly basic condition indicating as a good source of soil conditioners. N content for both substrates and vermicasts was not significantly different from each treatment. On the other hand, P content of vermicasts produced from varying substrates has considerably increased except for treatment 1. For total K, there were significant differences on different vermicasts as influenced by different substrates with vermi worms.
2. Thus, there were considerably decreased in terms of pH, total N, K from its initial sample (substrate) to its final sample (vermicast) except for total P. This could be attributed to the nature and properties of varying substrates fed to the earthworms.

RECOMMENDATIONS

1. Sufficient time should be allotted for the research to maintain the sustainability of vermicompost until harvesting of vermicasts and thus, having a reliable result.
2. It would be better if studies in the future can use and compare more leguminous plants as potential substrates that may increase N, P, K content of vermicasts.

Conflict of Interest

The authors would like to declare that there is no conflict of interests regarding this paper's publication. Hence, all authors are informed by the corresponding author before submission of this article for publication.

Authors' Contribution

This work was carried out in collaboration between the senior and junior authors. Both authors contributed to the conduct of the study up the final editing of the article before submission for publication.

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Investigation of the Lagged Effects of Livestock Supports on the Animal Production Value in Turkey

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Abstract

A significant part of the population in Turkey is under the malnutrition risk due to the food insecurity in terms of animal products. A number of policies have been implemented in order to increase animal production despite of unsatisfactory results. Thus, the main research question is whether livestock policies really affect animal production value, and if so, to what extent and how long its effect continues. In the study, it was used Koyck and Almon distributed lag models based on annual time-series data from 1986 to 2019. The results confirmed a significant and positive association between livestock supports and animal production value. Moreover, animal production value has increased steadily for six years due to supports. Further, necessary time to observe the effect of subsidies on animal production value for one-unit change was determined as 2.98 years by Koyk model. Therefore, long term and stable structural livestock policies should be implemented to increase the development and competitiveness of the sector.

Keywords: Distributed lag models, Koyck model, Almon model, agriculture.

Research article
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Abbreviations used: FAO (UN, Food and Agricultural Organization), OECD (Organization of Economic and Cultural Development), CAP (Common Agricultural Policiy), EU (European Union), IMF (International Monetary Fund), TL (Turkish Lira), USD (United State Dolar), Schwarz Information Criteria (SIC), OLS (Ordinary Least Square),

INTRODUCTION

Animal production has been significantly decreased in Turkey per capita, which was much faster especially in recent years. Per capita daily protein and energy production from animal origin can be considered as an important indicator to show relationship between animal production and nutrients. When this indicator is taken into consideration, it can be said that although energy and protein production level of foodstuff in Turkey is adequate, production of foods from animal origin is not at the sufficient level to ensure adequate nutrition. According to FAO data, per capita total energy supply in 2017 was 3720 kcal/day, while per capita energy supply from animal products was 567 kcal/day. Similarly, per capita total protein consumption quantity was 102.2 gr/day, while per capita animal protein supply was 35.6 gr/day. Experts suggest that the average protein requirement of the individuals for healthy and balanced nutrition should be average 1 gr for each kilogram of body weight per day, of which at least 42% (about 35-40 gr) should be provided from animal source foods (Saçlı, 2007). Compared to developed countries, a considerable part of the population in the country is under the malnutrition risk due to problems in terms of availability and accessibility of animal products. For example, daily per capita total protein supply and animal protein supply were 103.85 gr and 60.38 gr in EU, 109.6 gr and 69.78 gr in USA, respectively (FAO, 2020).

Livestock sector has faced many challenges in Turkey. Some of these challenges are small scale and dispersed enterprises, low productivity, insufficient livestock policies and the lack of sufficient support.

Livestock policy is one of the basic policies of every country regardless of development level. Although it is not sufficient, livestock sector has been supported by the different agriculture policy measures since the establishment of the republic in Turkey. The main purposes of the support policies are to provide sufficient nutrient for the society, to reach self-sufficiency in the animal production, to increase the productivity of holdings, to increase income of livestock farmers and to ensure rural development.

In Turkey, there has been a positive relationship between livestock supports and animal production value by the years. Increasing animal production supports increase animal production value. According to the Ministry of Agriculture and Forestry data, livestock support amount reached to 3 million TL in 2000s. Last ten years, livestock supports have increased more than 100% and the share of that in agricultural subsidies reached to 34.6% in 2019. The value of animal production was also reached to 259 billion TL by increasing 22 times in the same period (TurkStat, 2020).

In recent years, the number of studies about the effects of agricultural subsidies on various indicators such as production, farm income, and economic growth are increasing. In line with the diversity of agricultural policy programmes, empirical studies analysed different aspects of government subsidies in agriculture. Vozarova and Kotulic (2015), for instance, found that there was a strong correlation between amount of gross agricultural production and the volume of subsidies granted in Slovakia. Malan et al. (2016) found that price distortions had a strong, significant impact on cocoa and cotton yields in Africa. Skreli et al. (2015) found that government subsidy had a clear, positive impact on the area planted with olives and vineyards in Albania. Minviel and Latruffe (2014) found that targeted investment subsidies were positively associated with farm's technical efficiency, while Bojnec and Latruffe (2013) found that agricultural subsidies reduced the technical efficiency of Slovenian farms but improved their profitability. Brady et al. (2009) analysed the impact of decoupled direct payments on biodiversity and landscape and found that eliminating the link between support payments and production had only limited negative consequences for the landscape. Semerci and Çelik (2017) examined the utilisation level of subsidies in dairy cattle enterprises in Hatay province of Turkey and found that livestock subsidies were decreasing the production costs and increasing farmers' income significantly.

The various policy support mechanisms may affect production decisions in the agriculture sector. One of the critical issues in analysing the impact of subsidies in agriculture is to recognise the long lags involved. Especially, this situation is very crucial in livestock because the sector has the high investment cost. Supports on livestock sector today might result with investment of new enterprises and improvement of current enterprises in the sector in the future. Unlike crop production, one or more years is necessary to see the effect of supports on animal production sector. When taking into consideration the lag between the production of animal products and marketing, it would be seen that the length of lag of that is longer than that of crop production.

In order to determine the appropriate policy settings in the livestock, a necessary condition is to understand the relationship between livestock subsidies and the value of animal production. Therefore, the objective of this study was to investigate the role of subsidies in livestock production value. However, as well as the impacts of the subsidies are quite extensive, the study only focused on the reflection of subsidies on production value. In particular, the paper examines the short- and long-run pass-through of subsidies to animal production value in Turkey. Thus, the aim was not only to examine any relationship between subsidies payments and animal production value but also to investigate the scope and time span of this relationship. Investigating the time effect of livestock subsidies has substantial importance, as it offers us with the knowledge related whether subsidies payments cause future benefits and increase livestock value in the long run. There is no empirical evidence showing the association between livestock supports and animal production value from long lags perspective. In this context, this is the first study examining the long-term effect of subsidies on animal production value of livestock sector by using distributed lag models. Within this scope, analyses were conducted to see whether livestock policies really affect the production value of the sector and if so, to what extent and how long its effect continues.

MATERIAL and METHODS

Data

The data of the study were collected from records of Turkish Statistical Institute (TurkStat), Ministry of Agriculture and Forestry (MAF), and OECD (Producer Support Estimates database). The data related to the value of livestock production and livestock supports were put yearly from 1990 to 2019. Deflated values of animal production and supports according to producer price index were used in study. All series have been transformed in natural logarithms, because otherwise, with trending data, the relative error might decline over time and this is inappropriate (Tiffin and Dawson, 2000). In the models, total animal production value was represented as AV_t variable and total livestock supports amount was presented as Sub_t variable.

Figure 1 gives animal production value and livestock supports by the years in Turkey. Between 1990-2019 years, while total livestock supports with constant price has increased by 3.7 times, total animal production value with constant price has increased by 6.0 times.

Theoretical Framework

Distributed lag models have a specific place in literature of economics because it allows us to analyse the behaviour of economic units (consumer, producers, etc.) based on appropriate dynamic models.

Studied and used for the first time by Irving Fisher (Isyar, 1999), distributed lag models take into account not only the present year value but also the previous year values of defining variable (Erdal et al., 2009). If the length of lags for explanatory variable is not determined, this type of model is called an as "infinite lag model" and shown as follows:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + ... + u_t \quad (1)$$

On the other hand, if length of lags for explanatory variable is defined as *k*, this type model is called "finite distributed lag model" and can be written as:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + ... + \beta_k X_{t-k} + u_t \quad (2)$$

Mostly, dependent variable (Y) responds to the explanatory variable (X) after some time which is called as "lag period". Unknown parameters (α, β_0, …, β_k) in these models can be estimated by the ordinary least square method (OLS). But this estimation has certain drawbacks about the lack of information on maximum length of lags and decline of degrees of freedom. Besides, the most important problem is about multicollinearity between explanatory variables (Gujarati, 2004) that leads to biased results. To overcome these challenges in distributed lag models, Koyck (1954) has developed one of the distributed lag models. Koyck's method assumes that effects of lags of explanatory variable on dependent variable decrease geometrically:

$$\beta_k = \beta_0 \lambda^k \qquad k=0,1,... \quad (3)$$

Where λ ($0<\lambda<1$) is known as the rate of decline of the distributed lag. Besides, $1-\lambda$ is defined as the speed of adjustment. In other words, each estimated β coefficient is less than the previous β coefficient. The value of lag coefficient, β_k, depends on the value of λ. The closer the value of λ to one, the slower the rate of decline in β_k is. Whereas, the closer the value of λ to zero, the quicker the decline in βk is. Mean lag is the weighted average of all lags involved and can be formulated as (Gujarati, 2004):

$$\text{Mean lag} = \lambda / (1-\lambda) \quad (4)$$

Mean lag provides the summary information of the speed with which the dependent variable (Y) responds to the explanatory variable (X). For instance, assume that it is used annual data, and mean lag is found as "6," this means that it takes "6" years' for the effects of changes in explanatory variable (X) to be perceived on dependent variable (Y). The features of Koyck scheme assumes nonnegative values for λ and $\lambda<1$ and finite of the sum of β's (Gujarati, 2004). As a result, Koyck method on the infinite model can be formed as:

$$Y_t = \alpha + \beta_0 X_t + \beta_0 \lambda X_{t-1} + \beta_0 \lambda^2 X_{t-2} + ... + u_t \quad (5)$$

In this form, linear regression method cannot be applied to this form of model (Equation 5), since there are large number of parameters to be estimated and λ coefficients are highly nonlinear form. As a solution, Koyck suggests to take lag by one period back to obtain following form:

$$Y_{t-1} = \alpha + \beta_0 X_{t-1} + \beta_0 \lambda X_{t-2} + \beta_0 \lambda^2 X_{t-3} + ... + u_{t-1} \quad (6)$$

Thereafter, the equation (7) is obtained as a result of equation (6) multiplied by λ.

$$\lambda Y_{t-1} = \alpha + \lambda \beta_0 X_{t-1} + \beta_0 \lambda^2 X_{t-2} + \beta_0 \lambda^3 X_{t-3} + ... + \lambda u_{t-1} \quad (7)$$

The equation (8) is got by subtracting equation (7) from equation (5):

$$Y_t - \lambda Y_{t-1} = \alpha (1-\lambda) + \beta_0 X_t + (u_t - \lambda u_{t-1}) \quad (8)$$

Afterwards, the model can be rearranged as:

$$Y_t = \alpha (1-\lambda) + \beta_0 X_t + \lambda Y_{t-1} + v_t \quad (9)$$

where v_t in Equation (9) is equal to $u_t-\lambda u_{t-1}$ and the moving average of u_t, u_{t-1}. This procedure just described is known as Koyck transformation and Equation (9) is also called as Koyck model. In Koyck model, lag values of explanatory variable (X) are not defined to solve multicollineratiy problem. Therefore, Koyck model needs to estimate α, β and λ only to solve the distributed lag model (Gujarati, 2004).

Another model of distributed lag models is the Almon model. Since the β parameters of the Koyck model are continuously decreasing, many other situations that may be different can be ignored. For these reasons, in the case of the Almon model, β 's may increase first, then decrease, or decrease first and then increase.

Shirley Almon (1965) follows the "Weierstrass Theorem" in Mathematics and assumes that βi can be approximated by a suitable-degree polynomial in i, the length of the lag. There are two basic equations that generates the cruxes of Almon model (Gujarati, 2004);

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + ... + \beta_k X_{t-k} + u_t \quad (10)$$

$$\beta_i = a_0 + a_1 i + a_2 i^2 + ... + a_n i^n \quad (11)$$

βi is an *n*th-degree polynominal in *i* . It is assumed that *n* (the degree of the polynomial) is less than *k* (the maximum length of the lag).

In the stage of modeling, firstly suitable time lag is acquired by using Schawarz Information Criteria (SIC) or Akaike Information Criteria (AIC).

In the model, the lag that makes AIC and SIC value the minimum value is considered to be the suitable time lag (Kutlar, 2000). The notations related to AIC and SIC values are defined in Equation 12 and Equation 13;

$$AIC = T \ln + 2n \quad (12)$$

$$SIC = T \ln\sigma^2 + n \ln(T) \quad (13)$$

T = Number of usable observations, n = Number of parameters estimated, σ^2 = KKT /Tn =the highest probability estimation or error variance related to the model and KKT = Residual sum of squares (RSS).

After the determination of the suitable time lag, the polynomial degree needs to be determined. Polynomial degree is at least one more than the number of each flection (maximum or minimum points). The determination of the polynomial degree is mostly subjective. Thus, to determine these criteria is up to the researcher's forecasting (Akın, 2002). In this study, based on SIC the most suitable time lag has been determined as "X-6" season and polynomial degree has been determined as second-degree polynomial by forecasting. After the determination of the polynomial degree, the suitable "Z" values are acquired. In the acquisition of "Z" values, The Equations 14, 15 and 16 can be used;

$$Z_{0t} = \sum_{i=0}^{k} X_{t-i} \quad (14)$$

$$Z_{1t} = \sum_{i=0}^{k} i X_{t-i} \quad (15)$$

$$Z_{2t} = \sum_{i=0}^{k} i^2 X_{t-i} \quad (16)$$

In the Almon scheme, Y is regressed according to "Z" variables that have been generated, not according to "X". The equation (17) can be estimated by usual OLS method. So, the forecast of α and a_i (a_0, a_1 and a_2) would provide all the statistical conditions required, on condition that possibility disturbance term fulfils the forecast of classical linear regression Model (Gujarati, 2004).

$$Y_t = \alpha + \alpha_0 Z_{0t} + \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + u_t \quad (17)$$

Moreover, when the "a" coefficients are obtained from equation (17), the original βi's are estimated from equation (11) as follows in the Equations 18, 19, 20 and 21.

$\beta_0 = a_0$ (18)
$\beta_1 = a_0 + a_1 + a_2$ (19)
$\beta_2 = a_0 + 2a_1 + 4a_2$ (20)
$\beta_3 = a_0 + 3a_1 + 9a_2$ (21)
………………………
$\beta k = a_0 + ka_1 + k^2a_2$

Thus, the distributed lag model can be interpreted in according to equation (10) by putting into their places of the obtained βi values.

Although there are studies using Distributed Lag Models in agriculture sector, none of these studies is from subsidies perspective. For instance, several authors studied the relationship between production and price in buffalo milk (Çelik, 2015a), in sheep milk (Çelik, 2015b) and cow milk (Özsayın, 2017). Within this context, this study has the potential to add benefit to agricultural policy aspect of the sector by using this methodology.

RESULTS and DISCUSSION

An Overview of the Livestock Sector in Turkey

Livestock sector has a significant potential in Turkey. The sector's contribution to farm income is substantial, and livestock production and marketing activities are important for the economic development of rural areas in Turkey (Yurdakul et al., 1999). Animal production including meat, milk, eggs, honey, wool, and hides constituted approximately 32.2% of total agricultural production value in 2019 (TurkStat, 2020). However, this value is comparatively fairly low than that in developed countries, which is about 60-70%. In recent years, Turkey's livestock sector has displayed an increasing trend in terms of productivity but a decreasing trend for per capita consumption of animal products (Akbay and Boz, 2005).

Historically, according to livestock inventory data, the number of bovine and small ruminant animals were increasing until the early 1980s but it has decreased after this date. Between 1980-2009 years, the number of bovine animals decreased by 36.1% (about 6 million heads) and the number of small ruminants decreased by 60.3% (about 41 million head). As from 2009, it has been observed an increase in the number of livestock due to the increasing supports. Thus, the number of cattle and buffaloes in Turkey reached to 17.9 million heads with an increase of 65.3% in 2017 compared to 2009. The number of sheep and goat in Turkey reached to 48.5 million heads with an increase of 80.4% in 2019 compared to 2009 (TurkStat, 2020).

In contrast to the red meat sector, the numbers of poultry and beehives have steadily increased during the same period. Poultry products are gaining importance and account for a major share of animal products in human diets in Turkey as in many other countries (Akbay and Boz, 2005). By 2019, Turkey had 348.8 million head of poultry and 8.1 million beehives, almost 6 times higher for poultry and 3.7 times higher for beehives than those numbers in 1980.

Considering the animal number and production, the level of yields per animal in Turkey are considerable low in comparison with the developed countries. Despite the significant growth in carcass and milk yields, the productivity increases have not been sufficient to prevent reduction in output potential caused by declining animal inventories, particularly in the sheep sector (Koc et al., 2001).

For the past 100 years, Turkish government has implemented a number of policies aimed to improve production of animal production but the outcomes have been dissatisfactory. The supports for plant production was substantial within the agricultural policies in Turkey, while supports for animal production had been remained at a more limited level. As a result of this, important problems had begun to be experienced in livestock sector.

Implemented policies in this period had adversely affected both the quality and quantity of animal production. This situation had also caused the ambivalent in product prices and producers' incomes. In consequence of these adverse developments, in 1987, the government introduced "Agricultural Packet" measures, which particularly concerned livestock sector. As a part of this measure, subsidy payments for import of breeding animal, mixed feed sales and incentive premium payment for milk were initiated. Incentive premium payments for red and poultry meat were implemented periodically, but these subsidies were terminated in 1995. In addition, incentive premium was paid to private sector in order to support artificial insemination. Medicines used for animal health had been reimbursed at a rate of 20% over the drug price. However, these measures had not been sufficient, and as a result livestock had declined and Turkey's food imports have gradually increased after the 1980s (Aral and Cevger, 2000; Sayın, 2001).

In consequence of internal dynamics and external factors, the comprehensive agricultural reform had been added to agenda since 2000. One of the main reasons of agricultural policy reforms was the reducing the burden of agriculture on the economy especially after the economic crises in these years. Besides this internally factor, internationally binding and non-binding pressures played an important role in the reform initiatives. These were the Uruguay Round agreement on agricultural trade, the accession negotiations with the EU which put 'adjusting to the CAP' on political agenda, the 1999 agreement with the IMF reforming agricultural policy, and the agreement with the World Bank as an important financial supporter for the Agricultural Reform Implementation Project (ARIP) (Köse, 2012).

Therefore, after 2000, the aims of agricultural policies within the context of the agriculture reform had been changed considerably. The direct income support based on land (decoupled from type or quantity of production) had put into force as the main policy instrument instead of almost all input and output price subsidies and grants in various forms. In 2000, Decree of Supporting Livestock numbered as 2000/467 under "The Project of Supporting and Improving Livestock" was initiated for following five-year period in order to develop livestock and increase animal production. Along with this decree, incentives were brought for artificial insemination, calves born by artificial insemination, equipment to use for artificial insemination, animals with breeding certificate, and keeping the stud book records in order to bring the genetic breeding more efficient and common. Furthermore, supports such as breeding heifer support, beekeeping and honey support, support of incentive pay for meat and milk, forage crops support, and fisheries were implemented (Anonymous, 2000; Ertürk et al., 2015). In 2005, new decree numbered as 2005/8053 had been entered into force but it was withdrawn after one year. In the scope of this new decree, the supports of "payment per animal" were implemented as livestock policy instruments and artificial insemination supports were terminated (Saçlı, 2012).

In 2006, a legal framework was formed for supports via The Law of Agriculture entered into force (Ertürk et.al., 2015). The purpose of this law was to determine necessary policies and make regulations in order to be developed and supported of agriculture sector and rural area in line with development plans and strategies. Within this scope, main objectives of the support instruments for livestock were to increasing of coarse fodder production and animal breeding, increasing productivity, specialisation of animal enterprises, providing of animal health and welfare, ensuring the hygiene conditions in the enterprises, incentive of animal identification system, processing and marketing of animal products and their control, monitoring and improvement of standards, supporting of aquaculture (Anonymous, 2006).

Since 2017, Turkey has been initiated to implement a new subsidy program, which is called as "National Agriculture Project". This project covers a new subsidy allocation system for agricultural products.

The project was built on 941 agricultural basins based on climate and soil to subsidize specific crops for each zone. One of the important components of the project is "Domestic Production Support Model in Livestock". The main objective of this component is to eliminate import-based husbandry and to increase the livestock inventory in Turkey. The sub-components of the livestock subsidies are the establishing areas for grazing animals, the establishing breeding pregnant heifers' production centers, the establishing breeding ram and male goat production centers in order to produce high quality male stock for the other herds, the establishing buffalo production centers, the establishing resting and control/inspection stations in order to reduce the number of animal deaths and diseases from rough transport conditions (MAF, 2020).

In sum, especially from 2000s, Turkey has made enormous strides in terms of livestock policies. In this period, both the amount of new regulations in livestock supports and the share of livestock subsidies in total agricultural supports increased. As in recent years, many of the subsidies were given to livestock. While the share of livestock subsidies in total support was 0.02% in 1990, it reached 0.5% in 2000, 9.6% in 2005, 20.3% in 2010 and 34.6% in 2019 (MAF, 2020). Roughly 4.2 billion TL (0.5 billion USD) support was provided for the livestock sector in 2019, with 12 percent increase compared to the previous year.

The Results of Almon and Koyck Models

Almon and Koyck models, which are distributed lag models, were used to investigate the association between livestock support payments and animal production value in this study. In order to determine whether or not it was appropriate to distributed lag models of the relationship between these two variables at the studied period, a correlation analysis was performed. A correlation coefficient of 0.97 was found, indicating a strong relationship between the two variables. This result indicated that animal production value and livestock subsidies relationship could be studied using distributed lag models.

In order to form Koyck and Almon model, it was necessary to determine lag length of livestock subsidies series. For this purpose, it was used Schwarz Information Criteria (SIC). The lag length is found by determining value making the smallest to Schwarz value (Acquah 2010). At this stage, it was started with a very great k value (lag length) without making any restriction for the form of distributed lag (Özsayın, 2017). There is no general rule for determining the maximum lag length, so researchers usually determine this length by themselves subjectively. In the literature, the maximum lag length for monthly series is determined as 12 or 24, while this number can be set as 4, 8 or 12 for seasonal series (Kadılar 2000). In this study, maximum lag length was taken as "8" since dataset was yearly. In accordance with schwarz criterion value, which was determined for different lag lengths in Table 1, the smallest value of SIC was obtained as "6".

As it is seen in Table 1, the effect of livestock subsidies on animal production value would disappear after six years. After determining the lag length, the Koyck model was estimated to deal with multicollineratiy problems. The Koyck model estimation result was reported in Table 2. According to the results, livestock subsidies (Sub) had positive significant effect on animal production value (AV) with adjusted R^2 of 0.83 in value.

To investigate necessary time period for one-unit change in subsidies to have a perceptible effect on animal production value, it was calculated mean lags using Koyck model. According to the results, it took 2.98 years for subsidies to be felt on production value for livestock sector. (Table 2).

Considering that $\beta k = \beta_0\lambda^k$, it can be reached regression equation (22) by using β_0 and λ derived from Koyck model.

$$Yt = \alpha+\beta_0X_t+\beta_1X_{t-1}+\beta_2X_{t-2}+\ldots..+\upsilon_t \text{ and } \beta k = \beta_0\lambda^k \; k = 0,1,\ldots \quad (22)$$

$AV=1.630+0.054Sub_t+0.040Sub_{t-1}+0.030Sub_{t-2}+0.023Sub_{t-3}+0.017Sub_{t-4}+0.013Sub_{t-5}+0.010Sub_{t-6}$ (23)

Calculation of the coefficients reported in equation (23) are as follows:

$\beta_0 = (\lambda^0 \beta_0)= 0.054$; $\beta_1 = (\lambda^1 \beta_0)= 0.040$; $\beta_2 = (\lambda^2 \beta_0)= 0.030$; $\beta_3 =(\lambda^3 \beta_0)= 0.023$; $\beta_4=(\lambda^4\beta_0)=0.017$; $\beta_5 = (\lambda^5 \beta_0)= 0.013$; $\beta_6 = (\lambda^6 \beta_0)= 0.010$

The effect of subsidy expenses on production value are geometrically declining as seen in equation (23), since λ is between 0 and 1.

However, while Koyck model suggests that lag coefficients undergo geometric decay, that is, the values of the lag coefficients decline in the pattern of a geometric progression, Almon model assumes that a polynomial of a fairly low degree can represent the lag coefficients (Watson & Teelucksingh 2002). For this reason, The Almon model is more flexible than the Koyck model in that it allows the effect of X on Y to change over time.

In the Almon model, "$\beta_k = \alpha_0 + k\alpha_1 + k^2 \alpha_2$ "assumption is used instead of $\beta k = \beta_0\lambda^k$ assumption. It must be calculated α_0, α_1, α_2 values in order to be able to apply this assumption. In the Almon sequence that is created, the regression of dependent variable is acquired according to "Z" variables that have been generated, not according to "explanatory variable". Since polynomial model degree was determined as second, the empirical equation considering Z values can be written as follows (equation 24) according to results of the model in Table 3.

$Y_t=\alpha+ \alpha_0Z_{0t} + \alpha_1Z_{1t} + \alpha_2Z_{2t} + u_t$

$Y_t= 6.425 + 0.087Z_{0t} + 0.012Z_{1t} -0.013Z_{2t} + u_t$ (24)

The result in Table 3 showed that the overall model was statistically significant with having relatively high the adjusted R-squared value (87%).

$Y_t= \alpha + \beta_0 Sub_t +\beta_1 Sub_{t-1} +\beta_2 Sub_{t-2} +\beta_3 Sub_{t-3}+\beta_4 Sub_{t-4} +\beta_5 Sub_{t-5}+ \beta_6 Sub_{t-6} + \beta_7 Sub_{t-7}$

$Y_t= 6.425 - 0.062 Sub_t + 0.013Sub_{t-1} + 0.063Sub_{t-2} + 0.087Sub_{t-3}+ 0.086Sub_{t-4} + 0.060Sub_{t-5} + 0.008Sub_{t-6}$

According to Almon model results in Table 4, livestock support payments seemed to have a negative effect on animal production value in the current year, but after one year, this affect changed the sign and became positive. However, the parameters of supports "t-0" and from "t-2" to"t-5" found statistically significant. One unit increase for previous year in the livestock subsidies caused an increasing on current animal production value by 0.013 unit, this value fallowed an increase of animal production value for "t-2" period by 0.063, for "t-3" period by 0.087 and for "t-4" period by 0.086. After 5 years, the subsidies effect on production value decreased but impact was the positive.

CONCLUSION

Since the beginning of 2000s, agricultural policies related to livestock have changed rapidly and continuously. Besides, the share of that in total agricultural supports has also increased. Therefore, it has been necessary to carry out a study on determination of the effect of these changing supports on the value of animal production considering the lagged values. For this purpose, this study investigated that the existence and the effect of long-term relationship between animal production and subsidies in Turkey which has the problem of inadequate animal food production for many years. According to results, support payments for animal production came out as an important factor that would affect the farmer's production process. The results confirmed the expectations that subsidy payments could increase the attractiveness of livestock investments and accordingly, increase producer supply for the animal production. Besides, relatively high the adjusted R-squared value from Almon model indicated that 87% of the changes in animal production value could be explained by the support payments and lagged values of that.

Moreover, there was an increase in the value of animal production in the following years by means of the supports provided to livestock. According to the results provided by Almon model, the effect of this increase continued until the fourth year. After fourth year, this effect went on increase decreasingly. The Koyck model result showed that a 10% increase in subsidies would lead to an increase in animal production of 0.54% in current year, 0.40% in the following year, 0.30% in three years and 0.23% in the fourth year. This effect remained decreasingly until sixth year. According to Koyck model results, necessary time period for being felt on animal production value of one-unit change in subsidies took 2.98 years. As it could be seen in this study, livestock support payments could not only increase the value of animal production for current year, but also could increase the production value of the following years. In sum, animal production value was sensitive to the livestock subsidies of past periods. Supports had effect positively on farmers' decision and this effect remained 6 years.

In the last 100 years, the supports for plant production were substantial within the agricultural policies in Turkey, while supports for animal production has been remained at a more limited level. As a result of this, important problems have begun to be experienced in livestock sector. Implemented policies in this period have adversely affected both the quality and quantity of animal production. This situation had also caused the ambivalent in product prices and producers' incomes. The major problems of animal production in Turkey are low productivity and high production costs. This is closely related to the race characteristics of existing animals as well as animal husbandry and feeding. Besides that, some factors such as the high cost of animal feed, which is the important cost factor in animal breeding, small-scale production, unorganized and inadequacy of marketing infrastructures affects adversely the competitiveness of the sector. According to these results, animal production problem in Turkey should be solved by long term and stable structural livestock policies to be provided for livestock and the sector's competitiveness can be increased.

The study only aimed to focus on the investigation of the link between livestock subsides and livestock production value. However, further research is needed to the investigation of the effects of these subsidies from the various aspects such as socio-economic and productivity on the sector by based on comprehensive survey data.

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Tables and Figures

Table 1. Lag length values (Schwarz criterion)

Lag length	k=0	k=1	k=2	k=3	k=4	k=5	k=6	k=7	k=8
Schwarz criterion	3.01	0.02	-0.83	-0.56	-0.93	-0.62	-0.96*	-0.58	-0.77

Table 2. The results of Koyck model

$$AVt=1.630 + 0.054Sub_t + 0.749\ AV_{t-1}$$

	Parametres	Coefficient	Std. Error	t-Statistic	Prob.
Constant	α	1.630	0.398	3.365	0.001**
Ln(Sub)	β	0.054	0.027	1.769	0.088*
Ln(AV (-1))	λ	0.749	0.071	10.622	0.000**
Adjusted R^2=0.829 F=71.217 p=0.000 DW=1.95					
Mean lag value	=λ/(1−λ)	2.98			

*** and * indicate p-values significant at 1% and 10% levels respectively.*

Table 3. The results of Almon model

Parametres	Coefficient	Std. Error	t-Statistic	Prob.
Constant	6.425	0.050	128.365	0.000**
Z_0	0.087	0.021	4.201	0.000**
Z_1	0.012	0.005	2.420	0.025*
Z_2	-0.013	0.005	-2.359	0.029*

Adjusted R^2=0.874 F=53.983 p=0.000

*** and * indicate p-values significant at 1% and 5% levels respectively.*

Table 4. Lag effects of livestock subsidies on animal production value in Turkey in Almon model (m=2;p=6)

Lag Distribution of Variables	i	Coefficient	Std. Error	t-Statistic
* . |	β_0	-0.062	0.030	-2.030*
.* |	β_1	0.013	0.010	1.380
. * |	β_2	0.063	0.016	3.847*
. *|	β_3	0.087	0.021	4.201*
. *|	β_4	0.086	0.016	5.375*
. * |	β_5	0.060	0.011	5.624*
.* |	β_6	0.008	0.033	0.243
	Sum of Lags	0.256	0.023	11.205

*p<0.01

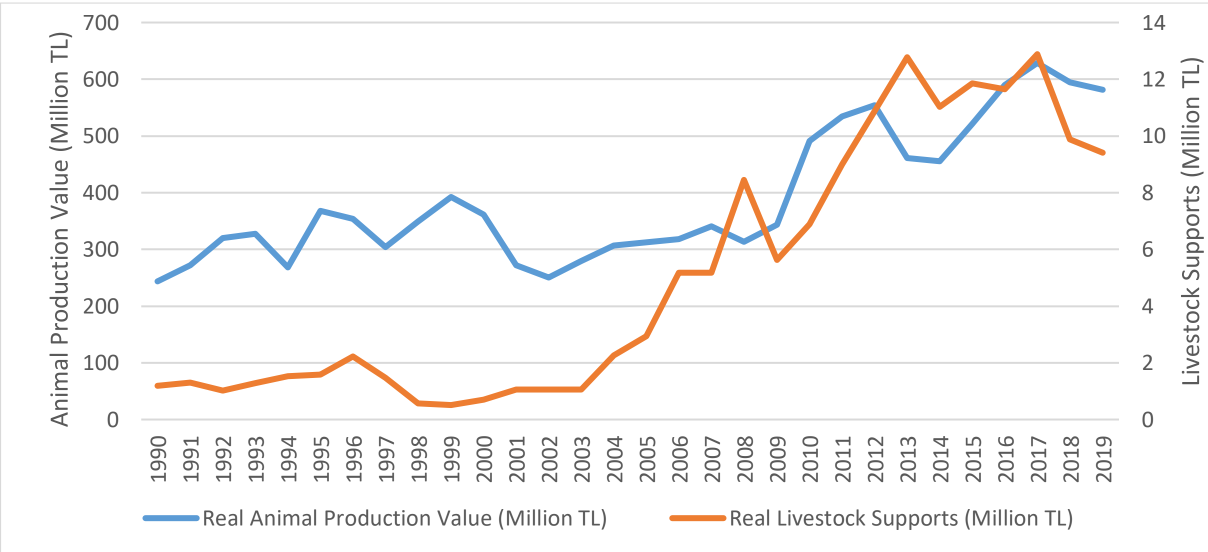

Figure 1. Animal production value and livestock supports by the years in Turkey (2003=100) (TURKSTAT, 2020; MAF, 2020; OECD, 2020).