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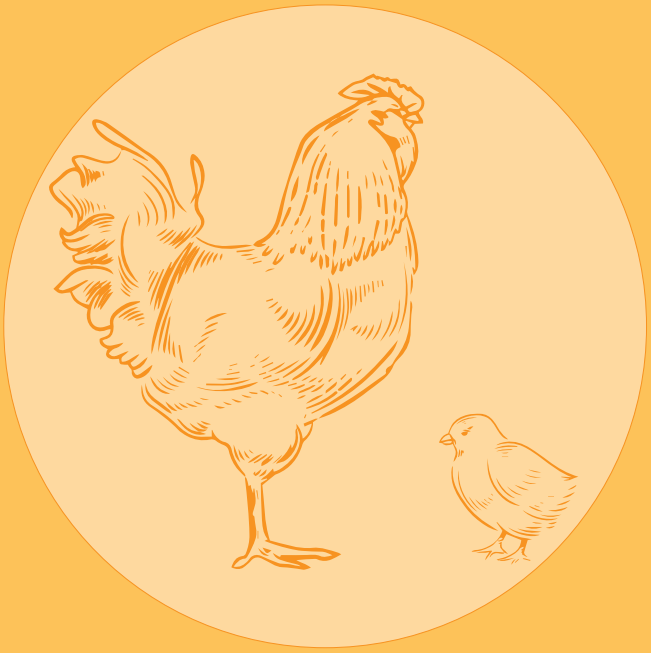

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INFLUENCE OF MOISTURE DEPLETION AND SURFACE DRIP IRRIGATION STYLE ON SOME SOIL HYDRAULIC PROPERTIES AND POTATO CROP

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ABSTRACT. This study aimed to determinate the impact of soil moisture depletion and surface drip irrigation style on some soil hydraulic properties such as infiltration, hydraulic conductivity, application efficiency, and water use efficiency for the potato crop. A field experiment was carried out in a site located northeast Ramadi, Iraq. The study consists of two factors: the first factor was two levels of moisture depletion percentages 25 and 50%, while the second factor includes two surface drip irrigation styles, which were traditional surface drip irrigation and partial drying surface drip irrigation. Consumptive use for potato plant reached 32.05 cm during the growing season. Results showed a significant influence on the treatments on application and water use efficiencies as well as on infiltration and soil hydraulic conductivity. The combination of the treatments partial drying drip irrigation style and 25% moisture depletion percentage can be recommended to achieve the best irrigation management for potato plant, which improves soil hydraulic properties and meets the best plant response in the same time.

Introduction

Water resources are the most important natural resource related to the biological and human durability through the all activities including agricultural, industrial and urban usages. It is clear that water resources renewable through the hydrological cycle but the freshwater resources faced a shortage as compared with the areas of land, which are capable for agricultural investing. Water resources shortage is the most affected limits for irrigated agriculture in Iraq due to the geographical location, which located within arid and semi-arid regions. It resulted by the limited and irregular amount of precipitation. These conditions led to increase desertification and include more planted areas under desert bands as well as the impact of drought on rivers and subsurface water reservoir. It has been estimated that the Tigris and Euphrates river discharges will continue to decrease with time, and they will be completely dry by 2040 (Al-Ansari, 2013). Water resources shortages led farmers to think about new irrigation technologies including drip irrigation to increase water unit productivity (Tolk *et al*., 2016). To reach the best water unit productivity we have to schedule irrigation to meet fit crop needs, that will save water and increase irrigated area. Using of drip irrigation for vegetable crops exceeded when compared with the other irrigation methods especially in application efficiency, power saving, controlling weeds growth and water losses. In addition to that, drip irrigation may provide advantages for growers to enhance water use efficiency by achieving better control of soil water and nutrient utilization in the root zone (Reyes-Cabrera *et al*., 2014). Irrigated agriculture still the most used for the freshwater resources which reached about 70–80% from the total freshwater demand, both shortage and surplus of irrigation water produce problems in irrigated lands such as erosion and salinity (Shirish *et al*., 2013). Evapotranspiration affected by soil moisture percentage in the root zone also the water uptake by plants affected by the available soil moisture. When

soil moisture tension increased the averages of evapotranspiration decreased (Shaw, 1964). Potato productivity studies showed that water is the most important factor, which affected yield (Panigrahi *et al.*, 2001).

Shock and Feibert (2002) mentioned that potato is one of the most sensitive plants for water stress. Many efficient irrigation methods applied for potato including drip irrigation, which reached 80% in application efficiency when compared with lower efficient surface irrigation methods in middle and south Iraq conditions (Abdul-Razak *et al.*, 2014).

Best irrigation management practices include controlling the applied water amount in each irrigation cycle. Application should be according to soil water holding capacity and plant requirements at each growth stage to meet the best plant production with fewer water losses. Drip irrigation is one of these practices due to the flexibility in applying the net depth of irrigation water amount. Irrigation can be applied within two or three batches with same time intervals between each other. Evans and Sadler (2008) mentioned that achieve high-frequency irrigation regimes is one of the factors can be used for water-saving by reducing losses through regulated deficit irrigation practices.

Reyes-Cabrera *et al.* (2014) presented drip irrigation for potato in Florida sandy soils as an alternative irrigation method with greater potential for water conservation than the traditional seepage irrigation; they also mentioned that the use of drip irrigation produces similar marketable yields of potato.

Potato plants showed a significant response to high-frequency irrigation methods. The results obtained by Kumar *et al*. (2009) cleared that drip irrigated potato registered 28.46% higher yield (mean of 2 years) over furrow irrigation. Their results also showed that the drip irrigation method also increased water use efficiency and fertilizer use efficiency when compared with furrow irrigation. Erdem *et al.* (2006) studied the effect of irrigation method (furrow and drip) and irrigation regimens (30, 50 and 70% soil moisture depletion percentages) on potato plant, their results cleared that increasing of soil moisture depletion percentages significantly decrease the potato yield for the growing season 2005. Roderick and Farquhar, (2002) found that potato tubers yield decreased when plants were underwater stress which was reached 33.63 megagram ha^{-1} as compared with 40.33 megagram ha^{-1} for the fully irrigated plants. Irrigation management practices, which save or improve soil physical properties led to improve the field condition for plant growth and production, Tartlan and Nugis, (2018) cleared that the improvement of soil bulk density produce a healthy condition for potato plants.

Potato consumptive use varying from site to other especially for high yield classes, water requirement for the best yield ranged between 400–800 mm $season^{-1}$ according to climate conditions for the classes ranged in life cycle between 120–150 days (FAO, 2002). The results which obtained by Eid *et al*. (2013) showed that potato consumptive use ranged between 350–436 mm $season^{-1}$ for different soil moisture depletion percentages, their results also cleared the increasing of soil moisture depletion percentages caused increase in the values of water use efficiency. A study conducted by Al-Kateeb *et al*. (2016) showed that potato consumptive use changed according to plant growth stages and it reached the highest value in tubers swelling stage while the lowest value was in vegetation growth stage. Kandil *et al*. (2011) presented that potato are one of the crops that planted in huge areas and it is the fourth economically important plant. Potato have a very high nutrition value due to the high content of carbohydrates, vitamins, minerals and some nutrients and it is one of the economic return plant (Bowen, 2003). In this study, we try to present and test partial drying surface drip irrigation as a management technology can be used to improve soil moisture condition in the root zone of potato plants as well as to evaluate the impact of this technology in some soil properties, irrigation efficiencies and plant response.

Materials and Methods

A field experiment was conducted during the fall season in silty loam soil at farm located about 4 km northeast Ramadi city, west of Iraq (latitude 33°27′49″ N, longitude 43°21′25.5″ E, altitude 48 m). A 0–30 cm depth, soil material sample was collected from the field and air-dried then sieved through 2 mm sieve for physical and chemical characteristics. Bulk density was 1.25 Mg m^{-3}, particle density was 2.63 Mg m^{-3}, porosity was 52.47%, volumetric water content at 0.3 bar was 33.04%, volumetric water content at 15 bar was 10.22%, available water was 22.82%. Hydraulic conductivity was 7.35 cm hr^{-1}, $pH_{1:1}$ was 7.21, Ca^{+2} 6.76 meq L^{-1}, Mg^{+2} was 4.55 meq L^{-1}, K^{+} was 0.11 meq L^{-1}, Na^{+} was 2.58 meq L^{-1}, CL^{-} was 0.12 meq L^{-1}, SO_4^{-2} was 12.28 meq L^{-1}, CO_3^{-2} was almost non-existent, HCO_3^{-} was 1.6 meq L^{-1}, and $EC_{1:1}$ was 1.4 dS m^{-1} determined according to Klute *et al.* (1986), Page *et al*. (1982) and Black (1965).

The field ploughed crossly and left some days for aeration then ground, levelled and divided to three blocks each one includes four experimental unites with 1.5 m distance between unites and 2.5 m between blocks. A factorial experiment using RCBD experimental design was carried out according to (Little and Hills, 1978). For the drip irrigation system Turbo type emitters were used with 4 L hr^{-1} flow rate at 0.5 bar operating pressure. Emission uniformity was tested before starting the experiment to be sure the system is working under optimum operating conditions. Potato tubers *Solanum tuberosum* L. class Riviera was planted with 0.08–0.10 m depth in 15/9/2017, distance between plants was 0.50 m. It was planted in one side of the lateral line for the traditional surface drip irrigation treatments and in the middle between two lines, which was 0.30 m for partial drying surface drip irrigation treatments. Fertilizers applied according to (Al-Kateeb *et al*., 2016). Anti-fungi treatments conducted using (Metalaxyl 8% WP + Mancozeb 64%) and for anti-

insects (Alpha-cypermethrin) was used. Irrigation applied using water pumped from Euphrates river. The experiment includes two factors: soil moisture depletion percentage (D) and drip irrigation style (I) as cleared in Table 1.

Table 1. Treatments description

Treatments	Description
$I_PD_{0.25}$	Partial soil surface drying with 25% moisture depletion
$I_PD_{0.50}$	Partial soil surface drying with 50% moisture depletion
$I_FD_{0.25}$	Traditional drip irrigation with 25% moisture depletion
$I_FD_{0.50}$	Traditional drip irrigation with 25% moisture depletion

Application efficiency: calculated according to the following formula mentioned by (Heermann *et al.*, 1990).

$$Ea = \frac{Ws}{Wf} \times 100 \quad (1)$$

Ea – application efficiency (%).
Ws – volume of water stored in the root zone (m^3).
Wf – volume of delivered water (m^3).

Consumptive use: irrigation applied according to soil moisture depletion, which was 25 and 50%. Applied water depth changed due to plant growth stages and was calculated using the following formula (Kovda *et al.*, 1973):

$$d = \{\theta_{F.C} - \theta_{bi}\} D \quad (2)$$

d – applied water depth (cm).
$\theta_{F.C}$ – volumetric soil water content at field capacity ($cm^3\ cm^{-3}$).
θ_{bi} – volumetric soil water content before irrigation ($cm^3\ cm^{-3}$).
D – root zone depth (cm).

Table 2 shows plant growth stages according to Scherer *et al.* (1999). Plant coefficient were 0.75, 1.15, 1.00 and 0.80 for the stages of vegetation growth, tubers starting stage, tubers swelling and maturity stage respectively (Shiri-e-Janagrad *et al.*, 2009). Gravitational method was used for the stage before emerge because of no suggested factor found in the previous sources.

Table 2. Growth stages, root depth and stage duration for potato plant (Scherer *et al*., 1999)

Growth stage	Root depth	Stage duration
Before emerge	10	15/9–13/10
Vegetation growth	20	14/10–31/10
Tubers starting	25	1/11–19/11
Tubers swelling	30	20/11–16/12
Maturity	35	17/12–23/12

Irrigation scheduling through growth season calculated according to measuring evaporated water from American evaporation pan class A. When applied, water depth was equalled to actual evapotranspiration as the following formula:

$$ETa = d \quad (3)$$

Application efficiency assumed 0.89.

$$ETo = \frac{ETa}{Kc} \quad (4)$$

$$Ep = \frac{ETo}{Kp} \quad (5)$$

ETo – reference evapotranspiration (mm day^{-1}).
Ep – pan evaporation (mm day^{-1}).
Eta – potato plant consumptive use (mm day^{-1}).
Kp – pan coefficient which was (0.75) according to (Darra and Raghuvanshi, 1999).
Kc – potato plant coefficient. Values assumed according to Shiri-e-Janagrad *et al.* (2009) for the four growth stages.

Irrigation water applied as the Ep reached the calculated amount. Application time calculated according to the following formula (Martin, 2011):

$$q \times t = a \times d \quad (6)$$

q – flow ($m^3\ hr^{-1}$).
t – run time (hr).
a – irrigated area (m^2).
d – applied water depth (m).

Saturated soil hydraulic conductivity estimated according to (Black, 1965) while infiltration measured using double-ring infiltrometer according to (Haise *et al.*, 1956).

Water use efficiency: estimated according to the formula presented in (Allen *et al.*, 1998):

$$WUE = \frac{Y}{WA} \quad (7)$$

WUE – water use efficiency (kg m^3).
Y – yield (kg ha^{-1}).
WA – amount of applied water ($m^3\ ha^{-1}$).

Data analysis. Data were subjected to analysis of variance using Genstat (ver. 9.1, VSN International Ltd., Hemel Hempstead, UK). If interactions were significant, they were used to explain results. If interactions were not significant, means were separated with L.S.D.

Results and discussion

Results in the variance analysis table showed significant differences in all measured traits (Table 3).

Table 3. Analysis of variance for main effects of surface drip irrigation methods and allowed depletion percentage on application efficiency, saturated soil hydraulic conductivity, basic infiltration rate and water use efficiency

Source	df	Application efficiency	Saturated soil hydraulic conductivity	Basic infiltration rate	Water use efficiency
Block	2	0.0758	0.9172	0.34750	2.6069
Irrigation (I)	1	12.9169**	5.0311**	4.68750**	19.6608**
Depletion (D)	1	5.4271**	1.7557*	1.68750**	7.3947**
I × D	1	0.2437ns	0.0271ns	0.00750ns	0.0867ns
Error	6	0.4839	0.2728	0.02750	0.7847
Corrected Total	11				

ns – not significant; *significant at 0.05 level; **significant at 0.001 level, ANOVA.

Application efficiency. Table 4 shows the impact of soil moisture depletion and drip irrigation style on application efficiency; the data cleared a significant impact for the partial drying surface irrigation on application efficiency, which reached 91.49% as compared with 89.42 for the traditional surface drip irrigation. The reason could be due to the separation of irrigation water into two parts, a part applied in one side of the plants and the other part applied to the other side in the middle time between two irrigation cycles. This technique may reduce deep percolation as well as evaporation losses. The results also showed increase application efficiency for the 25% soil moisture depletion treatments, which reached 91.12% when compared with 89.78% for the 50 depletion percentages. The using of short irrigation intervals (high-frequency irrigation management) reduced irrigation water losses which reflected in improve application efficiency (Evans, Sadler, 2008). High-frequency irrigation management decrease the amount of the applied water in each irrigation cycle. This technique increases the chance for the soil to hold most of the applied water in the root zone and minimize losses by deep percolation and runoff.

Table 4. Influence of soil moisture depletion percentages and drip irrigation styles on application efficiency (%)

Irrigation	Depletion		
	D0.25	D0.50	Average
I_P	92.02	90.96	91.49
I_F	90.23	88.60	89.42
Average	91.12	89.78	Gm=90.45
$L.S.D_{0.05}$	I=0.983	D=0.983	I.D=NS

Consumptive use. Table 5 shows the applied water depth for the treatments, which reached 32.05 cm for all treatments. Irrigation water depth for the stage before emerge was 17.32 cm due to the high level of temperature during this period as well as the long duration for the stage. The amount reached 4.41 cm for vegetation growth stage then increased in the other stages, this could be due to development of plant root and shoot also the increasing of plant leafs area (Zhao, Cheng, 2005). Consumptive use decreased in maturity stage and amounted 1.08 cm due to the reduction of plant water demand as growth completed and plants parts begin dry as well as decrease temperature at this period. The amount of potato consumptive use was close to the results obtained by Eid *et al*. (2013).

Saturated soil hydraulic conductivity. Table 6 presents the impact of treatments on hydraulic conductivity; results cleared a significant impact for drip irrigation styles, which reached 7.38, and 6.09 cm hr^{-1} for partially dried treatments and traditional drip-irrigated treatments in succession. The reason may be due to the dividing of net irrigation depth which decreases dry-moisture cycles impacts on soil structure including particles dispersion and sedimentation process. This technique also had a minimum effect on soil bulk density and the percentage of the big pore spaces, which control water movement. The hydraulic conductivity reached 7.12 and 6.35 cm hr^{-1} for 25 and 50% depletion percentages and this may be due to short intervals between irrigations and the same reasons above. The results agreed with (Al-Kateeb *et al*., 2016).

Table 6. Impact of drip irrigation styles and depletion percentages on hydraulic conductivity

Irrigation	Depletion		
	D0.25	D0.50	Averages
I_P	7.81	6.95	7.38
I_F	6.42	5.75	6.09
Average	7.12	6.35	GM=6.73
$L.S._{D0.05}$	I=0.738	D=0.738	I.D=NS

Table 5. Pan evaporation, applied water depth and number of irrigation cycles for potato plants

Treatments	Growth stage	Number of irrigation cycles	Depth of pan evaporated water (mm)	Depth of applied water (mm)	Notes
IPD0.25	Before emerge	37	191.0	172.3	First irrigation cycle was in the same amount for all treatments to recharge soil moisture to be at field capacity. Applied depth was 2.83 cm.
	Vegetation growth	5	78.0	44.1	
	Starting tubers	5	58.4	50.0	
	Tubers swelling	4	55.0	43.3	
	Maturity	1	18.0	10.8	
IPD0.50	Before emerge	19	191.0	172.3	Treatments IPD0.50 IFD0.25 received same number of irrigation cycles regardless the differences in depletion percentages.
IFD0.25	Vegetation growth	2+ stage complete	78.0	44.1	
	Starting tubers	2+ stage complete	58.4	50.0	
	Tubers swelling	2	55.0	43.3	
	Maturity	1	18.0	10.8	
IFD0.50	Before emerge	10	191.0	172.3	Stage complete means when growth stage completed but irrigation not required at the same time so water applied in amount calculated to recharge soil moisture to be at field capacity
	Vegetation growth	1+ stage complete	78.0	44.1	
	Starting tubers	1+ stage complete	58.4	50.0	
	Tubers swelling	1	55.0	43.3	
	Maturity	1	18.0	10.8	

Basic infiltration rate. Table 7 shows the impact of partial drying of the soil surface and traditional drip irrigation at 25 and 50% soil available moisture depletion percentages on basic infiltration rates. As one of the soil hydraulic properties (Horton *et al.*, 1994), the impact of the treatments on soil basic infiltration rates have the same trends with saturated hydraulic conductivity. The statistical analysis clarified a significant influence for the irrigation style on infiltration. Basic infiltration rate in soil reached 8.10 cm hr^{-1} for partially dried treatment as compared with 6.85 cm hr^{-1} for the traditional drip-irrigated treatment. The reason may be due to the impact of traditional drip irrigation, which increases soil bulk density and decrease the porosity especially the fine pore spaces and that decreased the cross-sectional area for flow in soil body. On the inverse, the partial drying for soil surface caused decreasing in soil bulk density and increase porosity as compared with their values before planting which caused improvement in soil structure. The values of basic infiltration rates were 7.85 and 7.10 cm hr^{-1} for depletion percentages 25 and 50% respectively and this may be due to the high frequency in irrigation with low amounts of applied water as well as to the reasons mentioned above.

Table 7. Impact of irrigation styles and depletion percentages on basic infiltration rates

Irrigation	Depletion		
	D0.25	D0.50	Averages
I_P	8.50	7.70	8.10
I_F	7.20	6.50	6.85
Averages	7.85	7.10	GM=7.48
$L.S.D_{0.05}$	I=0.2343	D=0.2343	I.D=NS

Table 8. Impact of irrigation styles and depletion percentages on water use efficiency kg m^{-3}

Treatment	Parameter		
	Total yield kg ha^{-1}	Applied water volume m^3 ha^{-1}	Water use efficiency kg m^{-3}
I_P	12733.00	840	15.17
I_F	10600.00		12.62
$D_{0.25}$	12333.00		14.68
$D_{0.50}$	11000.00		13.10
$I_PD_{0.25}$	13466.33		16.03
$I_FD_{0.25}$	11199.72		13.33
$I_PD_{0.50}$	11999.70		14.29
$I_FD_{0.50}$	9999.75		11.90
$L.S.D_{0.05}$	I= 1.251	D= 1.251	I.D=NS

Water use efficiency. Table 8 shows the impact of depletion percentages and irrigation style on water use efficiency. The results cleared a significant impact for irrigation style, which reached 15.16 kg m^{-3} for partial irrigation as compared with 12.62 kg m^{-3} for traditional drip irrigation. Dividing the applied water into two parts led to decrease losses and improve soil moisture conditions, which increases the yield also may be due to the response of potato plant to high-frequency irrigation methods (Kumar *et al.*, 2009). The values also reached 14.68 and 13.10 kg m^{-3} for 25 and 50% depletion percentages due to decrease irrigation intervals, which improve soil moisture condition for plants and reflected on yield. The results have the same trends with what obtained by Erdem *et al.* (2006); their results also showed the highest water use efficiency value was obtained for the treatment irrigated with lower depletion percentage in the 2005 growing season.

Conclusion

In order to improve irrigation water management in arid regions by testing a new practice for drip irrigation to achieve best soil moisture condition, we conduct this study for compare the new suggested practice named partial drying with the traditional surface drip irrigation. The impact of soil moisture depletion percentages also evaluated and potato plant was the biological indicator for the study. We can conclude that partial drip irrigation style led to improve the studied parameters including application efficiency, infiltration and water use efficiency, when compared with traditional drip irrigation as well as the 25% depletion percent, had a positive influence in soil hydraulic parameters and plant response compared with 50% soil available moisture depletion percentage.

Conflict of interest

The authors declare that they have no conflict of interest.
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Author contributions

SA 50%, AS 25%, MA 25% – study conception and design;
SA 100% – acquisition of data;
SA 25%, AS 25%, MA 25% and GH 25% – analysis and interpretation of data;
SA 50% and AS 50% – drafting of the manuscript;
MA 50% and GH 50% – critical revision and approve the final manuscript.

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AGRI-FOOD COMPARATIVE ADVANTAGES IN THE EUROPEAN UNION COUNTRIES BY VALUE CHAINS BEFORE AND AFTER ENLARGEMENT TOWARDS THE EAST

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ABSTRACT. To identify the European Union (EU) member states strong exports sectors and food chains, the revealed comparative advantage indices from trade data were calculated using the total global trade as the benchmark of comparison. The empirical results show that the level and patterns in the development of the revealed comparative advantage indices for agri-food products for each of the EU countries in the global markets were mixed. The most successful EU member states in agri-food export competitiveness in global markets were the Netherlands, France, and Spain. Differences between the EU member states were also identified for the main agri-food product groups. Latvia, Bulgaria, Estonia, Lithuania, and Luxembourg were the five EU countries that competed most successfully in global grain markets. In terms of fruit and vegetable produce exports Greece, Cyprus, Spain, Lithuania, and Bulgaria were the most competitive EU countries in world markets. With respect to global dairy markets Denmark, Luxembourg, Latvia, Ireland, and the Netherlands achieved the largest export advantages, although strong export competitiveness was evident for almost all of the EU member states in the global dairy markets. Cyprus, Bulgaria, Ireland, Hungary, and Denmark revealed significant export advantages in global meat markets. New EU-member states, particularly Bulgaria and Latvia, achieved high export advantages in the global markets for the select product groups.

Introduction

Exports and international competitiveness are crucial driving forces of contemporary sectoral and economic development. This can explain the motivation of studies investigating competitiveness and economic development scenarios as an analysis and economic policy issue (Traill, Pitts, 1998; Bierut, Kuziemska-Pawlak, 2017; Auzina-Emsina *et al*., 2018). In spite of widespread subsidies for agriculture and rural development that might influence competitiveness, literature on investigation of agri-food sectors competitive performance in general and in European Union (EU) countries (Carraresi, Banterle, 2015; Harvey *et al*., 2017; Smutka *et al*., 2018) as well as country case studies (Qineti *et al.*, 2009; Vitunskiene, Serva, 2015) have been developed.

There are rare studies to compare agri-food competitiveness between countries, four value chains, and before and after the European Union (EU) enlargement towards the East. More specifically, this paper investigates the key insights of revealed comparative advantages focusing on four main agri-food product chains in the EU-27 member states (prior of accession of Croatia to EU): grain products, fruit and vegetable products, dairy products and meat products. Buturac *et al.* (2017) investigated Croatian agri-food international competitiveness, while Croatian dairy sector competitiveness by Frohberg *et al.* (2010). The specific contribution is synthesis and comparisons of own empirical results between EU-27 member states for four different agri-food value chains before and after the EU enlargement towards the East. Our focus is on comparisons of agri-food comparative advantages in the EU-27 countries by value chains before and after enlargement towards the

East in 2004 (Estonia, the Czech Republic, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia) and in 2007 (Bulgaria and Romania). In 2004, Cyprus and Malta joined the EU as well.

The remainder of the paper is organised as follows: the next section presents materials and methods on revealed comparative advantage indices for agri-food exports by the EU-27 member states in global markets. The following section reports and discuses result on revealed comparative advantage indices for main agri-food supply chains by the EU-27 member states in global markets. The final section draws some conclusions.

Materials and Methods

The concept of 'revealed' comparative advantage was introduced by Liesner (1958) and later redefined by Balassa (1965). This index empirically identifies a country's weak and strong export sectors (e.g. Bojnec, Fertő, 2014a). Balassa (1965) defined the Revealed Comparative Advantage (RCA) index as:

$$RCA = (Xij / Xit) / (Xnj / Xnt) \quad (1)$$

where X represents exports, i is a country, j is a commodity, t is a set of commodities, and n is a set of countries that are used as the benchmark of comparison for export markets. RCA is based on observed export patterns. The results of the RCA index presented here are calculated at the World Customs Organisation's Harmonised System (HS) at the six-digit level. The calculated RCA indices at the six-digit level (in principle for 789 agri-food products/year/country, but the actual numbers of the RCA indices depend on the number of agri-food products exported by a certain EU country) are aggregated on the averages for subsectors of the Broad Economic Categories (BEC) for grain products, meat products and dairy products value chains exports, and on the averages for subsectors of the product groups of the Multilateral Trade Negotiations (MTN) for fruit and vegetable products value chain exports. Therefore, the presented results are calculated RCA averages for subsectors of the BEC/MTN categories from the HS at the six-digit level.

The RCA measures a country's exports of a commodity relative to its total exports and to the corresponding export performance of a set of countries, e.g. the world's agri-food exports. If RCA > 1, then a country's agri-food comparative advantage in the world market is revealed. The benchmark of the RCA index is the world market in denominator indicating that world market includes both extra-EU trade and intra-EU trade. In this way, we aim to capture global agri-food export competitiveness within and outside EU markets.

Despite some critiques of the RCA index as an export specialisation index, such as the asymmetric value problem (Laursen, 2015), the problem with logarithmic transformation (De Benedictis, Tamberi, 2004), gross- versus value-added trade flows (Brakman, Van Marrewijk, 2017) and the importance of the simultaneous consideration of the import side (Vollrath, 1991), it can provide useful evidence regarding the competitiveness in academic and policy analyses (French, 2017), in our case for the EU-27 agri-food export competitiveness in global markets.

The period of this study covers the years between 2000 and 2011. This retrospective approach and studied period have been selected due to captures similar length of the years pre and post EU enlargement towards the East. Following the literature on international trade liberalization and RCA index (Balassa, 1961, 1965), our main assumption is that the EU enlargement towards the East might have strengthened product specialization towards comparative advantages and utilization of economies of scale with positive effects on the EU-27 agri-food export competitiveness in global markets.

The UN Comtrade database – International Trade Statistics at the six-digit harmonised commodity description and coding systems (HS6-1996) is used for agri-food exports of the EU-27 countries to world markets. Agri-food trade as defined by the World Customs Organisation contains 789 product groups. The UN Comtrade database is used with the World Integrated Trade Solution (WITS) software developed by the World Bank, in close collaboration and consultation with various international organisations, including the United Nations Conference on Trade and Development (UNCTAD), the International Trade Center (ITC), the United Nations Statistical Division (UNSD, 2018) and the WTO (2018).

Results and Discussion

Comparative advantage indices for agri-food exports by the EU-27 member states in global markets

The revealed comparative advantage (RCA) indices differ between the EU-27 countries. The EU enlargements have slightly increased the agri-food export competitiveness of the EU-27 countries in global markets as a whole, and particularly of some of the established EU-15 countries (Figure 1).

The results for the RCA indices illustrate that most of the EU-27 countries had a mean value of RCA>1 for agri-food exports in /to the world markets in 2011, thus indeed indicating revealed comparative advantages. However, in most of these countries, the median values amounted to less than 0.5 which in turn suggests that the majority of agri-food products exhibited revealed comparative disadvantages (RCA<1).

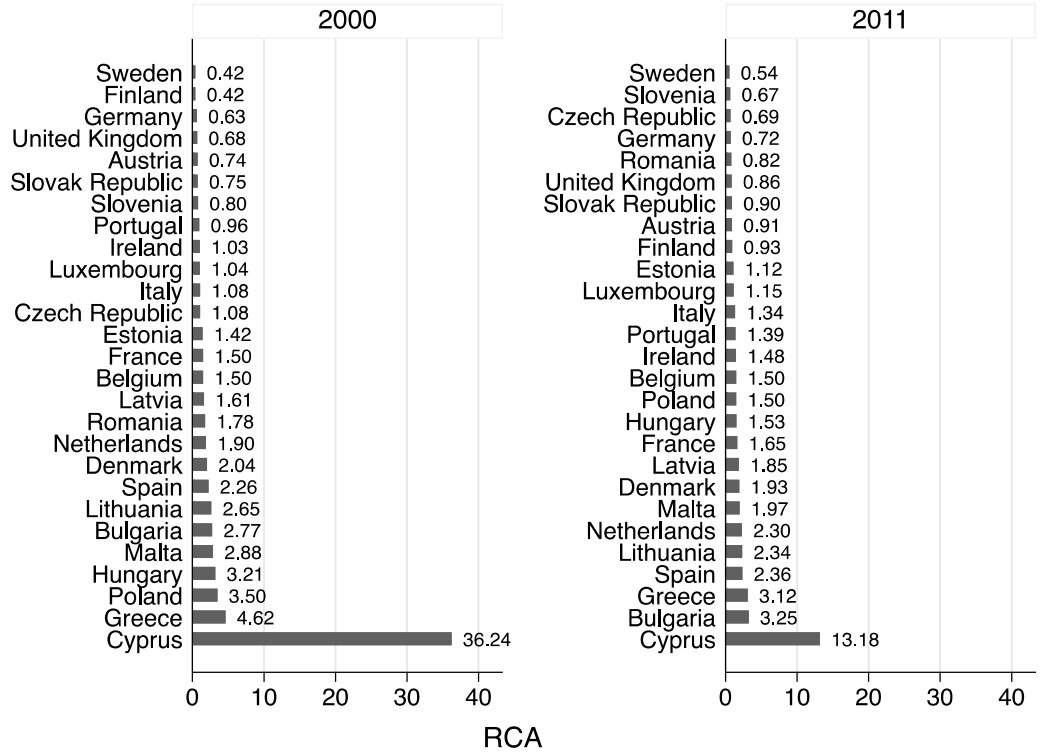

Figure 1. Mean values of RCA indices for agri-food exports in global markets for the EU-27 member states in 2000 and 2011
Source: Authors' calculations based on the UNSD Comtrade database with WITS (World Trade Integration Solution) software.

Comparative advantage indices for main agri-food value chains exports by the EU-27 member states in global markets

Grain products value chain. Grain products value chain international competitiveness varies between the EU-27 countries (Svatoš *et al.*, 2010; Bojnec, Fertő, 2016a). Particularly focussing on grain products, some new EU-12 member states could strengthen their export competitiveness (revealed comparative advantage with RCA > 1 indices) in the global grain markets (Figure 2): Bulgaria, Estonia, Hungary, Latvia, Lithuania, Romania, and Slovakia. A result that is also valid for some of the old EU-15 member states, namely Austria, Denmark, Finland, France, Ireland, Luxembourg, the Netherlands, and Spain.

Moreover, a deterioration pattern in export competitiveness in the global grain markets was experienced by Belgium, Cyprus, and Greece.

Revealed comparative disadvantages existed for the Czech Republic, Germany, Italy, Malta, Portugal, Slovenia, Sweden, and the United Kingdom (UK).

To quantify differences within the class of grain products, the analysis considers a more disaggregated level selecting the following BEC product groups: BEC 21 with primary grain products, BEC 111 with primary grain products mainly for industry, BEC 121 with processed grain products for industry, and finally the BEC 122 with processed grain food and grain products intended for final consumption in households. Figure A1 in Appendix presents disaggregated calculated RCA index results for grain products value chain exports.

As regards BEC 21, Austria, Bulgaria, Estonia, France, Hungary, Ireland, Latvia, Lithuania, Romania, Slovakia, and Sweden strengthened their revealed comparative advantage for the, while the other EU-27 member states largely suffered revealed comparative disadvantages in the global BEC markets.

Turning to the global markets for BEC 111, Bulgaria, France, Greece, Hungary, and Lithuania, and in most recent years also Denmark, Estonia, Latvia, Luxembourg, Poland, and Romania could gain revealed comparative advantages.

For the BEC 121, revealed comparative advantages could be experienced by Bulgaria, Cyprus, France, Hungary, Lithuania, Luxembourg, the Netherlands, Poland, and Spain, and in most recent years also Austria, Belgium, Denmark, Estonia, Finland, Greece, Ireland, Italy, Latvia, Portugal, and Slovakia.

In the global markets for BEC 122, revealed comparative advantages were gained by Austria, Belgium, Finland, France, Latvia, Lithuania, Slovakia, Spain, the UK, and in most recent years also Bulgaria, Cyprus, Denmark, Estonia, Ireland, and, to a lesser extent, the Netherlands.

Fruit and vegetable products value chain. In spite of the increasing importance of fruit and vegetables products value chain in developed countries nutrition, it has attracted less academic attention regarding their international competitiveness (Bojnec, Fertő, 2015, 2016b). In the group of fruit and vegetable products exports, only the three-member states Spain, Greece and Cyprus could achieve higher values of the RCA indices in the global markets than the other EU-27 countries (Figure 2).

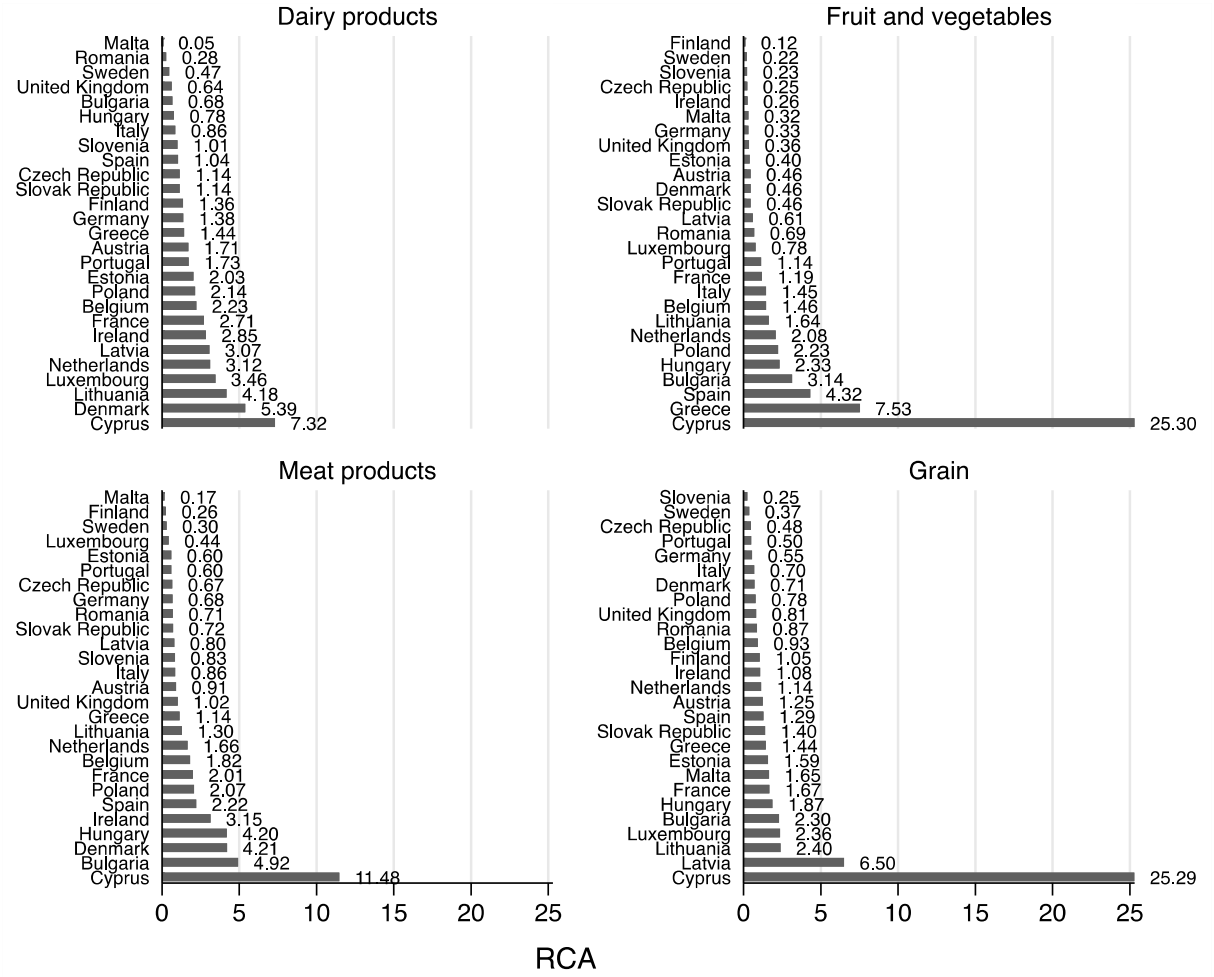

Figure 2. Mean values of RCA indices for grain products, fruit and vegetable products, dairy products and meat products exports in global markets for the EU-27 member states, averages of the years in the period 2000–2011

Source: Authors' calculations based on the UNSD Comtrade database with WITS (World Trade Integration Solution) software.

In addition, revealed comparative advantages were observed by the following EU-27 member states: Belgium, Bulgaria, France, Hungary, Italy, the Netherlands, Poland, and in most recent years also Lithuania, and Portugal.

However, considering the product groups of the MTN, then the corresponding results were different. Figure A2 in Appendix presents disaggregated RCA index results for fruit and vegetable products value chain exports. The analysis was conducted via the following MTN product groups: MTN 1201, with fruit and vegetables fresh or dried products, MTN 1202 denoting fruit and vegetables semi-processed products and MTN 1203 containing fruit and vegetables prepared or preserved products.

For MTN 1201, Cyprus, France, Greece, Italy, the Netherlands, Spain, and in most recent years Lithuania and Portugal gained/had revealed comparative advantages in these global markets.

For MTN 1202, the countries Bulgaria, Estonia, Greece, Italy, Lithuania, Poland, Romania, Spain, and in most recent years Belgium, Latvia, and the Netherlands achieved revealed comparative advantages in the global markets.

Finally, for MTN 1203, Belgium, Bulgaria, France, Greece, Hungary, Italy, the Netherlands, Poland, Spain, and in most recent years Portugal realised revealed comparative advantages.

Dairy products value chain. Dairy products are important agri-food sector in EU-27 member states and in global agri-food trade. This can be also a reason that more studies have investigated export competitiveness of dairy products (Drescher, Maurer, 1999; Tacken *et al*., 2009; Van Berkum, 2009; Bojnec, Fertő, 2014a; Couillard, Turkina, 2015; Irz, Jansik, 2015; Viira *et al.*, 2015; Krieviňa *et al.*, 2016; Balogh, Jambor, 2018).

Concerning dairy products exports, revealed comparative advantages in the global markets could be achieved by Austria, Belgium, Cyprus, Denmark, Estonia, France, Germany, Greece, Ireland, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, and in most recent years also Finland, Slovenia and Spain (Figure 2).

Figure A3 in the Appendix presents disaggregated calculated RCA index results for dairy products value chain exports. For the BEC 22 including industrial dairy supplies not elsewhere specified or processed, revealed comparative advantages could be gained by Denmark, France, Germany, Ireland, Latvia, and Poland.

Looking at the group of primary dairy products mainly for households' consumption as specified in BEC 112, more than half of the EU member states realised revealed comparative advantages, namely Austria, Belgium, Denmark, Estonia, France, Germany, Greece, Ireland, Lithuania, Luxembourg, the Netherlands, Portugal, Slovakia, Slovenia, Spain, and in most recent years also the Czech Republic, Finland, Hungary, Latvia, Poland, and the UK.

Almost the same goes for BEC 121 with processed dairy products mainly for industry. Here as well, a large group of member states experienced revealed comparative advantages: Belgium, Denmark, Estonia, France, Lithuania, the Netherlands, Poland, Portugal, and in most recent years also Bulgaria, Cyprus, Finland, Germany, Greece, Ireland, Latvia, and Spain.

Finally, exports to the global markets in the group of BEC 122 containing processed food and dairy products intended for final consumption in households also helped a relatively large number of EU-27 countries to get revealed comparative advantages: Belgium, Denmark, Estonia, France, Germany, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, and in most recent years Finland, Greece, Poland, and Sweden.

In summary, these results indicate export competitiveness for various dairy products for a large number of the EU-27 member states. The crucial role in dairy trade competitiveness can play processed products (Bojnec, Fertő, 2008).

Meat products value chain. Meat and meat products export competitiveness of EU countries on global markets have already attracted attention (Banterle, Carraresi, 2007; Fischer, Schornberg, 2007; Bojnec, Fertő, 2014b; Torok, Jambor, 2016). Considering meat products exports, the group of EU-countries that achieved revealed comparative advantages in the global markets including Belgium, Bulgaria, Cyprus, Denmark, France, Hungary, Ireland, the Netherlands, Poland, Spain, and in most recent years the UK also (Figure 2).

Having a closer look at more specific meat product groups, the group of countries with revealed comparative advantages in the global markets is changing both in number and in size (Figure A4 in Appendix):

Regarding only the primary meat products in BEC 21, revealed comparative advantages could be achieved by Belgium, Bulgaria, Cyprus, Denmark, Greece, Spain, the UK, and in most recent years also Austria, the Netherlands, and Slovakia.

For the group BEC 22 with industrial meat supplies not elsewhere specified or processed, the number of countries with revealed comparative advantages declined including Belgium, France, Slovakia, the UK, and, to a lesser extent, Denmark, and in most recent years Ireland, Italy, Portugal, and Spain.

In contrast to the just mentioned product group, BEC 121 with processed meat products mainly for industry, more countries scored revealed comparative advantages: Belgium, Denmark, France, Hungary, Italy, the Netherlands, Poland, Spain, and in the most recent years also Austria, Cyprus, Germany, and Lithuania.

Turning to processed food and meat products intended for final consumption in households in the BEC 122, again a relatively large number of countries realised revealed comparative advantages, namely Belgium, Bulgaria, Cyprus, Denmark, France, Hungary, Ireland, the Netherlands, Poland, Spain and in most recent years Lithuania and the UK.

In summary, Belgium, Cyprus, Denmark, France, Hungary, the Netherlands, and Spain are the EU-27 member states, which most frequently are competitive regarding meat products exports in the global markets.

Conclusion

The objective of this paper was to identify the EU-27 member states strong exports sectors and food chains. The revealed comparative advantage indices from the available trade data were calculated for the EU-27 member states using the total global trade as the benchmark of comparison. The empirical results indicate mixed revealed comparative advantage indices for agri-food products for each of the EU-27 countries in world markets, i.e. the calculated levels and patterns failed to indicate a unique development in the analysed period. Moreover, our main assumption that the EU enlargement towards the East might have increased the EU-27 agri-food export competitiveness was only partly approved. We have found that the EU enlargements from EU-15 to EU-27 was of limited effect since they only slightly increased the agri-food export competitiveness (RCA > 1) of the EU-27 countries in global markets as a whole, and in particular of some established EU-15 countries. This can be explained by a fact that the new EU member states might need more time to restructure and specialize their agri-food products value chains towards comparative advantages and utilization of economies of scale to compete with EU and other global competitors in intra- and extra-EU trade flows. However, the findings could identify/prove the three established countries Netherlands, France and Spain as the most successful member states in agri-food export competitiveness in global markets.

Looking at the development of the export competitiveness indices for agri-food products for each of the EU-27 countries in global markets, the calculations yielded mixed levels and patterns. Differences between the EU-27 member states were also identified for the main four agri-food product groups. In the global grain markets, an increase of revealed comparative advantage indices was true for, firstly the new EU-12 member states Bulgaria, Estonia, Hungary, Latvia, Lithuania, Romania, and Slovakia, and secondly, the old EU-15 member states Austria, Denmark, Finland, France, Ireland, Luxembourg, the Netherlands, and Spain. In the global fruit and vegetable markets, Spain, Greece and Cyprus achieved strong revealed comparative advantage indices, followed by Belgium, Bulgaria, France, Hungary, Italy, the Netherlands, Poland, and, during the most recent years Lithuania and Portugal also. In the global dairy markets relatively high revealed comparative advantage indices could be realised by

Austria, Belgium, Cyprus, Denmark, Estonia, France, Germany, Greece, Ireland, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, and, during the most recent years, also Finland, Slovenia and Spain. These results imply that there really was high export competitiveness for most of the EU-27 member states in the global dairy markets. As compared to the former product group, in the global meat markets only a smaller number of countries could gain good revealed comparative advantage indices: Belgium, Bulgaria, Cyprus, Denmark, France, Hungary, Ireland, the Netherlands, Poland, Spain, and during the most recent years also the UK.

The results suggest that most competitive EU-27 countries in a certain agri-food product do not necessarily represent a significant proportion of total EU-27 countries agri-food production and exports. Agri-food export competitiveness does not depend only on less or more favourable natural conditions for agricultural production and/or on less or more favourable structure of agricultural holdings, but also on some other factors of competitiveness in agri-food value chains as an issue for further research. Among study limitations, the presented results are based on calculated RCA index as a relative indicator of export competitiveness. In research in future it can be used in conjunction with some other trade indicators such as export unit price, average annual growth rate of export and other to display country export competitiveness.

The current paper focuses on pre- and post-EU enlargement agri-food export competitiveness. Meanwhile Croatia joined the EU and the UK is in a stage of Brexit. Yet, most EU countries have experienced the recession affecting their agri-food sector performance and export competitiveness. In addition, some important drivers of export competitiveness especially for dairy, meat and fruit markets are not captured in our results such as Russian embargo and African swine fever. Therefore, the update of data sample, recalculation with the updated datasets and drivers of export competitiveness are challenge for research in future.

Conflict of interest

The authors declare that they have no conflict of interest.

Author contributions

SB study conception and design; interpretation of data; drafting of the manuscript; critical revision and approval of the final manuscript.
IF acquisition of data; data analysis and drafting of the manuscript.

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Appendix

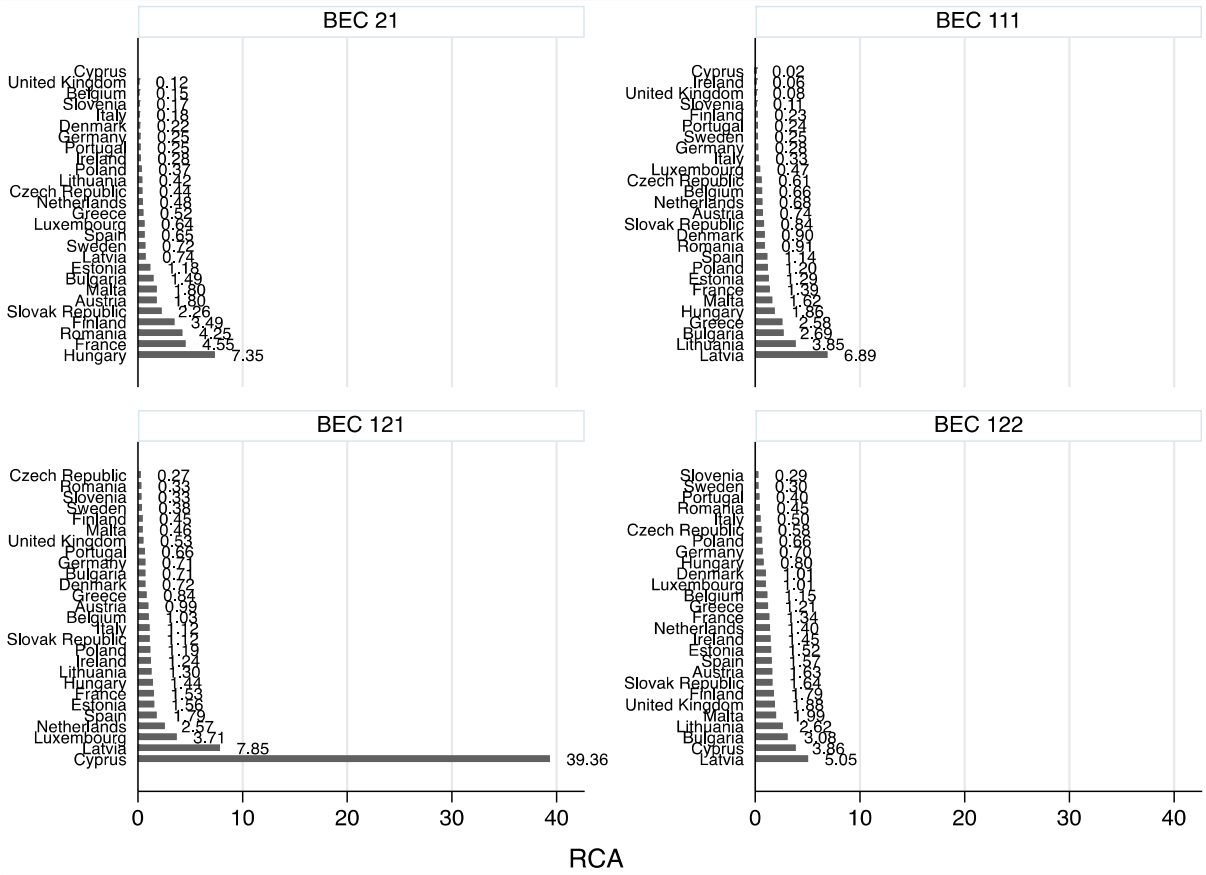

Figure A1. Mean values of RCA indices for grain products value chain exports in global markets for the EU-27 member states, averages of the years in the period 2000–2011
Source: Authors' calculations based on the UNSD Comtrade database with WITS (World Trade Integration Solution) software.

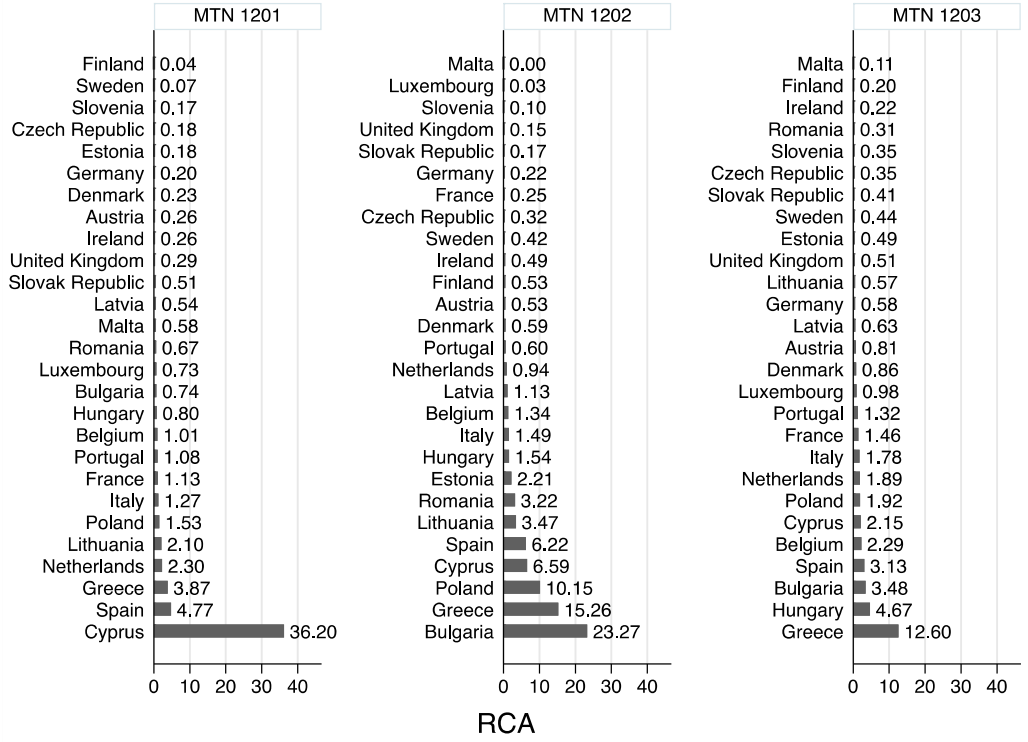

Figure A2. Mean values of RCA indices for fruit and vegetable products value chain exports in global markets for the EU-27 member states, averages of the years in the period 2000–2011
Source: Authors' calculations based on the UNSD Comtrade database with WITS (World Trade Integration Solution) software.

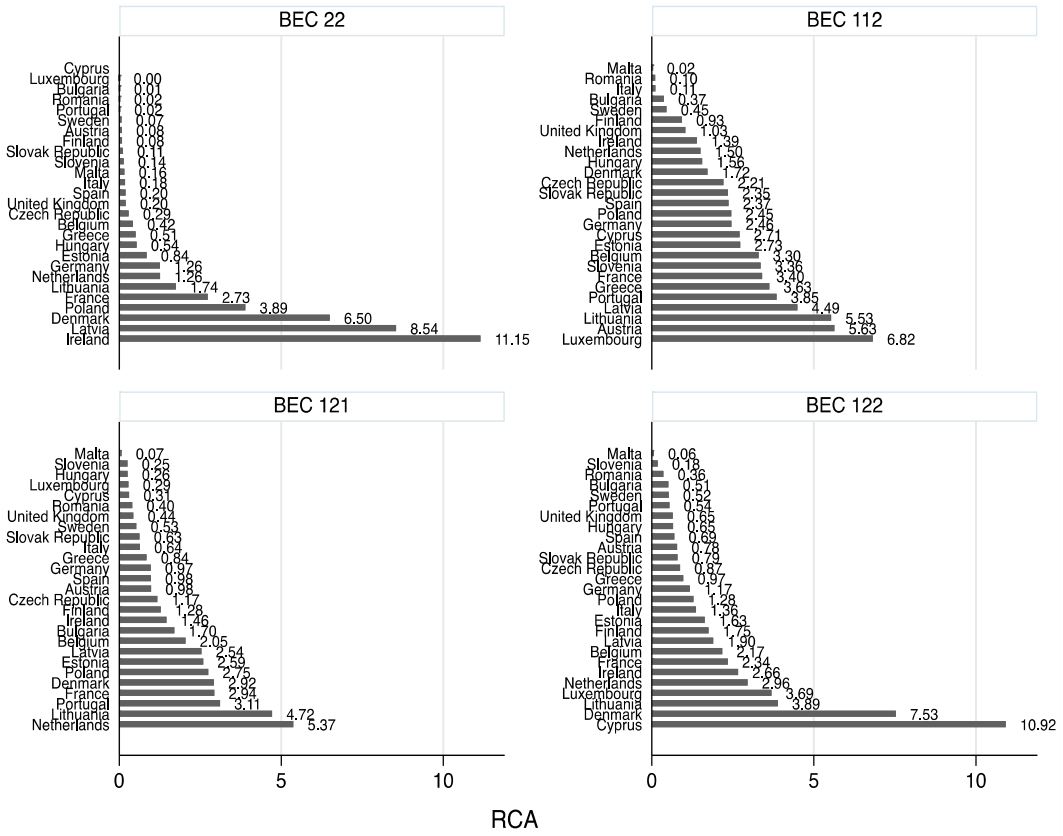

Figure A3. Mean values of RCA indices for dairy products value chain exports in global markets for the EU-27 member states, averages of the years in the period 2000–2011
Source: Authors' calculations based on the UNSD Comtrade database with WITS (World Trade Integration Solution) software.

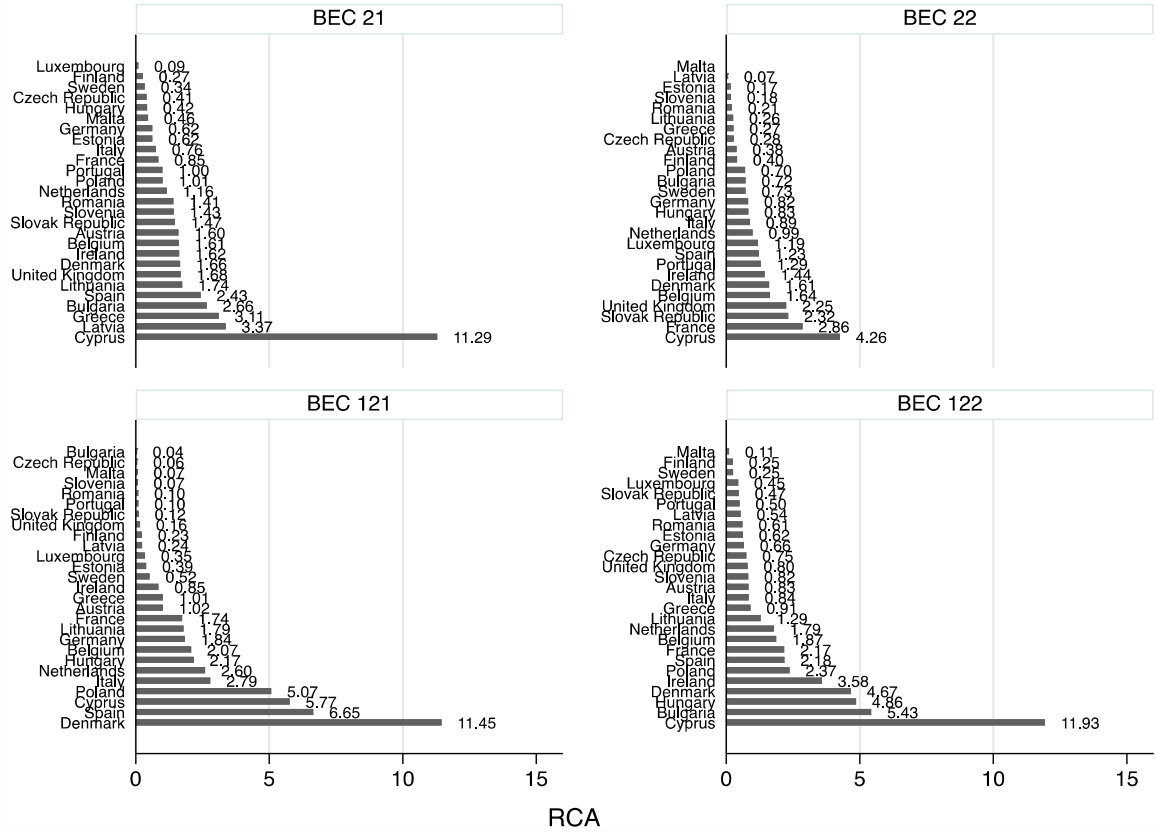

Figure A4. Mean values of RCA indices for meat products value chain exports in global markets for the EU-27 member states, averages of the years in the period 2000–2011
Source: Authors' calculations based on the UNSD Comtrade database with WITS (World Trade Integration Solution) software.

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THEORETICAL BACKGROUND FOR INCREASING GRIP PROPERTIES OF WHEELED TRACTORS BASED ON THEIR RATIONAL BALLASTING

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ABSTRACT. The correct selection of the level of mechanical ballasting for wheeled tractors is among the most important issues for increasing their utilisation efficiency, in particular, increasing their grip properties. The shortcoming of the earlier undertaken investigations was that they virtually did not take into account the allowed maximum pressure of the tractor's wheels on the soil. At the same time, little attention was paid to the impact of the maximum load-carrying capacity of the wheel tyres. The aim of the paper is to eliminate these deficiencies. Because of the authors' efforts, the new technique has been developed, which differs in that it employs the requirement of the tyre's ecofilic properties. The implementation of this requirement implies setting the maximum allowed level of the tractor wheels' pressure on the soil and taking into account the maximum load-carrying capacity of the wheel tyres as well as the vertically applied load on each of the tractor's axes under the simultaneous action of both the horizontal and vertical components of the tractive resistance of the employed agricultural implement. The practical effectiveness of the new approach is shown by the example of determining the possibility and level of ballasting the specific wheeled tractor operating as part of a ploughing unit.

Introduction

Recently, the scientists and practical experts have been more and more opting for tractor ballasting as a way of solving the problem of the efficient operation of agricultural machinery. This approach is based on the assumption that increasing the tractor's operating weight facilitates the improvement of its grip properties. At the same time, the reduction of the specific fuel consumption takes place (Spagnolo *et al.*, 2012; Lovarelli *et al.*, 2018).

However, if until recently the recommended level of tractor ballasting had stayed within the range of 0–23% of the tractor's operating weight, now many companies go for levels of 100% and even more (Boykov, Belkovskiy, 1988; Bulgakov *et al.*, 2016). That means that, in principle, some tractors can be ballasted with weights that are equal or exceeding their operating weights.

However, it has to be remembered that the greater the vertical load per tractor wheel tyre is, the higher the soil compaction rate is (Ansorge, Godwin, 2007). Moreover, this effect is quite pronounced not only in the upper soil layer but in the lower stratum as well (Taghavifar, Mardani, 2014). That note is of great importance since the soil compaction rate is much easier to control in the upper soil layer, than in the lower one.

The operators of agricultural machinery have to keep in mind that the ballasting weight must be correctly distributed between the tractor's axles. Otherwise, the traction efficiency of the tractor will inevitably become reduced, together with the agronomic background becoming substantially compacted (Pranav, Pandey, 2008; Nadykto *et al.*, 2015).

In general, the draught resistance of the employed agricultural implements shapes the distribution of the vertical load between the tractor's axles. In order to

reduce or even exclude its impact on the tractor operating in the transportation mode, the scientists have drawn the respective theoretical functional relations (Janulevičius, Giedra, 2005). However, since the paper scrutinises only the transport unit, the draught resistance of the towed implement is represented only by the horizontal component.

Moreover, the same research group have derived the equations that facilitate calculating the masses of the ballast loads needed to provide for the controlled movement of the tractor with the attached implements (Janulevičius, Giedra, 2008). Again, the vertical component of their resistance is not taken into consideration. Meanwhile, the practical experience of operating agricultural units has proved that its input in the distribution of the vertical loads between the tractor's axles is more significant than that of the horizontal component (Bulgakov *et al.*, 2016).

However, the most important omission in the earlier undertaken studies is that they do not include into the scope of consideration of the tractor-ballasting problem the maximum permissible pressure of its wheels on the soil (Wong, Huang, 2006; Šmerda, Čupera, 2010). In addition, the maximum load-bearing capacity of the wheel tyres is paid insufficiently much attention. Whereas omitting these parameters from consideration can result in the tractor ballasting becoming either insignificant or even completely impossible, even in case double (or triple) tyres are used. Moreover, this fact is crucial, since the issue of preserving the structure, which means the fertility, of the soil, is day after day becoming more urgent.

It is also worth noticing that the technique of theoretically determining the vertical loads on the tractor axles in the presence of the horizontal and vertical components of the tractive resistance of the operated agricultural implements (especially the tractor-mounted ones!) has been highlighted inadequately little in the scientific publications.

In this context, the aim of the paper is to develop such a technique for determining the tractor ballasting conditions, which will take into account: a) level of the maximum permissible pressure of the tractor's wheels on the soil; b) maximum load-bearing capacity of the wheel tyres; c) vertical load on each of the tractor's axles, when the tractor is under the action of both the horizontal and vertical components of the draught resistance of the operated agricultural implement.

Theoretical premises

It is common knowledge that the ballasting of a wheeled tractor is most effective on hard surfaces, while it happens exactly on soft backgrounds that need in ballasting arises (Guskov *et al.*, 1988; Nadykto *et al.*, 2015). In addition, the latter ones are more prone to such a negative process as soil compaction, especially in the early spring season.

Hence, the **first requirement** is defined as follows: the pressure on the soil generated by the tractor's wheels may not exceed the maximum permissible value $[Q_r]$.

The **second requirement** is as follows: the operating vertical load on the wheel N_{ek} may not exceed the maximum load-bearing capacity of the tyre P_w. Merging the two above-stated requirements, the following condition of the wheel tyre's **ecofilic property** recommended by the authors is arrived at:

$$\frac{N_{ek} \leq P_w}{F_s} \leq [Q_r], \quad (1)$$

where F_s – area of the tyre's supporting (ground contact) surface.

The parameter F_s can be calculated with a practically sufficient accuracy using the following relation:

$$F_s = \pi \cdot H_z \cdot \sqrt{(D - H_z) - (B - H_z)}, \quad (2)$$

where H_z – depth of the tread generated by the wheel; D, B – diameter of the wheel and width if its tyre, respectively. In its turn:

$$H_z = \frac{N_{ek}}{\pi \cdot \rho_w} \cdot \sqrt{D \cdot B}, \quad (3)$$

where ρ_w – pressure of the air in the wheel tyre.

From the expression (1), the following condition of the possibility to ballast the tractor's wheel results univalent:

$$\frac{N_{ek} < P_w}{F_s} < [Q_r]. \quad (4)$$

Therewith, when the condition (4) is fulfilled in practice, the ballast weight per tractor wheel can be determined with the use of the following formula:

$$M_b = (P_w - N_{ek})/g, \quad (5)$$

where g – free-fall acceleration.

In its general form, the process of determining the possibility to ballast some specific wheeled tractor (in terms of one wheel) has the following simple algorithm (Figure 1).

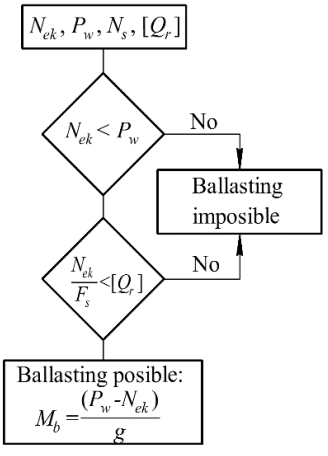

Figure 1. Flow chart of algorithm for determining possibility of tractor ballasting

In the formulae (4) and (5), the parameter N_{ek} – operating vertical load per wheel of the tractor, is an unknown quantity. In order to develop the method of its theoretical determination, an equivalent schematic model of the forces acting on the tractor with the mounted implement in the longitudinal and vertical plane will be analysed.

The first step is to examine the force system acting only on the tractor. For that purpose, the respective mechanical constraints will be replaced by their reactions. On the part of the mounted implement, the forces acting on the tractor are R_{zn} and R_{zv} (Figure 2).

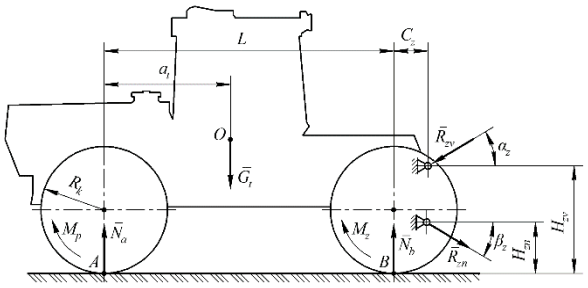

Figure 2. Equivalent circuit of forces influencing on the tractor

The first of the mentioned forces acts on the tractor via the top link, the second one – via the lower links of its rear linkage. Together with the tractor's weight force G_t, they generate the vertical reactions on the wheels of its front (N_a) and rear (N_b) axles.

That said, the following should be kept in mind. The tangential traction forces of the tractor axles and the respective forces of resistance to their movement are applied at points *A* and *B* and vectored strictly horizontally. In view of that, they are not used in the equations for determining the reactions (N_a) and (N_b), therefore, they are not shown in Figure 2.

The mounted implement is under the action of (Figure 3): a) reaction from the tractor R_{zn} and R_{zv}; b) implement weight force G_p; c) vertical reaction of the implement's carrier wheel N_k; d) force P_{fk} and moment M_{fk} of implement carrier wheel rolling resistance; e) vertical (R_z) and horizontal (R_x) components of the implement's draught resistance applied at point *D*.

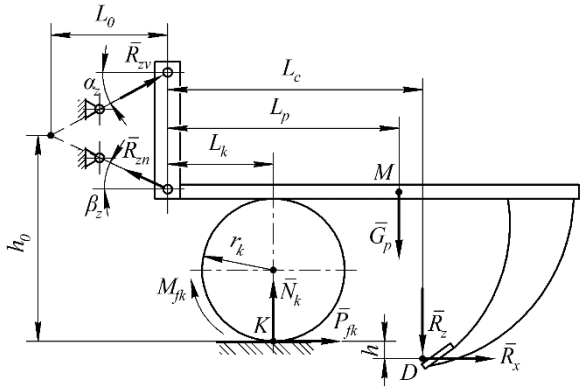

Figure 3. Equivalent circuit of forces influencing on the agricultural implement

For the combination of the tractor and the mounted implement (Figure 2 and Figure 3), the following five forces are unknown quantities: N_a, N_b, N_k, R_{zv}, R_{zn}. In order to determine them, it is sufficient to have five independent equations of the tractor and implement equilibrium in the longitudinal and vertical plane.

The above-mentioned equations appear as follows:

$$\begin{aligned}
&N_a - G_t + N_b - R_{zv}\cdot\sin\alpha_z - R_{zn}\cdot\sin\beta_z = 0;\\
&G_t\cdot a_t - N_b\cdot L + f\cdot R_k\cdot(N_a + N_b) + R_{zv}\cdot K_1 + R_{zn}\cdot K_2 = 0;\\
&N_k - G_p - 0.2\cdot R_x + R_{zv}\cdot\sin\alpha_z + R_{zn}\cdot\sin\beta_z = 0;\\
&f\cdot N_k + R_x + R_{zv}\cdot\cos\alpha_z - R_{zn}\cdot\cos\beta_z = 0;\\
&R_x\cdot[0.2(L_c + L_0) - h_0 - h] + N_k\cdot(f\cdot r_k - L_k - L_0 - f\cdot h_0) + G_p\cdot(L_p + L_0) = 0,
\end{aligned} \qquad (6)$$

where

$$K_1 = -\cos\alpha_z\cdot H_{zv} + \sin\alpha_z\cdot(C_z + L);$$

$$K_2 = \cos\beta_z\cdot H_{zn} + \sin\beta_z\cdot(C_z + L);$$

$$L_0 = \frac{H_{zv} - H_{zn} + l_{zn}\cdot(\tan\alpha_z\cdot\cos\beta_z + \sin\beta_z)}{\tan\alpha_z + \tan\beta_z};$$

$$h_0 = L_0\cdot\tan\beta_z + H_{zn} - l_{zn}\cdot\sin\beta_z.$$

In the system of equations (6), f − coefficient of rolling resistance; α_z, β_z − angles of inclination with respect to the horizontal plane of the central and lower links of the tractor's linkage, respectively; l_{zn} – length of the lower links of the tractor's linkage; a_t, L, L_c, L_o, L_k, L_p, h_o, h, r_k, C_z, H_{zn}, H_{zv} − parameters, the meaning of which is obvious from Figure 2 and Figure 3.

The system of equations (6) makes it rather easy to determine the vertical reactions on the tractor axles N_a and N_b. If the parameters of the tractor's tyres/wheels are known and the $[Q_r]$ has been selected, then, using the equations (4) and (5), both the possibility and level of ballasting for each of the tractor axles can be determined.

It is to be noted that the system of equations (6) can easily be transformed for the case of the tractor operated with a trailing implement. For that purpose, it will be sufficient to analyse the equilibrium state of the tractor, when the implement acts on the tractor only with the force R_{zn}, inclined at a respective angle of β_z to the horizontal (Figure 2).

Materials and Methods

The accuracy of the above-stated theoretical background was verified with the use of the ploughing unit comprising a HTZ-17221 tractor and a PLN-5-35 five-bottom force-measuring plough (Figure 4).

Figure 4. Ploughing implement on HTZ-17221 carrying tractor

Summary specification of HTZ-17221	
Operating weight force (G_t,kN)	85.4
Engine output rating (kW)	129
Tyres	23.1R26
Static load per tyre (kN):	
- front axle (N_{ast})	26.7
- rear axle (N_{bst})	16.0
Static diameter of tyre (D, m)	1.6
Width of tyre section (B, m)	0.587
Maximum load-carrying capacity of tyre (P_w, kN)	30.9
Air pressure in tractor's tyres (ρ_w, kPa)	120

The ploughing was carried out in the autumn season. In accordance with the requirements of DSTU 4521: 2006 "Mobile agricultural machinery", the maximum permissible pressure of the tractor wheels on the soil [Q_r] was assumed at 160 kPa.

The tractor weight force (G_t) and its distribution between the axles (N_{ast}, N_{bst}) as well as the plough weight force (G_p) were determined by weighing them with the use of the DPU-5 load gauge to an accuracy of 0.5 kN. The obtained resulting data were used for determining the longitudinal coordinate of the tractor's centre of mass (a_t) with the use of the following formula:

$$a_t = \frac{N_{ast} \cdot L}{G_t}, \quad (7)$$

where L – tractor's wheelbase (Figure 2). This parameter, as well as the linear parameters Lc, Lk, Lp, rk, Cz, Hzn, Hzv and lzn, were measured with the use of a gauge tape to an accuracy of 1 cm.

During the field-testing of the ploughing unit, the tractor travelled on the stubble field of winter wheat. In order to determine the coefficient of rolling resistance f, the tested tractor together with the plough were towed by another tractor. The effort applied for the translation of the ploughing unit (P_f) in the five test repetitions was registered with the use of the strain-gauge link that sent a signal to the analogue-digital converter, which transmitted it to the PC. The required unknown coefficient was determined with the use of the following expression:

$$f = \frac{P_f}{G_t + G_p}. \quad (8)$$

The draught resistance of the plough (R_x) was measured with the use of the draught strain-gauge link installed on it (Figure 5).

The signal from that link was registered in the PC after being processed by the analogue-digital converter. The ploughing unit was set up for three different tilling depths: 22, 25 and 28 cm. The travelling velocity of the unit during its ploughing to each of the specified depths was determined on a leg with a length of 250 m in two repetitions (travelling ahead and returning). The unit travelling time t was measured to an accuracy of 0.2 s with the use of the COC-26-2-000 stopwatch. On the same leg, the effective rolling radius of the tractor wheel R_k was determined. This was done with the use of the following formula:

$$R_k = \frac{60 \cdot 250}{\pi \cdot t \cdot n_k}, \quad (9)$$

where n_k – number of the tractor wheel's revolutions. This parameter was registered with the use of hermetically sealed reed relay sensors (Figure 6).

After each run of the unit, the depth of tilling was measured with the use of a mechanical depth gauge. The measurement spacing was 1 m, the number of measurements – at least 200.

The following statistical characteristics were computed for the arrays of data on the plough draught resistance and the depth of ploughing: mean, variance, coefficient of variation, correlation function and spectral density.

The data obtained as a result of the measurements were input into the system of equations (6) in order to determine the vertical reactions on the front (N_a) and rear (N_b) axles of the tractor. Then, using the formulae (4) and (5), the possibility and level of the tractor axle ballasting were found.

Figure 5. Draught strain-gauge link

Figure 6. Wheel rpm pickup

Results and Discussion

First, the assessment is to be done of the impact of the plough's oscillations on the tractor. This assessment will take into account the fact that the more stable its traction load is, the more stable values of the vertical loads on the tractor axles are.

In their turn, the stability of the plough draught resistance oscillations (force R_x, Figure 3) is largely defined by the characteristics of the tilling depth (parameter h) oscillations.

The analysis of the experimental data has shown that the variance of this parameter's oscillations does not substantially differ for different tilling depths (Table 1). According to the F-test of Fischer, it can be stated with a confidence level of 95% that the null hypothesis of the equality of the compared variances is not rejected.

The coefficient of variation of the ploughing depth oscillations at all depth values does not exceed 6%. That indicates that the process under consideration has low variability (Dospehov, 1985). Moreover, it turns out to be also a low-frequency process. This conclusion results from the analysis of the normalized correlation functions of the ploughing depth oscillations (Figure 7).

As can be seen in the diagrams presented in Figure 7, the length of correlation for all three functions is equal to about 3.5 m. That means that this is the distance, at which the correlation between the tilling depth values disappears virtually completely. Admittedly, the said length of correlation suggests the low frequency of the process of oscillation of the depth, to which the unit under investigation ploughs the soil. Moreover, it is virtually stochastic, since the analysed normalized correlation functions do not contain any more or less pronounced periodic components.

The low variability of the ploughing depth oscillations (*i.e.* the parameter h) is reflected respectively in the characteristics of the plough draught resistance (force R_x) oscillations. As is proved by the analysis of the experimental data (Table 1), the variance of these parameter oscillations is virtually independent on the tilling depth. Again, in accordance with the F-test of Fischer, the difference between its values is statistically random. Also, since the values of the coefficient of variation stay within 10% (Table 1), the process under consideration is a low variability one (Dospehov, 1985).

The frequency spectrum of the plough draught resistance oscillations can be assessed by analysing the respective normalized spectral densities (Figure 8).

The analysis has shown that the cut-off frequency for the normalized spectral densities of the R_x force oscillations is within the range of 16–18 s^{-1} (*i.e.* 2.5–2.9 Hz) for all the three ploughing depth settings. The maximums of the plough draught resistance oscillation variances are observed within the frequency range of 0 to 6 s^{-1}, which altogether does not exceed 1 Hz. All that unequivocally indicates that the oscillations with such characteristics are low-frequency oscillations.

It is appropriate to suggest that the stable properties of the variation of the tilling depth and the plough draught resistance oscillations provide no ground for any significant oscillations of the vertical load on the tractor's axles. For the purposes of the theoretical computation, they can be assumed, to a first approximation, to be virtually constant.

Using the measurement results obtained during the experiments and the system of equations (6), the vertical loads on the front (N_a) and rear (N_b) axles of the tractor have been obtained (see Table 1). The calculations have been done with the use of the following values for the parameters in the system of equations (6):

G_t = 85.4 kN; G_p = 8.4 kN; L = 2.86 m; f = 0.07; a_t = 1.1 m; r_k = 0.2 m; L_c = 1.7 m; L_k = 1.5 m; L_p = 1.5 m; C_z = 0.4 m; l_{zn} = 0.93 m; α_z = 5°; β_z = 1°; R_k = 0.78-0.80 m;H_{zv} = 1.2 m; H_{zn} = 0.45 m.

The values of the variable parameters h and R_x are shown in Table 1. The analysis has determined that, in the presence of a draught load, considerable redistribution of the vertical loads on the tractor axles takes place. Specifically, the vertical load on the front axle decreases and on the rear axle increases. Overall, additional loading of the whole tractor takes place. The characteristic of this process is shown in Figure 9.

As is obvious, the greater the plough draught resistance is, the greater the additional vertical load on the tractor becomes, even though at an insignificant rate (by 2-3 kN). Together with the operating weight (G_t = 85.4 kN), this makes up the adhesion weight of the tractor within the range of 87.4-88.4 kN.

The further calculations with the use of the formulae (4) and (5) have been carried out using the following values of their parameters: N_{ek} = N_a or N_b; $[Q_r]$ = 160 kPa; D = 1.6 m; P_w = 30.9 kN; ρ_w =120 kPa; B = 0.587 m.

Table 1. Results of experimental and calculated data of ploughing unit

Ploughing depth h			Plough's draught resistance R_x			Calculated data	
Mean (cm)	Variance (cm^2)	Coefficient of variation (%)	Mean (kN)	Variance (kN^2)	Coefficient of variation (%)	Dynamic load N_a (kN)	Dynamic load N_b (kN)
21.9	1.65	5.9	25.0	3.50	7.5	50.4	37.0
25.7	1.73	5.1	28.4	4.00	7.0	50.6	37.2
28.5	1.88	4.8	31.8	4.60	6.7	50.8	37.4

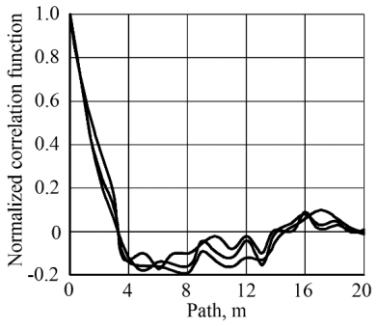

Figure 7. Normalized correlation function of ploughing depth

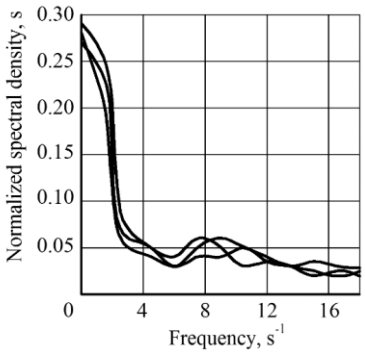

Figure 8. Normalized spectral density of plough draught resistance

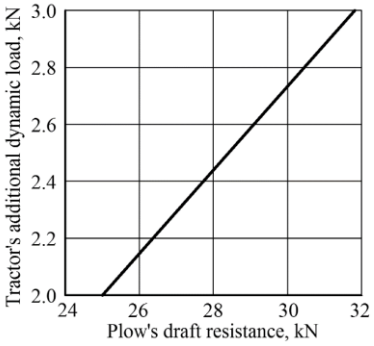

Figure 9. Tractor's additional dynamic load dependence on plough's draught resistance

The results of calculations show that the front axle of the tractor under consideration when operated with a plough, can be in principle additionally loaded with a weight at a rate of 1140 kg. However, in reality this is **not** to be done. The reason is as follows. When the tractor travels without a traction load (or stands), the vertical reaction on its front axle is N_{ek} = 53.4 kN. If the ballast weight equal to (1140 · 9.81)/1000 = 11.2 kN is added to it, the resulting sum will be N_{ek} =53.4 + 11.2 = 64.6 kN. However, that violates the condition (4). In accordance with the expression (5), the maximum ballast weight that can be used to load additionally the front axle of the tractor under consideration may not exceed 900 kg. However, if the maximum permissible pressure of the wheels on the soil is set at a level of $[Q_r]$ = 130 kPa, then this ballasting weight (i.e. 900 kg) will also become unacceptable.

The front axle of a HTZ-17221 tractor, when operated with a plough, can be additionally loaded, as follows from formula (4), by a weight of 2500 kg. In that case, if the maximum permissible pressure of the wheels on the soil is set at $[Q_r]$ = 130 kPa, the maximum permissible ballasting of the tractor will be not greater than 530 kg.

Overall, at $[Q_r]$ = 160 kPa, the total ballasting weight on a HTZ-17221 tractor planned to be used with a five-bottom plough with a working width of 1.75 m may not exceed M_b = 900 + 2,500 = 3,400 kg. However, this value is equal to only 39% of the operating weight of the above-mentioned tractor.

At $[Q_r]$ = 130 kPa, ballasting this tractor is altogether not allowed. Otherwise, that will result in both overloading the tractor's tyres and inexcusably strong compaction of the soil, the fertility of which has to be maintained at all times. Ballasting such a tractor at $[Q_r]$ = 130 kPa becomes possible only in case of using twin tyres. However, that engineering solution is technologically impracticable in case of operating the HTZ-17221 tractor with a plough.

Conclusions

Improving the efficiency of operation of wheeled tractors by means of increasing their grip properties can be achieved through the correct selection of the level of their mechanical ballasting. When solving the problem of ballasting wheeled tractors, it is suggested to take as the basis the new condition of the ecofilic property of the tyre. The devised technique of the practical implementation of this condition implies: 1) deciding on (setting) the maximum permissible pressure of the tractor wheels on the soil; 2) taking into account the maximum load-carrying capacity of the wheel tyres of the specific tractor; 3) finding out / taking into account the real values of the vertical loads on each of the tractor axles, when both the horizontal and vertical components of the draught resistance of the operated agricultural implement act on the tractor.

The specific example of application of the devised technique has revealed that, when a tractor with an operating weight of about 8700 kg and the maximum permissible pressure of the wheels on the soil of 160 kPa unitised with a plough with a working width of 1.75 m is used, the maximum permissible level of ballast on the engine unit may not exceed 39% of its weight. If the permissible pressure of the wheels on the soil is set at $[Q_r]$ = 130 kPa, ballasting the tractor under consideration is altogether not allowed.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author contributions

VB – study conception and design;
VN, SK, VN, JO and SI – acquisition of data;
VN and VN – analysis and interpretation of data;
VB and JO – drafting of the manuscript;
SI – editing the manuscript;
VB and JO – critical revision and approval of the final manuscript.

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FACTORS INFLUENCING ADOPTION OF IMPROVED POTATO (BELETE) VARIETY: EVIDENCE FROM ETHIOPIAN SMALLHOLDER FARMERS

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ABSTRACT. Improving the adoption of improved crop varieties is very important to increase income, reduce hunger, sustain food security, and to reduce poverty in sub-Saharan Africa like Ethiopia. Similarly, Belete potato variety is one of the improved varieties that have been utilized by Ethiopian farmers, but this variety was not conjointly adopted in all parts of the country. Thus, this research was intended to analyze factors influencing rural farmers' decision for the adoption of improved potato varieties in Southern Ethiopia. Both qualitative and quantitative data were collected from primary and secondary sources. To select the sample respondents, two-stage sampling techniques were employed and finally, 146 households' heads were selected. To get the data survey questionnaires, interview schedules, Focused Group Discussions, observations and key informant interviews were employed. To analyze the data, both descriptive statistics and econometric model were employed. Accordingly, the econometric model indicated that family labour, access to fertilizer, access to credit service, frequency of extension contacts, participation in training and field day, and educational level were positively and significantly influenced the adoption of Belete potato adoption, however, the market distance was influenced negatively. Therefore, this result implies that researchers, policymakers, extension service providers and other concerned bodies should be given attention to increasing the adoption of improved Belete potato variety.

Introduction

Agriculture in the Ethiopian economy prominently is the largest contributor to the national economic development and the main income-generating sector for the majority of the rural population. Among the agricultural sectors, potato production is one that plays a crucial role in the livelihoods of the people. Ethiopia is known in potato production and it is the fourth-best very important crop next to others and cultivated on about 18.1 million hectors of land (FAOSTAT, 2010). In Ethiopia, potato is mainly produced not only for consumption, but it is also important to improve the livelihoods of the people by using it as exchanges with other commodities, for market purposes to increase the income of households and foods of crops where there is land grazing problem. Potato is used to overcome the problem of seasonal food shortage when other food crops are decreased from storages (Singh, Rana, 2013) and it also encourages farmers as the monetary rewards for those farmers who are participating in potato production (Elraiah *et al*., 2014). Thus, the demand for potato production in Ethiopia is very high and the producers cover huge amount of land farming for potato production. Potato holds great potential for improving the livelihoods of Ethiopian people in multi-dimensions: high yield, early maturity, excellent food value, increasing household revenues and reduction of food deficiency (Leprince *et al*., 2014).

Potato production is seasonal based and farmers tolerate to find out an appropriate season for its farming base on climate variability (CSA, 2014). These potatoes are produced from both traditional and scientific methods in the Ethiopian context. The scientific one is mostly produced in the process of adoption mechanism with selection of improved varieties coming from either

domestic or abroad. Adoption of improved varieties has its own pattern and its impact the likelihood of the farmers is different too. Adoption inculcates improved potato varieties, better storage facilities, value-added products and enlightening right of entry to marketing (Ayalew, 2014). In Ethiopia, adoption of potato is steered by low level of technologies (Abebe *et al*., 2013; Ortiz *et al*., 2013). Though there is adoption of improved potato varieties, farmers are not utilizing, as it is required because of factors of high price of seed, inadequate supply of seeds, low level of technologies, inadequate supply of fertilizers and pesticide, not sufficient credit services especially to buy the required inputs. Most of the time farmers are getting limited varieties through informal ways, in a sense, farmers-to-farmers or brokers to farmers. This is because of the low capacity of formal sectors to supply the nation's demand and thus, those farmers who did not get the improved one they come back to producing the traditional one, which has low quality in the existing context (Abera, 2013).

To come up with the solution, Ethiopian Institute of Agricultural Research released different improved potato varieties and fore example, Belete potato was one of the improved potato varieties released by Holetta Agricultural Research Center (MOA, 2013). Doyogena district is where this study was carried out and this district has the potential for the potato production but farmers are still old varieties, which were released before two decades. These old varieties are very susceptible to diseases and their yield is also quite low. Evidence shows rural people are facing the problem of food insecurity when there is inadequate other crop productivity because of factors like shortage of rainfall, climate change, lack of improved seeds and lack of technologies. Therefore, why farmers do not want to shift from the old varieties to more the improved one is the basic investigation waiting for research and knowing the reason why adoption of this variety lagging behind is also quite relevant to solve the problem of the community. It is pertinent to undertake area-specific studies to assess the status of potato adoption and identifying factors that hamper further adoption of this improved variety, hence, factors affecting the adoption of Belete potato variety was not systematically and empirically studied that leads to an information gap. Therefore, to fill up the gap critical research investigation was carried out to identify the factors that limit smallholder farmers not to adopt Belete potato variety in the study context. Based on the stated problems the scientific research questions were withdrawn including: Is potato variety the improved or the old variety? Which potato variety is more adopted than others are? Is there Belete potato variety? Is it fully adopted by farmers? If not, why the reason? Do the farmers know about this type of variety clearly? What factors limit the farmers not to use this variety? How is the comparison between the old potatoes with the new one?

Research Methods

The study was conducted in Doyogena District, in Kembata Tembaro Zone, Southern Ethiopia. To carry out this research cross-sectional data was employed. To analyze the data both qualitative and quantitate data were used from both primary and secondary sources to identify the explanatory variables that affect the adoption of smallholder Belete potato producers in the study area. The primary data were collected from sample smallholder farmers, local elders, model farmers, agricultural extension workers and different seed enterprise agencies and brokers by using survey questionnaires, semi-structured interview schedule, focused group discussion and key informant interviews. Secondary data were collected from district agricultural offices, journals and articles and office records. Besides, key informant interview schedule was used to understand the challenges of Belete potato producers by focusing on the factors affecting the adoption of this improved variety. In this regard, twelve smallholder farmers' potato producers were purposefully selected by carrying out depth interview to obtain the knowledge and experience about the improved potato production with the help of checklist.

The district was selected purposively on the basis of the better production potential of potatoes. From the district four kebeles were randomly selected since all kebeles in the district have the production potential of potato. Accordingly, the potato producers were stratified into two categories (adopters and non-adopters) of subgroups. Finally, taking out the list of potato producers from each kebeles, 146 sample respondents were selected by grouping them into 52 adopters and 94 non-adopters of Belete potato producers based on the probability proportional to size from the selected kebeles. Then, a total of respondents were used for personal interview by using well-trained and qualified enumerators. Moreover, the following (Table 1) shows how selection of final sample household heads was done. The study used a formula designed by Yamane (1967) and if the sample size is too small, the objective of the analysis may not be addressed precisely. To determine the required sample size at 95% confidence level and the degree of variability = 0.5 and the way sampled households captured is seen in the following formula:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

$$n = \frac{2480}{1+2480(0.08)^2} = \frac{2480}{16.872} = 146,$$

where
n – the sample size,
N – the population size (total household heads size)
e – the level of precision.

Table 1. Sample size distribution with respective kebeles

Name selected	Adopte	Non-	Total	Adopte	Non-	Sample
Serera	235	530	765	14	31	45
Lemi Suticho	225	490	715	16	27	43
Bekafa	175	335	510	12	18	30
Murasa Weramo	160	330	490	10	18	28
Total	795	1685	2480	52	94	146

Source: Authors Competition (2018)

To achieve the objective of the research different approaches of analysis were adopted. In view of that, both descriptive statistics and econometrics model have used to analyze the data. Descriptive statistics such as average mean, frequency and percentages were used. Chi-square and t-tests were used to see the presence of the significant association between the dependent and explanatory variables between the adopters and non-adopters of Belete potato producers. Statistical packages including SPSS and STATA were used to run data entry and analysis purposes. To identify factors affecting the smallholder farmers' adoption of Belete potato varieties logistic regression model was used. This model is selected for this study and it was also used when the response of the respondents is binary (yes or no). Here, the dependent variable is adoption categories for adoption of Belete potato variety: 1 if the farmers adopt this improved variety and 0 otherwise. The functional formula of the logistic regression model used in this study is presented as follows:

$$p_i = \frac{1}{1+e^{-z_i}}, \quad (2)$$

where

Pi – the probability of being willing to adopt Belete potato for the i^{th} farmers

Zi – the function of n explanatory variables (xi) and expressed as:

$$z_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n X_n, \quad (3)$$

where

Bo – the intercept and

Bi – the slope parameters in the model.

The slope tells how the log-odds in favour of being willing to adopt Belete potato variety cultivation change as independent variables change. Since the conditional distribution of the outcome variable follows a binomial distribution with a probability given by the conditional mean Pi, interpretation of the coefficient was understandable if the binary logistic model can be rewritten in terms of the odds and log of the odds, (Gujarati, 1995). The odds were defined as the ratio of the probability that a farmer will adopt Belete potato variety (Pi) to the probability of non-adopter of Belete potato variety (1-Pi). But

$$(1 - p_i) = \frac{1}{1+e^{z(i)}}, \quad (4)$$

therefore

$$\left(\frac{p_i}{1-p_i}\right) = \frac{1+e^{z(i)}}{1+e^{-z(i)}} = e^{z(i)} \quad (5)$$

and

$$\frac{p_i}{1-p_1} = \frac{1+e^{z(i)}}{1+e^{-z(i)}} = e^{\beta_0} + \sum_{i-1}^{m} \beta_i Y_i \quad (6)$$

Taking the natural logarithms of the odds ratio of equation (5) will result indicated as the following formula:

$$ln\left(\frac{p_{(i)}}{1-p_{(i)}}\right) = \ln\left[e^{\beta_\circ} + \sum_{i-1}^{m} \beta_i x_i\right] = z_{(i)} \quad (7)$$

If the disturbance term Ui is taken into account, the Logit model becomes:

$$z_i = \beta_\circ + \sum \beta_i x_i + u_i \quad (8)$$

Therefore, the above binary logit model was employed to estimate the effect of the hypothesized explanatory variables on the adoption decision of farmers to use Belete potato variety. Before taking the selected variable into the model, it was authoritative to check for the existence of multicollinearity among the continuous variables so that Variance Inflation Factor (VIF) was used. This technique tells us large VIF are indicators of multicollinearity and those explanatory variables with VIF>10 were excluded from the regression analysis. Its formula is indicated as:

$$VIF\ (Xi) = (1\text{-}Ri^2)^{-1}, \quad (9)$$

where

Ri^2 is multiple correlation coefficients between Xi and other explanatory variables. Similarly, when there is an interaction between two qualitative variables, it leads to the problem of high association. To detect the problem, the contingency coefficients were computed and when contingency coefficient is greater than 0.75, it is an indication of existence of multicollinearity among qualitative variables. Here the following formula:

$$C = \sqrt[2]{\frac{\chi^2}{\chi^2+n}}, \quad (10)$$

where

C refers to contingency coefficient, x^2 is chi-square and n is the total sample size. Many factors are influencing decision of farmers to adopt or reject Belete potato in the study context. Table 2 shows the definitions, descriptions and hypothesized variables.

Table 2. Definition of explanatory variables for analyses

Variables	Measure-ment	Description	Expected sign
AGEHH	Continuous	Age of household head (in years)	-ve
FAMILAB	Continuous	Family labour available for	+ve
DISTNMkt	Continuous	The distance of home from	-ve
TLU	Continuous	Livestock owned Measured	+ve
OFFAIM	Dummy	Involvement in off farm	-ve
PARTFIDA	Dummy	Participation on field	+ve
CONTEXA	Continuous	Contact with extension	+ve
LANDHLG	Continuous	Total land holding	+ve
EDULEVEL	Continuous	Education of the household	+ve
ACSCRDT	Dummy	Access to credit (0=no, 1=yes)	+ve
ACSTRAIN	Dummy	Access to training (0=no, 1=yes)	+ve
RADIOWN	Dummy	Radio owner ship (0=no, 1=yes)	-ve
AVALFER	Dummy	Availability of fertilizer (0=no, 1=yes)	+ve
SEX	Dummy	1 if the household head is	+ve

Source: Authors Computation (2018)

Results

Results of descriptive statistics

The following Table 3 and Table 4 clearly revealed the summary of social, economic and institution of descriptive and econometric results. Accordingly, the results in Table 3 show the relationship between the continuous variables with the adoption categories of the respondents at different probability level. For example, age of household head has a vital role in agricultural production with special reference to adoption of Belete potato variety production. The maximum and minimum age of the sample households is 60 and 27 years, respectively. On the other hand, the average age of sample adopter and non-adopter was 38.84 and 41.12 years, respectively. The t-test result revealed that the statistical mean difference between adopter and non-adopter categories of the respondents was statically significant at 5% probability level. The educational level of farmers influences the adoption of Belete potato and the comparison was done between adopter and non-adopter in relation to their mean educational level. Accordingly, the result of t-test shows that the statistical mean difference between adopter and non-adopter of Belete potato was significant at 1% probability level. This shows that the education level of adopters of Belete potato is higher than non-adopters of the technology, implying the influence of the variable in making adoption decisions. Landholding and ownership is the critical factor for agricultural production and adoption of agricultural innovation for the farm community. In this study, the average landholding of sample respondents was found to be 1.025 hectares with standard deviation of 0.271 hectares. The maximum land size owned by the sample households was 2 hectare while the minimum is 0.50 hectare. The average landholding for adopter group was 1.08 hectare while that of non-adopter group is 0.992. The t-test result shows that there is a significant mean difference between adopters and non-adopters at 5% probability level.

Table (3) also indicates that access to having human labour may increase the probability of households to adopt Belete potato variety. In view of that, in this study, the maximum and minimum family size was 9 and 3 persons per family. The average person equivalent of sample adopter and non-adopter households is 6.192 and 5.329, respectively. Hence, the family labour in man equivalent shows that there is significant mean difference between both adopter and non-adopter groups at 1% probability level. Regarding livestock holding, the average cattle ownership of sample households for the adopters was 4.35 TLU, while for the non-adopters was 3.96 TLU. The result of t-test shows that the livestock holding owned mean difference between the two groups was statistically significant at 1% probability level. The minimum and the maximum distance that a farmer had to travel to access nearest market centre were 0.30 hr and 3 hr, respectively and it takes on average 1.56 hr with standard deviation of 0.747. Mean distance travelled to the nearest market centres by adopters, and non-adopters were 1.427 hr and 1.640 hr, respectively. The t-test result shows that there is statistically insignificant mean difference between both adoption categories in terms of distance to the market centre. The average score of frequencies of farmers contact with agricultural development agent accounts for adopters and non-adopter farmers were 9.67, and 3.32, respectively shown in Table 3. Therefore, the t-test analysis result shows that there was significant mean difference between both adoption categories in terms frequency of contact with the extension agent at 1% significance level.

Table 3. Summary of continuous variables

Variable	All sample		Adopter		Non-adopter		t-value	p-value
	Min	Max	Mean	SD	Mean	SD		
Age of HHH	27	60	38.84	6.15	41.12	6.13	–2.149	0.033**
Family labor	3	9	6.192	1.32	5.329	1.19	4.012	0.000***
Market distance	0.30	3	1.427	0.759	1.640	0.733	–1.655	0.1000^{NS}
Education level	0	12	7	2.457	4.372	2.305	6.443	0.000***
Livestock owned	2.06	6.9	4.35	0.763	3.96	0.794	2.940	0.004***
Extension contact	2	12	9.67	1.854	3.32	1.447	22.891	0.000***
Land holding	0.50	2	1.08	0.270	0.992	0.268	2.033	0.044**

Sources: Authors computation (2018); ** and *** at 5% and 1% probability level, respectively; NS = non-significant

Table 4 shows the association between the dependent variables (adoption groups) and the dummy explanatory variables at different probability level. Accordingly, sex of household head affects the adoption of Belete potato variety in such ways that, because of the existing socio-cultural contexts males have freedom of mobility, participating in different meetings and training. From the total respondents, 94.2% and 5.8% of the adopter sample farmers were male and female-headed households, respectively. Therefore, sex of household head is statistically significant and positive relationship with the adoption decision at 5% probability level. This implies that male-headed households had capability to participate freely in different social organization to have better exposure to the production of the selected variety than their counterparts did. Coming to the off-farm activities out of the total households interviewed 36 (69.2%) had participated in off-farm activities, while 52 (55.3%) had not participated. Unlike prior expectation, participation in off-farm activities had insignificant relationship with adoption of Belete potato variety at 5% probability level.

Access to credit service is another factor that influences the adoption decision of farmers and most of the Belete potato adopter farmers got the loan in kind especially the improved seeds and fertilizers; because those are only obtained from input supply office in collaboration with Omo Microfinance and Kebele multi-purpose saving and credit cooperatives. Out of the total sample respondents, 41.1% got credit service from the district credit service were delivering institutions to run their agricultural production. On the other hand, 58.9% of the total sample households were non-credit recipients. Additionally, 55.8% and 34.0% of the adopter and non-adopter sample households accessed credit services. The chi-square result showed that access to credit service had an association with the adoption of Belete potato variety among farmers at 1% probability level. Regarding access to training service, the sample households had taken training on fertilizer application, planting methods and other management methods like chemical application for the variety. Training is also important for easily applying the innovation at farmers' level to get more yields by the farm community in the district. 67.3% and 30.9% of the adopter and non-adopter sample respondents have participated in training related to Belete potato variety, respectively. The chi-square result revealed that training has statistically significant relationship with the adoption of Belete potato variety at 1% probability level.

On the field day participation, farmers exchange information on agricultural practices, which have an important role in the adoption of improved agricultural technologies, which is evidence-based extension system where information is shared easily on the comparative advantage, agro-ecological suitability of the technology to be adopted by showing tangible results in the real-life situation. The sample adopter and non-adopter sample households selected for the study participated on field day were 76.9% and 40.4%, respectively. The chi-square result indicates that the association between participation in field day and the two adoption categories of Belete potato variety is statistically significant at 1% probability level. Fertilizer availability on time determines adoption decision of Belete potato varieties and which helps to increase production and productivity. Accordingly, out of the total sampled respondents, 47.9% got access to fertilizer from the district service delivering institutions to run their agricultural production. 71.2% and 35.1% of the adopter and non-adopter sample households accessed fertilizer on time. The chi-square result showed that the relationship between fertilizer availability and the adopter of Belete potato variety is statistically significant at 1% probability level. In this study, respondents' radio ownership was measured on having radio to get up-to-date information which contributes to the adoption of agricultural innovation and farmers who have radio ownership on Belete potato production had the opportunity to decide to use the variety. When we compared the adopters and non-adopters radio ownership, 48.1% of the adopters had radio ownership whereas 37.2% of the non-adopters got access to utilize radio, which had statistically insignificant with adoption of Belete potato production in Table 4.

Table 4. Summary of discrete/dummy variables

Variable	Response	Adopter		Non-adopter		Total		X^2	P-value
		N	%	N	%	N	%		
Sex of house hold head	M	49	94.2	76	80.9	125	85.6		
	F	3	5.8	18	19.1	21	14.4	4.867	0.027**
Access of training	Yes	35	67.3	29	30.9	64	43.8		
	No	17	32.7	65	69.1	82	56.2	18.074	0.000***
Off-farm participation	Yes	36	69.2	52	55.3	88	60.3		
	No	16	30.8	42	44.7	58	39.7	2.706	0.100^{NS}
Field participation	Yes	40	76.9	38	40.4	78	53.4		
	No	12	23.1	56	59.6	68	72.3	17.923	0.000***
Access to fertilizer	Yes	37	71.2	33	35.1	70	47.9		
	No	15	28.8	61	64.9	76	52.1	17.431	0.000***
Access to credit service	Yes	29	55.8	31	34.0	60	41.1		
	No	23	44.2	63	67.0	86	58.9	7.184	0.007***
Radio ownership	Yes	25	48.1	35	37.2	60	41.1		
	No	27	51.9	59	62.8	86	55.5	1.626	0.202^{NS}

Sources: Authors computation (2018); ** and *** at 5% and 1% probability level, respectively; NS = non-significant

Results of the econometric model

The results in Table 5 indicate how a logistic regression model explains explanatory variables such as economic, institutional, demographic and as indicated, 85.6% of the total variation for the Belete potato variety. The chi-square result also shows that the parameters are significantly different from zero at P<0.01 for the adoption of Belete potato variety. The model correctly predicted sample size of 75% and 91.5% for adopters and non-adopters, respectively. From fourteen explanatory variables hypothesized to influence the adoption decision, eight of them; namely, family labour, availability of fertilizer, access to credit service, frequency of contacts with extension agents, participation in training, education status and field day participation were found to be significantly influencing the probability of adoption of Belete potato variety at 1% and 5% level of significance. Whereas market distance influenced the adoption of Belete potato variety negatively at 10% level of significance. On the contrary, the remaining six non-significant explanatory variables; sex of household head, age of household head, participation of farm activity, livestock owned, radio ownership and cultivated land size are influencing the adoption of Belete potato variety but not statistically significant.

Table 5. Binary logistic regression for factors influencing the adoption of Belete potato variety

Variables	B	S.E.	Wald	Sig.	Odd ratio
Sex of house hold head	0.825	1.019	0.655	0.418	2.281
Age of household head	–0.070	0.045	2.361	0.124	0.933
Educational status	0.635	0.322	3.891	0.049**	1.888
Access to training	1.707	0.629	7.363	0.007***	5.513
Off-farm participation	0.123	0.626	0.039	0.844	1.131
Livestock ownership (in TLU)	0.200	0.362	0.307	0.580	1.222
Family labor	0.500	0.239	4.371	0.037**	1.649
Access to credit service	1.447	0.613	5.563	0.018**	4.249
Availability of fertilizer	1.346	0.647	4.335	0.037**	3.844
Frequency of extension contact	1.073	0.352	9.278	0.000***	2.923
Radio ownership	0.389	0.598	0.423	0.516	1.475
Market distance	–0.607	0.356	2.916	0.088*	0.545
Cultivated land size	1.107	0.981	1.273	0.259	3.024
Field participation	1.596	0.668	5.713	0.017**	4.932
Constant	–11.239	3.298	11.612	0.001	0.000
- 2log likelihood	87.401				
Significance	0.000				
Chi-square(X^2)	102.74***				
Correct Prediction of adopter	75				
Correct prediction of non-adopter	91.5				
Overall percentage	85.6				

Source: Authors computation (2018); Note: ***, ** and * are significant at less than 1%, 5% and 10% level of significance

Discussion

From the above result in (Table 5) from the total fourteen variables, eight of them had positively influence adoption of Belete potato variety. Additionally, the detail relationships of those statistically significant explanatory variables with the adoption of Belete potato variety are described as: Educational status had positively and significantly influenced the probability of adoption of Belete potato variety at less 5% level. The odds in favour of adopting Belete potato variety increased by a factor of 1.88 for potato producers who are more educated, keeping all other factors constant. This shows that education raises the awareness of Belete potato producers they get more access to information and this recommends that farmers with higher educational background would have better chance to access information can simply realize the use of Belete potato. This result is consistent with earlier studies of (Bekele *et al*., 2013). Access to training was positively and significantly influenced the adoption of Belete potato variety at 1% probability level. The odds ratio in favour of adopting Belete potato variety increases by a factor of 5.513 when the farmer is trained, keeping the influence of other factors constant. When farmers get knowledge, skills and attitudes training their probability to accept and adopt the improved new varieties as Belete potato increased too. This finding is similar to the results of (Ahmed *et al*., 2016).

Family labour was positively and significantly influenced the adoption of Belete potato variety at 5% probability level. The outcome of the odds ratio indicates that if the household head has raised in the number of family labour in mam equivalent in one unit, the logs of odds ratio is in favour of the households' adoption of Belete potato variety will raise by 1.649 as labour works raise by one unit. This result is the fact that when farmers are not facing shortage of labour works at farming activities they can easily manage the adoption activities of Belete potato. The finding of this study endorses the findings of (Adesope, 2006; Garba, 2016). Access to credit service was positively and significantly influenced the adoption of Belete potato variety at 5% probability level. The result of the model shows that the odds ratio in favour of farmers' adoption Belete potato increases by the factor of 4.249 when there is access to credit services. This reveals that access to credit increases farmer's opportunity to adopt Belete potato variety and the findings of (Garba, 2016; Kafle, 2011) confirms this also.

Availability of fertilizer had positive and significant influence to the adoption of Belete potato at 5% probability level. The odds ratio in favour of adopting Belete potato technology increases by a factor of 3.844 as availability of fertilizer raises by one unit as the fertilizer available on time, keeping all other factors constant. This means that those farmers who get chemical fertilizer on time are more likely to adopt Belete potato variety than those who do not have access to fertilizer on time. Chilot et al. (1996) reported a similar result. Frequency of extension contact was found to be positively and significantly affecting the adoption of Belete potato production at 1% probability level. The odds ratio in favour of adopting Belete potato variety increases by a factor of 2.923 as a farmer-extension contact raises by one unit, keeping all other factors constant. This could be because increased farmers' contact with extension agents significantly raises farmers' awareness of available technologies. This study was similar to the findings of (Adella, 2014; Namwata *et al*., 2010).

The market distance was negatively and significantly associated with the adoption of Belete potato production at 10% probability level. Moreover, as the market distance increases, the logs of odds ratio in favour of farmers' adoption of Belete potato will decrease by 0.545 as market distance raises by one unit, keeping all other factors constant. This further shows that as market distance decreases, adoption of the variety by the household raises. The result is consistent with the finding of (Legesse *et al.,* 2001; Yishak, 2005). Field participation has positive and significant relationship to adoption of Belete potato variety at less than 5% probability level. Keeping all other factors constant, the odds ratio in favour of adopting Belete potato varieties raises by a factor of 4.932 as a farmer meeting in field days raises by one unit. The result shows having formal information through field day Participation raises the likelihood of adoption of Belete potato variety. This result is in line with (Tesfaye *et al.,* 2001).

Conclusion and Policy implications

The aim of this study was to assess Belete potato varieties the adoption determinates in Doyogena district in Southern Ethiopia. The variations in adoption perform among the households were assessed from the point view of various factors which influence farmers' adoption behaviour. These influencing factors are categorized as demographics, institutional, economic and resource ownership factors. The outcome result indicates that the relative influence of different variables on probability of adoption of Belete potato variety. Thus, seven variables namely family labour, availability of fertilizer, access to credit service, frequency of extension contact, access to training, education status and field day participation were positively and significantly influenced the adoption of Belete potato variety. However, market distance was influenced negatively. Thus, to promote the adoption of Belete potato variety by smallholder farmers in the study context the following suggestions are forwarded for the concerned bodies for further interventions:

- Extension and other organizations to target them during on-farm research and improved technology promotion, as they can easily understand about the technology.
- Farmer training centres may be well equipped with training facility will help to deliver qualified knowledge and skill-based training to farmers to improve the adoption decision.
- Well-equipping work force with the necessary skill and knowledge through training is important to increase the production performance of the variety.
- Establishing rural micro-institutions to expand access to credit in all-inclusive manners so that farmers can easily access it.
- Providing technical support on access to get fertilizer should be encouraged.
- Providing rural FTC systems with well-equipped work force who can deliver training.
- Establishing rural markets at village levels with accessible roads
- Finally, the government and other stakeholders should support Belete potato producing farmers so as to increase the adoption degree of improved varieties.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author contributions

AF – contributed to the design and implementation of the research, the analysis of the results and to the writing of the manuscript.
GR – supervised and advised starting from title selection to the publication of the manuscript. GR also contributed to taking the initiation of manuscript publication on the appropriate and reputable journal.
MM – has a role of advising only.

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REVIEW: VERMICOMPOST, ITS IMPORTANCE AND BENEFIT IN AGRICULTURE

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ABSTRACT. Vermicomposting is described as "bioxidation and stabilization of organic material involving the joint action of earthworms and mesophilic micro-organisms". Under appropriate conditions, worms eat agricultural waste and reduce the volume by 40 to 60%. Vermicompost produced by the activity of earthworms is rich in macro and micro-nutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulase and chitinase and immobilized microflora. The enzymes continue to disintegrate organic matter even after they have been ejected from the worms. Reduced use of water for irrigation, reduced pest attack, reduced termite attack, reduced weed growth; faster rate of seed germination and rapid seedlings growth and development; greater numbers of fruits per plant (in vegetable crops) and greater numbers of seeds per year (in cereal crops) are only some of the beneficial effects of the vermicompost usage in agricultural production. Earthworms and vermicompost can boost horticultural production without agrochemicals. In spite of the benefits associated with vermicompost, its use is not widespread yet. This review attempts as increasing awareness of this local soil amendment.

Introduction

In recent years, the disposal of organic wastes from domestic, agricultural and industrial sources has caused increasing environmental and economic problems and many different technologies to address this problem have been developed. The growth of earthworms in organic wastes has been termed vermiculture and the processing of organic wastes by earthworms is known as vermicomposting (Edwards, 2004). There is a marked trend towards the use of novel technologies, mainly based on biological processes, for recycling and efficient utilization of organic residues. Therefore, it is possible to conserve the available resources and to recover the natural products, and in some cases, to combat the disposal problems and minimize the pollution effects. Vermicomposting has been arising as an innovative biotechnology for the conversion of agro-industrial wastes into value added products, which can be utilized for improving the soil structure and fertility in organic farming (Garg, Gupta, 2009).

Reduced use of water for irrigation, reduced pest attack, reduced termite attack, reduced weed growth; faster rate of seed germination and rapid seedlings growth and development; greater numbers of fruits per plant (in vegetable crops) and greater numbers of seeds per year (in cereal crops) are only some of the beneficial effects of the vermicompost usage in agricultural production (Anonymous, 2009).

Pure vermicompost is not so good for agricultural production, because it contains too much nutrients (Olle 2016a, Olle, 2017).

The beneficial effects in using vermicompost based substrates in agriculture (Olle, 2016b): it accelerates growth; increases crop yields; creates a favorable environment for beneficial micro-organisms; permanently improves soil structure; increases plant secretion; in case of plants with longer growing season, additional fertilization with biohumus or its leotion is sufficient, provision of mineral fertilizers is not necessary in this case; 100% natural, ideal for use in organic farming and in artificial environments.

Therefore the author decided to give a literature overview article about vermicompost, its importance and benefit in agriculture.

What is vermicomposting?

Vermicomposting is generally defined as the solid phase decomposition of organic residues in the aerobic environment by exploiting the optimum biological activity of earthworms and microorganisms (Garg, Gupta, 2009).

Vermicomposting is described as "bioxidation and stabilization of organic material involved by the joint action of earthworms and mesophilic micro-organisms". Vermicompost produced by the activity of earthworms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulase and chitinase and immobilized microflora. The enzymes continue to disintegrate organic matter even after they have been ejected from the worms (Barik *et al*., 2011).

Vermicomposting involves the composting of organic wastes through earthworm activity. It has proven successful in processing sewage sludge and solids from wastewater, materials from breweries, paper waste, urban residues, food and animal wastes, as well as horticultural residues from processed potatoes, dead plants and the mushroom industry (Dominguez, Edwars, 2004).

Vermicomposting is a decomposition process involving the joint action of earthworms and microorganisms. Although microorganisms are responsible for the biochemical degradation of organic matter, earthworms are crucial drivers of the process, by fragmenting and conditioning the substrate and dramatically altering its biological activity. Earthworms act as mechanical blenders and by comminuting the organic matter they modify its physical and chemical status, gradually reducing its C:N ratio, increasing the surface area exposed to micro-organisms and making it much more favourable for microbial activity and further decomposition. Greatly during passage through the earthworm gut, they move fragments and bacteria-rich excrements, thus homogenizing the organic material. The end-product, or vermicompost, is a finely divided peat-like material with high porosity and water holding capacity that contains most nutrients in forms that are readily taken up by the plants. These earthworm casts are rich in organic matter and have high rates of mineralization that implicates a greatly enhanced plant availability of nutrients, particularly ammonium and nitrate (Dominguez, Edwars, 2004).

The vermicomposting process different phases during the process are as follows (Garg, Gupta, 2009): (1) Initial pre-composting phase: The organic waste is pre-composted for about 15 days before being fed to earthworms. During this phase, readily decomposable compounds are degraded and the potential volatile substances are eliminated which may be toxic to earthworms. (2) Mesophilic phase: During this phase, earthworms, through their characteristic functions of breaking up organic matter, combine it with the soil particles and enhance microbial activities and condition organic waste materials for the formation of organic manures. (3) Maturing and stabilization phase.

History

Earthworm has caught imagination of philosophers like Pascal and Thoreau (Adhikary, 2012). Civilizations, including Greece and Egypt valued the role earthworms played in soil. The ancient Egyptians were the first to recognize the beneficial status of the earthworm. The Egyptian Pharaoh, Cleopatra (69–30 B.C.) said, "Earthworms are sacred." She recognized the important role the worms played in fertilizing the Nile Valley croplands after annual floods. Removal of earthworms from Egypt was punishable by death. Egyptian farmers were not allowed to even touch an earthworm for fear of offending the God of fertility. The Ancient Greeks considered the earthworm to have an important role in improving the quality of the soil. The Greek philosopher Aristotle (384–322 B.C.) referred to worms as the intestines of the earth (Medany, 2011).

Sir Surpala (10 Cent. A.D., the ancient Indian scientist) recommended to add earthworms to the soil to receive sufficient yield of fruits as pomegranates (Sinha, 2014b).

Earthworms are truly justifying the beliefs and fulfilling the dreams of Sir Charles Darwin who called them as unheralded soldiers of humankind and friends of farmers and said that there may not be any other creature in world that has played so important a role in the history of life on earth (Sinha *et al*., 2014a). They are also justifying the beliefs of great Russian scientist Dr. Anatoly Igonin (Sinha *et al*., 2014a), who said: Nobody and nothing can be compared with earthworms and their positive influence on the whole living Nature; they create soil and improve soils fertility and provide critical biospheres functions: disinfecting, neutralizing, protective and productive (Sinha *et al*., 2014a).

Composition and quality of vermicompost

The agro-industrial wastes are huge source of plant nutrients and their disposal means the ultimate loss of the resourceful material. Some agro-industrial processing wastes explored for vermicomposting are presented in Table 1.

Table 1. Potential agro-industrial processing wastes (Garg, Gupta, 2009)

Agricultural wastes
Rice husk, cereal residues, wheat bran, millet straw *etc*.
Food processing waste
Canning industry waste, breweries waste, dairy industry waste, sugar industry waste press mud and trash, wine industry waste, oil industry waste-non edible oil seed cake, coffee pulp, cotton waste *etc*.
Wood processing waste
Wood chips, wood shavings, saw dust
Other industrial wastes
Fermentation waste, paper and cellulosic waste, vegetal tannery waste
Local organic products
Cocofiber dust, tea wastes, rice hulls *etc*.
Fruits and vegetable processing waste

Vermicompost is a peat like material containing most nutrients in plant available forms such as nitrates, phosphates, calcium, potassium, magnesium *etc*. It has high porosity, water holding capacity and high surface area that provides abundant sites for microbial activity and for the retention of nutrients. The plant growth regulators and other plant growth influencing materials *i.e.* auxins, cytokinins and humic substances etc. produced by the microbes have been found in vermicomposts. The nutrients status of the vermicompost obtained from different organic materials is given in Table 2 (Garg, Gupta, 2009).

Table 2. Chemical composition of vermicompost (Garg, Gupta, 2009)

Characteristics	Value
Organic carbon, %	9.15 to 17.88
Total Nitrogen, %	0.5 to 0.9
Phosphorus, %	0.1 to 0.26
Potassium %	0.15 to 0.256
Sodium %	0.055 to 0.3
Calcium & magnesium (Meq/100 g)	22.67 to 47.6
Copper; mg kg^{-1}	2.0 to 9.5
Iron, mg kg^{-1}	2.0 to 9.3
Zinc, mg kg^{-1}	5.7 to 9.3
Sulphur, mg kg^{-1}	128.0 to 548.0

Vermicomposting technology is a suitable tool for efficient conversion of agro-industrial processing wastes, which serves as a rich source of plant nutrients. These waste materials are packed with a tremendous source of energy, protein and nutrients, which would otherwise be lost if they are disposed as such in the open dumps and landfills. Moreover, with the use of vermicompost as organic amendments in the agriculture, recycling of the nutrients back to the soil takes place, in turn, maintaining the sustainability of the ecosystem (Garg, Gupta, 2009).

Roles of vermicompost

Beneficial roles of vermicompost (Adhikary, 2012): (1) Red worm castings contain a high percentage of humus. Humus helps soil particles form into clusters, which create channels for the passage of air and improve its capacity to hold water. (2) Humus is believed to aid in the prevention of harmful plant pathogens, fungi, nematodes and bacteria. (3) A worm casting (also known as worm cast or vermicast) is a biologically active mound containing thousands of bacteria, enzymes, and residues of plant materials that were not digested by the worms. (4) Castings contain nutrients that are readily available to plants. (5) The activity of the worm gut is like a miniature composting tube that mixes conditions and inoculates the residues. (6) Worm castings are the best imaginable potting soil for greenhouses or houseplants, as well as gardening and farming. (7) Plant Growth Regulating Activity: Some studies speculated that the growth responses of plants from vermicompost appeared more like "hormone induced activity" associated with the high levels of nutrients, humic acids and humates in vermicompost. (8) Ability to Develop Biological Resistance in Plants: Vermicompost contains some antibiotics and actinomycetes that help in increasing the "power of biological resistance" among the crop plants against pest and diseases. Spray of chemical pesticides was significantly reduced by over 75% where earthworms and vermicompost were used in agriculture. (9) Ability to Minimize Pests Attack: There seems to be strong evidence that worm castings sometimes repel hard-bodied pests. (10) Ability to Suppress Plant Disease: Studies reported that vermicompost application suppressed 20%–40% infection of insect pests *i.e.* aphids (*Myzus persicae*), mearly bugs (*Pseudococcus spp.*) and cabbage white caterpillars (*Peiris brassicae*) on pepper (*Capiscum annuum*), cabbage (*Brassica oleracea*) and tomato (*Lycopersicum esculentum*). (11) Vermimeal Production: With the increasing demand for animal feed protein bolstered by the continuing growth of human population and food source, the production of vermimeal be considered as the most economically feasible application of vermiculture.

The beneficial impacts of vermicompost on soil (Sinha, 2014b):

1. Increase the 'Soil Organic Matter' (SOM), soil structure and prevent soil erosion.
2. Increase beneficial soil microbes, microbial activity and nutrients.
3. Improve cation exchange capacity.
4. Reduces bulk density of soil, prevents soil compaction and erosion.
5. Suppression of soil-born plant diseases.
6. Increase water-holding capacity of soil.
7. Remove soil salinity and sodicity.
8. Maintain optimal pH value of soil.

Vermicompost is ideal organic manure for better growth and yield of many plants due to following reasons (Joshi *et al*., 2015):

1. Vermicompost has higher nutritional value than traditional composts.
2. This is due to increased rate of mineralization and degree of humification by the action of earthworms.
3. Vermicompost has high porosity, aeration, drainage, and water-holding capacity.
4. Presence of microbiota particularly fungi, bacteria and actinomycetes makes it suitable for plant growth. Nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost.
5. Plant growth regulators and other plant growth influencing materials produced by microorganisms are also present in vermicompost.
6. Production of cytokinins and auxins was found in organic wastes that were processed by earthworms.
7. Earthworms release certain metabolites, such as vitamin B, vitamin D and similar substances into the soil.
8. In addition to increased N availability, P, K, Ca and Mg availability in the casts are found.

Vermicompost's role in the nutrition of agricultural fields has attracted attention of researchers worldwide only in recent decades. Waste management is considered as an integral part of a sustainable society, thereby necessitating diversion of biodegradable fractions of the societal waste from landfill into alternative management processes such as vermicomposting. Earthworms excreta (vermicast) is a nutritive organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes; nitrogen-fixing, phosphate solubilizing bacteria, actinomycets and growth hormones auxins, gibberlins and cytokinins. Both vermicompost and its body liquid (vermiwash) are proven as both growth promoters and protectors for crop plants (Adhikary, 2012).

Vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B. The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pests and diseases (Theusnissen *et al*., 2010).

Vermicompost is made up primarily of C, H and O and contains nutrients such as N, P, Ca, K, Mg, S and micronutrients that exhibit similar effects on plant growth and yield as inorganic fertilizers applied to soil. Similarly, vermicompost contains a high proportion of humic substances, which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeasts (*Sporobolomyces* and Cryptococcus) and fungi (*Trichoderma*), as well as chemical antagonists such as phenols and amino acids (Theunissen *et al*., 2010).

Earthworms and vermicompost can boost horticultural production without agrochemicals. It will provide several social, economic and environmental benefits to the society by way of producing 'chemical-free' safe, 'nutritive and health protective' (rich in minerals and antioxidants) foods (even against some forms of cancers) for the people; salvaging human wastes and replacing the dangerous 'agrochemicals' from the face of earth. The use of vermicompost in farms also 'sequester' huge amounts of atmospheric carbon (assimilated by green plants during photosynthesis) and bury them back into the soil improving the soil fertility, preventing erosion or compaction and also reducing greenhouse gas and mitigating global warming (Sinha *et al*., 2013).

Effect of vermicompost on agricultural crop performance

Yield. Studies on the production of important vegetable crops like tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena)* have yielded very good results (Adhikary, 2012). Similarly the overall productivity of potato was significantly higher on vermicompost applied about 6 tons/ha as compared to control (Adhikary, 2012). Vermicast produced higher garden pea green pod plants, higher green grain weight per plant, and higher green pod yield as compared to chemical fertilizer (Adhikary, 2012). The perusal of the data revealed that "Parthenium Vermicompost" applied at 5 t/ha enhanced the yield of eggplants (*Solanum melongena*) (Seethalakshmi, 2011). The use of vermicompost as a source of organic manure in supplementing chemical fertilizer is becoming popular among the farmers of the country. Vermicompost increase in crop yield probably because of higher nutrient uptake (Seethalakshmi, 2011).

Growth. Worms and vermicompost promoted excellent growth in the vegetable crop with more flowers and fruits development (Adhikary, 2012). Vermicompost can have dramatic effects upon the germination, growth, flowering, fruiting and yields of crops (Mistry, 2015). Vermicompost stimulated growth of tomato transplants, with up to a 2.2-fold increase occurring in shoot biomass. Differences in growth were attributed mainly to differences in nutrient content of the potting mixtures, but some changes in physical and biological properties of the substrate could also be responsible (Tringovska, Dintcheva, 2012). The perusal of the data revealed that "Parthenium Vermicompost" applied at 5 t/ha enhanced the growth of eggplants (*Solanum melongena*) (Seethalakshmi, 2011). Application of vermicompost increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plant (Joshi *et al*., 2015).

Nutrient content. Vermicast produced higher percentage of protein content and carbohydrates in garden pea as compared to chemical fertilizer (Adhikary, 2012). The perusal of the data revealed that "Parthenium Vermicompost" applied at 5 t/ha enhanced the food quality of eggplants (*Solanum melongena*) (Seethalakshmi, 2011). Application of vermicompost increased chlorophyll content, pH of juice, total soluble solids of juice, micro and macronutrients, carbohydrate (%) and protein (%) content and improved the quality of the fruits and seeds. Studies suggested that treatments of humic acids, plant growth promoting bacteria and vermicomposts could be used for a sustainable agriculture discouraging the use of chemical fertilizers (Joshi *et al*., 2015).

Plant protection. The most significant observation was drastically less incidence of diseases in worm and vermicompost applied plant (Adhikary, 2012). Accordingly, vermicompost also protects plants against various pests and diseases either by suppressing or repelling them or by inducing biological resistance in plants (Sinha *et al*., 2013). Disease resistance is a plus Cornell University lab trials have shown promise for applying the solid vermicompost and its non-aerated extract as a control for *Pythium aphanidermatum*, a disease common to many vegetable crops. "Garlic doesn't tend to have *Pythium* problems," points out Fraser (Dunn, 2011). "So I was looking for how well

the compost would support plant growth. We saw a definite impact on leaf growth and weight gain." "The healthier and more vigorous the plants are with the microbiology in their root zone, the more the plants are able to thwart attacks from destructive crop pathogens and insect pests," he elaborates Recent Ohio State University studies also concluded that crops fed with vermicompost are also more resistant to blight, bacterial wilt, parasitic nematode attacks and powdery mildew than those on synthetic fertilizers (Dunn, 2011).

Human health. Organically grown fruits and vegetables especially on 'earthworms and vermicompost' have been found to be highly nutritious, rich in 'proteins, minerals and vitamins' and 'antioxidants' than their chemically grown counterparts and can be highly beneficial for human health. They have elevated antioxidants levels in about 85% of the cases studied. They have been found to be protective against several forms of 'cancers' and against 'cardiovascular diseases' (Sinha, 2012).

Conclusions

Vermicompost produced by the activity of earthworms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulose and chitinase and immobilized microflora. Vermicompost is optimal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment. Application of vermicompost increased growth, improved plants nutrient content, and improved the quality of the fruits and seeds.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author contributions

MO – contributed to the preparation, creation and/or presentation of the manuscript.

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SHORT COMMUNICATION: **THE EFFECT OF SILICON ON THE ORGANICALLY GROWN LEAF LETTUCE GROWTH AND QUALITY**

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ABSTRACT. The purpose was to assess the effect of silicon on the leaf lettuce production. The experiments in the greenhouse were carried out in the spring 2014 at the Estonian Crop Research Institute. Treatments: 1) stabilized silicic acid treatment; 2) control. Si treatment (2 mL L^{-1} of silicic acid): First spray, when 1 true leaf was present; second spray was two weeks after spray 1; third spray was two weeks after spray 2. The pH of spray solution was 5.5. pH of spray solution was 5.5. Control plants were treated with water. The plants were 26% higher in Si variant. The width of leaf lettuce was 32% larger in Si variant. In leaf lettuce the phosphorus content was 14% higher, the content of calcium was 32% higher, the content of magnesium was 12% higher in Si variant than in control.

Introduction

Silicon is the second most abundant element in soil, comprising 50–70% of soil mass. All plants contain some Si in their cells and tissues (Olle, 2014). Still, the plant-available Si content in soils for plant growth and development may be insufficient. Plant available Si fertilization might help to provide plants with this nutrient. Silicon enhances growth, improves protection against pathogens (pests and diseases) and abiotic stresses like ions, salinity, water, temperature (Guntzer *et al.*, 2012; Thilagam *et al.*, 2014; Olle, Narits, 2015; Olle, Schnug, 2016). Silicon nutrition reverses succulence induced by high nitrogen and enhances crop growth and yield (Vasanthi *et al.*, 2014).

Silicon treated plants become stronger, sturdier and naturally more tolerant to drought, mineral imbalance and extremes of temperature (Bent, 2014). Silicon application could improve crop production under extreme climatic conditions (Shakoor, 2014; Shakoor, Bhat, 2014). Bioactive silicon helps to take up more nutrients and utilize water and minerals more efficiently, reducing their requirements for water, fertilizers and plant protection chemicals during cultivation (Bent, 2014).

Silicic acid agro technology (SAAT), developed by Dr Henk-Maarten Laane (Bent, 2014), is effective on almost every crop with increases of root system, loner stem/tillers, leaf area and chlorophyll content and nutrient uptake resulting in increased yield quantity and quality (Bent, 2014). Silicic acid agro-technology decreases biotic and abiotic stresses. Due to lower infection, rates pesticide use can be reduced (Bent, 2014). The product is safe for plants, soil, growers and consumers. The investigation was undertaken to determine effects of silicon on the leaf lettuce growth and quality. Those experiments were important to carry through because of silicon nutrition is substantive, because of it enhances growth, improves protection against pathogens (pests and diseases) and abiotic stresses like ions, salinity, water, temperature.

Materials and Methods

Experiments in a greenhouse were carried out in March to May of 2014 at the Estonian Crop Research Institute. In experiment leaf lettuce cv. 'Aficion' was used. The treatments were stabilized silicic acid treatment and a water control. Seed were sown in plastic trays in a heated glass greenhouse on 21 March 2014. When seedlings were 12 days-old they were transplanted into individual pot (9 cm diameter) containing Novarbo B2 Organic Biolan substrate (lime content 6 kg m^{-3}, fertilizer content 1.0 kg·m^{-3}, fertilizer N12:P6:K22, pH neutral) for organic cultivation.

Silicic acid (2 mL L^{-1}) was applied when 1 true leaf was present (14 April 2014) then again after 2 weeks

(28 April 2014), and with a third application in another 2 weeks (12 May 2014). The pH of treatment solution was 5.5. Control plants were treated with water with pH 5.5. The lighting at a plant level was approximately 380 lumen. Day and night temperatures were 20 and 18°C, respectively. Treatments consisted of 96 plants consisting of 12 plants in 8 replications. The experiment was arranged in a randomized complete block design (RCBD). On 15 May 2014 stem height and diameter of stem were recorded. Nitrate, nitrogen, phosphorus, potassium, calcium and magnesium contents were determined. The content of nitrogen was determined according to copper catalyst Kjeldahl Method (984.13). Nitrate contents were determined in extracts by Fiastar 5000. Phosphorus was determined with a Kjeldahl digest by Fiastar 5000 (AN 5242; Stannous chloride method, ISO/FDIS 15681). Potassium was determined with a flame photometric method (956.01). Determination of calcium was with the o-cresolphthalein complexone method (ISO 3696, in Kjeldahl Digest by Fiastar 5000). Magnesium was determined with the Fiastar 5000 (ASTN90/92; Titan Yellow method). Analyses of variance were carried out on the data obtained using the programme Agrobase. Fisher's LSD test was run on data.

Results

Treatment affected plant height with those treated with Si being taller than the controls variant (Table 1). The height increased by 26% in Si treated plants. Lettuce shoot width was affected by treatment as follows: in Si treated plants the width of lettuce plants increased by 32% (Table 1). Treatment did not affect leaf nitrate and nitrogen content (Table 2). The phosphorus content of lettuce leaves dry matter was higher in Si treated plants compared to control (Table 2). Si treatment increased the content of phosphorus in lettuce leaves dry matter by 14%. Potassium content in lettuce leaves dry matter was not affected by treatment (Table 2). The calcium and magnesium contents in lettuce leaves dry matter were higher in Si treated plants (Table 2). Si treatment increased the content of calcium in lettuce leaves dry matter by 22%. Si treatment increased the content of magnesium in lettuce leaves dry matter by 15%.

Table 1. Leaf lettuce transplant height (A) and width (B) as a result of treatment with silicon (Si) as opposed to the water control.

Item	Plant height (cm)		Plant width (cm)	
	Si	Control	Si	Control
Average	9.75	7.19	9.94	6.75
St. dev.	0.79	0.40	1.53	0.45
P	<0.001		<0.001	

Table 2. The content of nitrates in raw leaf lettuce transplant; the contents of nitrogen, phosphorus, potassium, calcium and magnesium in leaf lettuce as a result of treatment with silicon (Si) as opposed to the water control.

Item	Nitrate content (mg kg^{-1})		Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Calcium content (%)		Magnesium content (%)	
	Si	Control	Si	Control	Si	Control	Si	Control	Si	Control	Si	Control
Average	3.38	3.37	2.15	1.96	0.51	0.44	4.86	4.51	1.48	1.15	0.41	0.35
St. dev.	1.19	0.95	0.53	0.31	0.04	0.04	0.82	0.63	0.15	0.05	0.03	0.02
P	0.98		0.55		0.04		0.52		0.006		0.03	

Discussion

The leaf lettuce growth was enhanced due to treatment with Si as has been reported for other crops (Haghighi *et al.*, 2012; Torabi *et al.*, 2012; Olle, Narits, 2015; Zhu, Gong, 2014; Roohizadeh *et al.*, 2015). Silicon nutrition reverses succulence induced by high nitrogen and enhances crop growth and yield (Vasanthi *et al.*, 2014). Greger *et al.* (2011) found that biomass in lettuce was increased by Si and the root:shoot ratio was unchanged.

In this investigation, weight was not measured, but it can be assumed that increased height and width of plants the biomass is also increased. Application of Si can increase yield (Jarosz, 2014). Improved Si management is important to sustain crop productivity (Meena *et al.*, 2014).

By Si treatment, the elements phosphorus, calcium and magnesium contents were increased in leaf lettuce. Bent (2014) found that treatment with silicon increases nutrient uptake and that silicic acid agro-technology increases nutrient uptake by plants. Greger *et al.* (2011) reported that for some nutrients silicon in lettuce affected the uptake and distribution, while not affecting other nutrients. In the present investigation phosphorus was increased by treating leaf lettuce with silicic acid solution compared to the untreated control. In contrast, Greger *et al.* (2011) found that phosphorous decreased with Si in lettuce. Decrease of phosphorus is mainly a dilution effect; the amount of P was unchanged or increased because of the Si-induced increase of biomass (Greger *et al.*, 2011). Higher calcium content is useful in suppressing insect and disease attack and increasing transportability and storage quality (Olle, 2013). Increased magnesium after Si treatment is desirable because higher Mg reduces incidence of insect pests and diseases (Cakmak, 2013). Jayawardana *et al.* (2014) found that disease incidence was delayed by 2 days in plants treated with Si. Marodin *et al.* (2014) reported that Si reduced occurrence of fruit deformities. Foliar application of Si is effective against aphids (Guntzer *et al.*, 2012).

At a glance: silicon fertilisers with high plant-available silicon content have many potential benefits and sufficient Si supply aids healthy growth and product development. Applied silicon fertilisers interact positively with applied major and trace elements improving their agronomic performance and efficiency. Silicon fertilisers also enhance the plants' ability to resist or tolerate biotic stress such as attack of insect

pests and fungal attacks (Bent, 2014; Smith, 2011; Zhu and Gong, 2014; Vasanthi *et al.*, 2014). Silicon fertilisers can help alleviate abiotic stresses due to acidity, salinity and toxicities. Silicon fertilisers can help reduce water loss and transpiration (Smith, 2011).

In addition to decreased susceptibility to fungal pathogens (and insects), the beneficial effects of adequate Si include reduced manganese and iron toxicity, reduced salinity and water stress, protection of leaves from ultraviolet radiation damage and increased growth in some plants (Smith, 2011).

Si treated plants become stronger, sturdier and tolerant to dryness and drought, mineral imbalance and extremes of temperature (Bent, 2014). Therefore, silicon application could improve crop production under extreme climatic conditions (Shakoor, 2014; Shakoor, Bhat 2014). Bent (2014) describes, that bioactive silicon helps to take up more nutrients and utilize water and minerals more efficiently, reducing their requirements for water, fertilizers and plant protection chemicals during cultivation.

Conclusion

Silicon promoted the growth (the height and the width) of lettuce plants and improved its nutritional quality, by increasing phosphorus, calcium and magnesium contents in leaves of lettuce.

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Conflict of interest

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Author contributions

MO contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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DETERMINANTS OF TRAINING NEEDS OF YOUTHS IN BROILER CHICKEN PRODUCTION IN OSUN STATE, NIGERIA AND IMPLICATIONS FOR EXTENSION WORKERS

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ABSTRACT. This study identified the factors influencing the training needs of youth in broiler chicken production and drew implications for extension workers in Osun State, Nigeria. Data were collected from 221 youth farmers through a purposive sampling procedure and a snowball sampling technique. The data were analyzed using descriptive statistics, correlation, regression and factor analytical techniques. Findings reveal that 43.4% of the respondents were between the ages of 26 and 30 years, 26.7% were between the ages of 31 and 35 years, 19.0% were above 36 years of age while 10.9% of the respondents were less than 25 years of age. Majority (60.2%) of the respondents were males while others 39.8% were females. In addition, 40.7% of the respondents had at least three years of broiler chicken production experience, 34.8% had four to six years of experience, 17.6% had seven to nine years of experience and the remaining 6.8% had more than 10 years of broiler chicken production experience. In addition, vast Majority 86.0% of the respondents raise below 200 birds at the time of this research, 8.1% raise between 201 and 300 birds, 5.0% raised above 401 birds while the remaining 0.9% of the respondents raised between 301 and 400 birds. Furthermore, majority (60.2%) of the respondents have not received any training in poultry farming in the past one year while 39.8% of respondents received training between two to five times in the past one year. In addition, respondents were highly in need of training in five standard practices involved in broiler chicken production, which are: growing management / daily routine management, poultry housing, marketing of birds, litter management and equipment. Two groups of factors; income factors (33.2%) and training related factors (21.0%) that were isolated contributed 54.2% to the training needs of youth in broiler chicken production in Osun State, Nigeria.

Introduction

Poultry according to Adeyemo and Onikoyi (2012) is generally considered as a domesticated fowl kept primarily for meat and eggs, which includes; chicken, turkey, guinea fowl, pigeons, ostriches, pheasant, quail, peafowl and swimming birds such as duck, geese and swans. According to Partnership Initiatives in the Niger Delta (PIND) (2013), the poultry sector can be split into commercial poultry farming and rural poultry farming or backyard poultry farming. The commercial poultry farming ranges from small-scale businesses to large integrated poultry farms, and it is conducted with the explicit purpose of the commercial-scale sale of meat and eggs, while the rural poultry farming or backyard poultry farming is reared for subsistence purposes as well as an occasional source of income. Chicken is the dominant form of poultry in the country, and accounts for over 90% of the sector.

In the early 1980s there was a boom in intensive chicken farming when the government subsidized the prices of day-old chicks and feed ingredients, since then, there has been significant transformation in poultry farming in Nigeria, from backyard, peasant, subsistence rearing of domesticated indigenous birds to modern, cash-oriented and commercial rearing of

chicken occupies a place of pride among the livestock enterprises due to its rapid monetary turnover. This single reason pointed out by Laseinde (1994) and among others has made the enterprise attractive and popular among small, medium, as well as large-scale poultry farmers.

However, PIND (2013) reported that the commercial sector collapsed in 1986, when Nigeria subscribed to the World Bank's Structural Adjustment Programme. Under this programme, the Naira was devalued massively, making poultry inputs such as day-old chicks, feed components, vaccines and equipment (which were largely imported) unaffordable, reducing competitiveness. In order to fill the gap created by this collapse, dependence was heavily tilted towards importation of poultry products. Nevertheless, Heise *et al.* (2015) stated that Nigeria government felt compelled to check its importation and drain on foreign exchange and balance of trade, this action therefore led to the ban on poultry products import. In the meantime, backyard poultry farming, common across rural households has grown steadily during this period.

Similarly, Oyeyinka *et al*. (2011) pointed out that poultry industry in Nigeria has been rapidly expanding in recent years and is therefore one of the most commercialized (capitalized) subsectors of Nigerian agriculture involving thousands of birds. Large poultry units have replaced the backyard poultry units while more efficient strains of meat or egg type birds, balanced feed, intensive housing and better poultry equipment came into use by farmers.

The broilers meat value chain consists of parent stock rearing farms and farmers who rear broilers, feed companies and other input suppliers. The value chain begins at the grandparent stock rearing farm. The process includes rearing parent stock, which lay fertilized eggs. The eggs are then hatched and reared into broilers. The input suppliers such as feed companies and poultry equipment manufactures play an important role in this whole process. The chief feed input supplied by these feed companies includes raw materials such as maize, soybean, salt, vitamins and minerals.

Maize is the major component of the feed ration at about 65%. At the level of the farmer, feed costs constitute about 70% of total production costs. Other input costs consist of veterinary services, heating, bedding, and transport, labour and general expenses. The major output produced from the broiler chain includes day-old chicks, pullets, live birds and broiler meat sold to retailers, restaurants, consumers and exporters.

Osun State Government in 2012, embarked on several projects to mitigate youths' unemployment in the state. The Government empowered 20,000 youths in Community Development Programmes (CDP) but also embarked on developmental projects aimed at taking the State and citizenry out of poverty to socio-economic prosperity. Among the projects introduced was O' Chicken (Broiler Programme). The State Government of Osun imbibed the youths into poultry farming so that they would become self-reliant after their graduation instead of seeking white-collar jobs endlessly without success.

According to Farayola *et al*. (2013), the poultry sector is characterized by relatively faster growth in consumption and trade volume than any other agricultural sector. In terms of the provision of employment, Central Bank of Nigeria (CBN) (2007) has earlier reported that about 75% of the populace depends on agriculture and agro-based businesses for their livelihood and youth dominated this percent.

Farayola *et al.* (2013) also reported that in Osun State, it was made known that poultry farming is dominated by youth, who are considered to be young agile and active poultry farmers, they are considered to be capable of the tasks involved in poultry production. More so, according to them they are likely to be a set of youth that are unemployed but eventually settled for poultry business but in small-scale production. To buttress this Agbamu (1993) has earlier reported that there was a predominance of medium aged people in farming population.

In the Nigerian context, Nigerian National Youth Policy (2001) defines "youth" as all young persons of 18–35 years old who are citizens of the Federal Republic of Nigeria. However, Torimiro and Laogun (2005) implied from the Nigerian reality and defined the country's youth as young men and women between the ages of 13 and 30. This was based on the expected age of entry into primary education or vocational apprenticeship training, which is usually 13 years, while 30 years is the terminal age for participating in National Youth Service Corps (NYSC) – a youth programme for Nigerian graduates from Universities, Polytechnics or Colleges.

Conclusively, the Children and Youth-in-Agriculture Programme (CYIAP-Network, 2006) define youth as people from ages 19 to 40 years, this age bracket is adopted by CYIAP due to the circumstances of poverty, unemployment and deprivations that are prevalent in Nigeria and some other developing countries which make some people to still depend on others for survival, protection and development up to the age of 40 years.

Abiola (2007) expounded that poultry farming can provide wider employment opportunities (especially for youth) than any other livestock business because of chains of the effects on the aspects of poultry industry. In order to achieve optimum levels of performance in broiler chicken production, Farayola *et al.* (2013) explicated that it requires high standards of management which according to Food and Agricultural Organisation of the United Nations (FAO) (2013) it is often difficult to achieve, owing to less-than-optimal housing conditions and inadequate of quality feed, vaccines and trained staff. To achieve optimum performance Manimekalai (2010) asserted that there is need to train employed and unemployed youth in the poultry industry, with the purpose of improving their productivity, quality and income. Good-quality poultry meat

can fetch good price for the produce, improve consumption and help in branding poultry products. In addition, these can contribute to foreign exchange earnings of the country by way of increased exports.

Flippo (1965) defined training as the act of increasing the knowledge and skills of an employee in doing a particular job. On the other hand, Williams (1978) defined training as the process of applying appropriate educational methodology to those situations in which improved performance can result from effective learning. The definition given by Williams above goes in line with the definition given by Van Dersal (1968), he conceives training as the process of teaching, informing and educating people so that they become well qualified to do their work and to perform in a position of greater difficulty and responsibility. From this definition, it is clear that Van Dersal includes trainer and trainee in this definition of training. He considers that a more qualified personnel (trainer) have to transfer knowledge to people that is less qualified (trainee) in terms of knowledge. In addition, Laogun (1991) states that training deals with the acquisition of knowledge, skill and attitude by an individual to bridge the gap between actual situation and the desired situation. Thus, training aims at filling the gap between what the trainee knows and what he/she should know.

Need according to Ajayi (1995) is a state of want, which exists because of the desire to meet up with a targeted goal of production or achievement in the performance of a job. Previous studies have also established several definitions of needs; Leagan (1971) explicate that need is the difference between what is and what ought to be, this infers that need led to a gap being created between two conditions. Ditto to this, Laogun (1985) referred to need as "the difference between what exists and what is desired". Adesoji *et al*. (2006) concluded that need show that there is lack of something, which if present, would better the welfare of an individual or group of individuals whose situation is at stake.

Igwua (1987) recognized training need as an aberration that needs to be corrected. Proctor and Thornton (1961) defined training needs, as skills, knowledge and attitude an individual requires in overcoming problems as well as avoiding creating problem situations. In addition, Morrison (1976) stated that training needs exists anytime an actual condition differs from a desirable condition in the human or people aspect of organizational performances or more specifically when a change in present knowledge, skill and attitude can bring out the desired performance.

Therefore, training needs could be looked upon as a present deficiency that can be corrected by learning requisite knowledge, adequate and relevant skills and developing positive attitude aimed at correcting the deficiency.

Many studies have established the differences in the training needs of different target audience, which are based on set of determinants. Adesoji *et al.* (2006) identified level of education and formal trainings earlier attended as very crucial factors to predict the training needs of fadama farmers in Osun State. Farinde and Ajayi (2005) stated that the empowerment of women farmers through adequate training in all the expressed areas of training needs in livestock production is a predisposing factor to sustainable rural development. Farayola *et al.* (2013) investigated extension strategy development and training needs for small-scale commercial poultry farmers in Nigeria and Okeoghene (2013) investigated the competency level and training needs of laying bird farm attendants in Delta State, Nigeria.

All these studies have determined various areas of training needs across different demographics; however, none of them has identified or isolated the factors that determine the training needs of youth in poultry farming hence, this study intends to fill this knowledge gap.

The main objective of the study was to isolate the determinants of training needs of youth in broiler chicken production in Osun State, Nigeria. The specific objectives are to:

1. Describe the socio-economic characteristics of youth in broiler chicken production in the study area;
2. Examine the youth's levels of knowledge and skill in broiler chicken production;
3. Determine the training needs of youth in broiler chicken production and
4. Identify the factors influencing the training needs of youth in broiler chicken production in Osun State.

Materials and Methods

The study area is Osun state in Southwestern Nigeria. It was created on August 27, 1991 from the old Oyo state. Its capital is Oshogbo. The state lies within the rainforest region of the western Nigeria between latitude 60501N and 80101N on the northern-south pole and longitude of 40051E and 50051E on the east-west pole. Osun state, which is located at the centre of the western part of Nigeria and shares boundary with Kwara state in the north, Oyo state in the west, in the east partly by Ekiti State and partly by Ondo State and Ogun state in the south. The state has a population of about 3, 423, 535 as indicated by the 2006 census (National population commission, 2006).

There are over 200 towns in the state. A considerate number of highly urbanized settlements are found in the state. The state is divided into three Senatorial Districts, viz, Osun Central Senatorial District, Osun East Senatorial District and Osun West Senatorial District. The State is made up of 30 Local Government Areas and Ife-East Area Office. Majority of people in the state speak Yoruba language with other ethnic group also seen within the state.

Two geographical seasons are identified in the state, they are; the rainy season starting in March and ending in October, and the dry season starting in November and ending in early March. Annual temperature of the state varies between 21.1 °C and 31.1 °C. Annual rainfall is within the range of 800mm in the derived

savannah agro-ecology to 150mm in the rainforest belt. The state covers a land area of approximately 8,882.55 sq.km.

Agriculture, which is the traditional occupation of the people, is supported by the variety of edaphic and climatic conditions in the State. Major crops grown include cassava, vegetables, yam, maize, tomatoes, pepper and cocoa. The people of the State were also involved in rearing of livestock such as goat, cow and most especially poultry farming (chicken).

The target population was youth in broiler chicken production in Osun State between the ages of 19 and 40 years. Youth have been considered in this study because of the significant roles they play in broiler chicken production and ensuring food security. They have always been considered the future leaders, innovative and energetic all these characteristics are very significant would be exploited in ensuring higher productivity and income in broiler chicken production. Primary data were collected using a pre-tested and validated questionnaire. The questionnaire used captured the personal and socio-economic characteristics of the respondents, relevant information regarding their attendance at previous organised training and information on their knowledge and skill levels in broiler chicken production while secondary data provided by Poultry Association of Nigeria (PAN), Osun State Chapter was used to identify the number of registered youth poultry farmers in the state. Poultry Association of Nigeria (PAN), Osun State Chapter has 243 registered poultry farmers in their database, out of which 100 were youth poultry farmers.

The Agricultural Development Project had divided the state into three zones: Osogbo zone, Ife/Ijesha zone and Iwo zone. Osogbo zone consists of twelve Local Government Areas (LGAs); Ife/Ijesha zone consists of eleven Local Government Areas while Iwo zone consists of seven Local Government Areas. Purposive selection of seven LGAs was chosen from Osogbo zone, five LGAs from Ife/Ijesha and four from Iwo zone, making a total of 16 LGAs, due to the predominance presence of youth in broiler chicken production in the zones. The selection was based on those with the highest number of registered youth members of the Poultry Association of Nigeria (PAN) Osun State chapter.

A snowball sampling technique was used to identify other youth poultry farmers that were not registered under Poultry Association of Nigeria (PAN) Osun State chapter. Using a snowball sampling technique, 15 youth poultry farmers were picked out from each LGA selected making a total of 240 respondents for the study. However, due to incomplete responses, only 221 questionnaires were used for the analysis. Table 1 below shows the distribution of respondents by location.

The dependent variable is the training needs of youth in broiler chicken production. Their mean scores in knowledge and skill levels in selected broilers poultry standard practices or operations indicate their present knowledge and skill levels. The gap between their present knowledge and skill levels in standard practices or operations and the desired (standard) level was used to identify their training needs.

Table 1. Distribution of respondents by location

Zones	LGAs sampled	Number of respondents selected
Osogbo Zone	Osogbo	15
	Olorunda	15
	Irepodun	12
	Ifelodun	14
	Orolu	13
	Boripe	13
Ife/Ijesha Zone	Ife Central	15
	Ife East	13
	Ife North	15
	Ilesa East	15
	Ilesha West	11
	Obokun	12
Iwo Zone	Iwo	15
	Ede North	15
	Ede South	15
	Irewole	13
Total	16	221

Descriptive statistical techniques such as frequency counts, percentages and mean were used to describe the data collected. However, to determine the relationship between dependent variable (training needs of the youth in broiler chicken production) and independent variables (personal and socio-economic characteristics), correlation analysis and regression analysis were used. Factor analysis was used to identify factors influencing the training needs of youth in broiler chicken production in Osun State. All the statistical computation was done using Statistical Package for Social Sciences (SPSS) version 20.

Results and discussion

Personal characteristics of youth farmers

Age. Results in Table 2 show that 43.4% of the respondents were between the ages of 26 and 30 years, 26.7% were between the ages of 31 and 35 years, 19.0% of the respondents were above 36 years of age while 10.9% of the respondents were less than 25 years of age. The mean age of the respondents was 30.9 years.

Sex. About 60.2% of the respondents as presented in Table 2 were males while others 39.8% were females. This implies that majority of the respondents were males and shows the dominance of the male respondents towards broiler chicken production as a venture in Osun State. This finding agrees with that of Adisa and Okunade (2005) that reported that since most farming work or activities is energy demanding, hence men tend to be more involved in production while marketing and processing are often the routines of women.

Religion. Results from Table 2 further reveal that 64.7% of the respondents were Christians while 35.3% practiced Islam. This translates to mean that religious beliefs do not forbid broiler chicken production in the study area.

Marital status. The results from Table 2 further reveal that above half (53.4%) of the respondents were married while 46.6% were single. The implication drawn from this result is that young and agile people are showing interest in the poultry industry.

Ethnicity. Also, from Table 2 vast majority (95.0%) of the respondents belong to Yoruba ethnic group although, not necessarily from the study area, 4.1% were from Igbo ethnic group while 0.9% of the respondents were from Hausa ethnic group. The results therefore showed that majority of the respondents were native of Yoruba land and speaks Yoruba dialect, although some of the respondents were not a native of study area, they have migrated into the study area in search of 'greener pasture'. This implies that most of the respondents were from within the same ethnic group of the area of study and would at least speak and understand the common language of the ethnic group. This would bring about effective communication among youth farmers and other members of the community and therefore, communication might not be a barrier among youth farmers in broiler chicken production.

Table 2. Distribution of respondents by personal characteristics n=221

Variables	Frequency	Percentage	Mean
Age(years)			
≤ 25 years	24	10.9	
26–30 years	96	43.4	30.9
31–35 years	59	26.7	
36 years +	42	19.0	
Sex			
Male	133	60.2	
Female	88	39.8	
Religion			
Christianity	143	64.7	
Islam	78	35.3	
Marital status			
Single	103	46.6	
Married	118	53.4	
Ethnicity			
Yoruba	210	95.0	
Hausa	2	0.9	
Igbo	9	4.1	
Educational level			
Primary education	6	2.7	
Secondary education	37	16.7	
Post-secondary education	178	80.5	

Source: Field survey (2016)

Educational level. It was obvious from the results in Table 2, that all the respondents had one form of formal education or the other; above one-third (35.7%) of the respondents had Bachelor of Science Degree (B. Sc.), 24.4% had Higher National Diploma (HND), 16.7% had secondary education, 14.5% had Ordinary National Diploma (OND), 5.9 % had Master of Science Degree (M.Sc.) while only 2.7% of the respondents had primary education. This result agrees with the result of Okeoghene (2013) who reported that the poultry industry is no longer a sector for less literate people. This type of result according to Farayola *et al.* (2013) would help youth farmers to respond to challenges, innovation and other broiler poultry technologies, which results to high productivity and income.

Economic characteristics

Broiler chicken production experience. Results in Table 3 reveal that 40.7% of the respondents had at least three years of broiler chicken production experience, 34.8% of the respondents had four to six years of experience, 17.6% had seven to nine years of experience and the remaining 6.8% had more than 10 years of broiler chicken production experience. This implies that most of the respondents had less experience in the poultry business. Their little experience might be the cause of their low productivity and income. According to Fetuga (1992) the knowledge on management, which is a key to profitable poultry production, is gained through years of experience of the poultry farmer.

Purchase of day-old chicks. Results in Table 3 show that 77.4% of the respondents purchased their day-old chicks from hatchery, 18.1% purchased them from friends while 4.5% purchased them from community cooperative. This implies that majority of the respondents purchased their day-old chicks from hatchery. This might because they wanted a reliable source of day-old chicks and might have been because the farmers are purchasing at least one cartoon of day-old chicks. A cartoon of day-old chicks consists of 51 birds, half of a cartoon is not sold unless it is divided between two or more people, therefore, the respondents purchasing from friends and community cooperative might have done so because they were purchasing less than a cartoon of day-old chicks.

Number of broilers kept. Results in Table 3 reveal that 86.0% of the respondents raise below 200 birds at the time of this research, 8.1% raise between 201 and 300 birds, 5.0% raised above 401 birds while the remaining 0.9% of the respondents raised between 301 and 400 birds. The mean number of broilers kept was 105.2 birds. This is an indication that majority of the respondents were Small Commercial Poultry farmers, this is based on the classification given by Obi *et al*. and PIND (2013) with bio-safety serving as criterion because they were farmers keep between 1-5000 birds and they operate with the explicit objective of earning an income from broilers. This result might be due to the reason given by Akanni (2007) that most small-scale poultry farmers have limited finance to raise larger number of flocks.

Major target of production

Major target of production. Results from Table 3 show that vast majority (93.7%) of the respondents raise their birds for the purpose of selling while the remaining 6.3% raise their birds for family consumption. This implies that majority of the respondents were raising their birds mainly for commercial purpose. This is a hint that majority were practicing Commercial Poultry Production as based on the categorisation given

by Adene and Oguntade (2006) using scale, stock, husbandry and productivity as criteria because this categorisation is capital and labour intensive; as well as inputs and technology demanding.

Duration before reaching market weight. Furthermore, the results from Table 3 show that 41.2% of the respondents raised their birds up 10 weeks before selling them, 31.2% raised them to above 15 weeks while the remaining 27.6% of the respondents raised them between 11 and 14 weeks before reaching market weight. The mean number of weeks in reaching market weight was 12.28 weeks. This result indicates that none of the respondents follow the recommendation given by FAO (2003) that broiler should be raised between six to seven weeks before consumption. This result might be due to two reasons; first, the respondents might be raising the birds for more than 10 weeks because according to FAO (2008) Nigerian market demands big birds, so they are raising them to achieve that bigger size, or secondly, it might be due to slow growth rate resulting from poor quality feed and disease infestation.

Bird loss. Results from Table 3 show that 68.3% loses more than 4% of their birds before reaching market weight while 31.7% of the respondents loses less than or equal to 4% of their birds. This implies that majority of the respondents loses more than 4% of their birds before reaching market weight. The mean of bird loss is 1.68%. This shows that majority of the respondents do not follow the recommendation given by FAO (2003) that a mortality rate of 4% up to market age is admissible. According to the same source, it was advised that a higher mortality rate than 4% calls for strict disease control measures from the farmer.

Therefore, since the mortality rate should not exceed 4%, it is of great importance that the respondents should adopt the appropriate disinfecting and disease control measures to keep the mortality rate to a permissible rate. This type of result might be due to the small number of years of experience of respondents in the poultry business.

Selling of live-bird. In addition, results from Table 3 show that more than half (57.0%) take their birds to the market directly to sell by themselves, 27.6% sell it at home, 9.0% sell it to middle man, while the remaining 6.3% consume theirs. This implies that vast majority (84.6%) of the respondents sell directly to consumers. This result disagrees with PIND (2013) that reported that Small commercial producers who engage in broiler production sell 20% of their produce directly to live-bird retailers, 40% directly to consumers, and 40% to distributors but the result agrees with FAO (2013) who reported that most Small Scale broiler farmers sell the mature broilers directly to the consumer.

Price range. Results from Table 3 show that 6.3% of the respondents sold a bird to be less than or equal to ₦2,000, 17.6% sold a bird between ₦2,000 and ₦2,999, 46.6% sold a bird between ₦2,500 and ₦2,999, 10.9% sold a bird between ₦3,000 and ₦3,499 while the remaining 18.6% sold a bird above ₦3,500. The mean price range of birds sold was ₦2,613.

Income (during the last production cycle need). In addition, results from Table 3 show the income of the respondents after the expenses on vaccination, drug and feed has been deducted. The results reveal that majority (71.9%) of the respondents earned less than or up to ₦18,000 as income from broiler chicken production, 15.4% earned between ₦18,001 and ₦168,000, 4.5% earned between ₦168,001 and ₦318,000, 1.8% earned between ₦318,001 and ₦468,000, 5.0% earned between ₦468,001 and ₦618,000, 0.9% earned between ₦618,001 and ₦768,000 while 0.5% earned more than ₦768,001 as their income during the last production cycle. The mean income of the respondents was ₦69,871.06.

Table 3. Distribution of respondents by economic characteristics n=221

Variables	Frequency	Percentage	Mean
Broiler chicken production (years)			
≤3	90	40.7	
4–6	77	34.8	4.5
7–9	39	17.6	
10+	15	6.8	
Purchase of day-old chick			
From hatchery	171	77.4	
From friends	40	18.1	
From community cooperative	10	4.5	
Numbers of broilers kept			
≤200	190	86.0	
201–300	18	8.1	105.1
301–00	2	0.9	
401+	11	5.0	
Target of production			
Family consumption	14	6.3	
Sales	207	93.7	
Duration before reaching market weight			
≤10	91	41.2	12.2
11–14	61	27.6	
15+	69	31.2	
Number of bird loss			
≤4%	70	31.7	1.6%
4.01%+	151	68.3	
Selling of live-bird			
Not applicable	14	6.3	
To middleman	20	9.0	
Taking them to local market	126	57.0	
Selling at home	61	27.6	
Prince range (₦)			
<=2,000	14	6.3	
2,000–2,499	39	17.6	₦2,613
2,500–2,999	103	46.6	
3,000–3,499	24	10.9	
3,500+	41	18.6	
Income (₦)(during the last production cycle)			
<=18,000	159	71.9	
18,001–168,000	34	15.4	₦69,871.06
168,001–318,000	10	4.5	
318,001–468,000	4	1.8	
468,001–618,000	11	5.0	
618,001–768,000	2	0.9	
768,001+	1	0.5	

Source: Field survey (2016)

The overall results show that the respondents were not breaking even. These results contradicts the results of Lawal *et al*. (2009) who reported that poultry represents an appropriate system to provide income for small-scale farmers, but it agrees with Akanni (2007)

findings who stated that low income from poultry business is one of the constraints to increased productions faced by small scale poultry farmers. In addition, judging by the small number of birds kept by the farmers coupled with the general low level of farm income, it implies that majority of the farmers is still operating at the subsistence level.

Social characteristics

Household size. Results in Table 4 show that 74.7% of the respondents had a household size of less than five persons, 23.1% had a household size of between six and seven persons, 0.5% had a household size of between eight and nine persons and remaining 1.8% had household size of more than 10 persons. The mean household size was 5 persons. This according to Aromolaran *et al*. (2013) indicated that respondents with family size above 2 people would have more hands to work in their poultry which could aid increase in their output.

Source of labour. In addition, results in Table 4 revel that 52.9% of the respondents employed owner's labour for their enterprise, 36.2% make use of family/relatives while 10.9% hire labour for their enterprise. The finding shows that majority of the respondents are using owner's labour. This might be due to its cheapness coupled with the fact that they were Small Commercial Poultry farmers. This result contradicts Farayola *et al.* (2013) who reported that more than half of poultry farmers make use of family/relatives for their enterprise.

Membership of local organization. Results in Table 4 show that 58.4% of the respondents belonged to one religious organization or the other while 16.3% and 34.8% belonged to cooperative societies and community development association respectively. Only 31.2% of the respondents do not belong to any association. This implies that majority of the respondents belonged to one organization or the other. Youth's membership of association(s) could be employed in disseminating agricultural information to youth and in influencing decision making by the respondents as emphasized by Adesoji *et al.* (2006). This could also imply that group-learning methods would be better appreciated by the respondents during training.

Cosmopoliteness. Results in Table 4 reveal that all (100%) youth farmers normally travel out of their places of abode. Out of this, 78.3% of them had travelled to other states in the country, 14.0% had travelled out of the country while only 7.7% had travelled to other (LGAs) within the state. Less than half (33.3%) of the respondents travelled out of the community on weekly basis while 22.4% travelled on monthly basis. It could be inferred from this finding that since all the youth farmers travelled out of their places of abode, their external orientation might have exposed them to new ideas and practices in broiler chicken production, which might also reduce their training needs.

In addition, from Table 4 it was revealed that 29.0% of the respondents travelled out of their places of abode for leisure while 27.1% travelled out for business. In addition, 15.4% of the respondents travelled out to greet friends and family, 14.9% travelled out of their places of abode because they are schooling there while the remaining 13.6% of the respondents travelled out to purchase poultry farming inputs and marketing of poultry products respectively. This implies that 44.4% of the respondents travelled out either to greet friends and family or for leisure. This implies that training programmes aimed at improving broiler chicken production in the area should take place at the communities of the respondents for adequate participation since only a few of them travel out of their places of abode to purchase poultry farming inputs and marketing of poultry products.

Table 4. Distribution of respondents by social characteristics n=221

Variables	Frequency	Percentage	Mean
Household size			
≤5	165	74.7	
6–7	51	23.1	5
8–9	1	0.5	
10+	4	1.8	
Source of labour			
Hired labour	24	10.9	
Family labour	80	36.2	
Owner's labour	117	52.9	
***Organisational membership**			
Religion organisation	129	58.4	
Cooperative association	36	16.3	
Community development association	77	34.8	
Farthest distance travelled			
Outside the LGA	17	7.7	
Other states	173	78.3	
Outside the country	31	14.0	
Purpose for travelling			
Greet friends and family	34	15.4	
Leisure	64	29.0	
Business	60	27.1	
School there	33	14.9	
To purchase poultry farming inputs	15	6.8	
Marketing of poultry products	15	6.8	
***Source of information**			
Extension agents	-	-	
Farmers' organisation	26	11.8	
NGOs in agriculture	14	6.3	
Fellow farmer and friends	121	54.7	
Media	22	10.0	
Poultry Association of Nigeria	–	–	
School attended	38	17.2	

*Multiple responses (exceeds 100%). Source: Field survey (2016)

Sources of information. Results in Table 4 reveal that fellow farmers and friends were sources of information on poultry management practices to more than half (54.7%) of the respondents, Farmers' association provided information on poultry management practices to 11.8% of the respondents, media provided information about poultry management practices to 10.0% of the respondents while NGOs in Agriculture serve as source of information to 6.3% of respondents on poultry management practices. It was obvious from the results that none of the respondents indicated that Extension worker and Poultry Association of Nigeria

were sources of information on poultry management practices and many (49.3%) of the youth received information on poultry management practices from fellow farmers and friends, this show that peer groups play an important role in ensuring the sustainability of the enterprise. This result agrees with the result of Farayola *et al.* (2013) who reported that extension agents are not all that recognized by the farmers, which is an indication that they pay little attention to poultry production.

Attendance at previously organized trainings

Contacts with extension agents. Results in Table 5 show that none (100%) of the respondents had contact with extension agents before. This indicated that extension agents have not been carrying out their duties has expected.

Past training(s) in broiler chicken production. Also, from the results in Table 5, 60.2% of the respondents indicated that they have not received any training in poultry farming in the past one year, while the remaining 39.8% had received training, out of this, 15.4% of the respondents have attended training twice in the past one-year while only 7.2% attended training five times in the past one-year. The respondents also indicated that 21.3% of them attended the training organized by the schools they attended, 11.3% attended the training organized by NGOs while the remaining 7.2% attended the one organized by one religious organization or the other. This implies that majority have never been trained before. This might be the major reason of their low productivity and income level.

Poultry management trained on. Results from Table 5 also revealed that all the respondents (39.8%) that claimed to have received training before stated that they had received training on poultry housing, equipment, growing management/daily routine management, vaccination and disease control respectively, 33.3% of them were trained on management practices from brooding to weeks, 20.0% were trained on litter management, 14.2% were trained on record keeping while the remaining 12.5% of the respondents were trained on marketing. To this end, it is advisable to carryout training need identification which according to Okeoghene (2013) would help to know the kind of training that is required so that training can be effective. Training needs identification is of paramount importance to every successful training programme.

Reason(s) for not attending past trainings. Among the 60.2% of the respondents that did not attend any training before in the past, the results in Table 5 show that 31.7% of them said they were not aware of any, 19.9% said they were aware but not interested while the remaining 8.6% said that they have no money to pay for the training. The implication that can be drawn from this is that for youth to be interested in training training programmes must address their needs; the planners of training programmes must note this. In addition, efforts should be made to subsidize the price of training programme so as to make it affordable for youth if it could not be made totally free to ensure more youth to participate in the programme and the planners should stimulate the interest of youth into attending the training. In addition, adequate publicity should be made to invite as many youths in broiler chicken production as possible to participate in the programme.

Table 5. Distribution of respondents by attendance at previously organized trainings n=221

Variables	Frequency	Percentage
Contact with extension agents		
Once a month	0	0.0
Fortnightly	0	0.0
Not at all	100	100.0
Attendance at previous training		
Yes	88	39.8
No	133	60.2
Number of training previously attended in the past one year		
None	171	77.4
2 times	34	15.4
5 times	16	7.2
***Poultry management trained on**		
Poultry housing	88	39.8
Equipment	88	39.8
Management practices from brooding to two weeks	74	33.34
Growing management/daily management routine	88	39.8
Litter management	44	20.0
Vaccination and disease control	88	39.8
Record keeping	31	14.2
Marketing	28	12.5
Reason(s) for not attending past training		
Not aware of any	70	31.7
Aware, interested but not invited	44	19.9
No money to pay for training	19	8.6

*Multiple responses (exceeds 100%). Source: Field survey (2016)

Knowledge and skill levels of respondents in standard practices or operations involved in broiler chicken production

The respondents' knowledge and skill levels mean scores in the standard practices or operations involved broiler chicken production were presented in Table 6. Eight standard practices or operations were presented to the respondents based on the recommendations by FAO (2003) and FAO (2008). These operations include the following: poultry housing, equipment, management practices from brooding to 2 weeks, growing management, litter management, vaccination and disease control, record keeping and marketing of birds. Maximum point obtainable for each of the operations is 5 points while the minimum is one. The range adopted to categorise them as high or low mean score is as follows: 0–3.05 (low) and 3.06–5.0 (high) according to Ajayi (1995).

A. Knowledge level of respondents in standard practices or operations involved in broiler chicken production

1. Poultry house. It can be deduced from the results in Table 6 that youth farmers had low mean knowledge level in poultry housing (mean score = 2.70). This shows that they were not familiar with construction of

the poultry house; also, it shows that they might have not been housing their birds properly because of their low knowledge level. This agrees with Farinde and Ajayi (2005) that concludes farmers had low mean knowledge score in construction of modern houses for poultry birds.

2. Equipment. The knowledge level of the youth farmers in equipment is low (mean score = 1.73) as reflected in Table 6. This implies that the youth farmers were not knowledgeable in handling the poultry equipment adequately such as feeders and drinkers spaces requirement for different stages of the birds, which means they have been feeding their birds without considering the uniformity in their feeding, this will cause the birds not to grow uniformly, while some are big, others will be small. This result agrees with Farayola *et al.* (2013) that reported that poultry farmers have not been feeding their birds properly but this result contradicts the result given by Farinde and Ajayi (2005) that poultry farmers have high knowledge in feeding of poultry birds.

3. Management practices from brooding to 2 weeks old. Results in Table 6 show that the knowledge level of youth farmers in management practices from brooding to 2 weeks old was high(mean score = 3.23); this result contradicts the result given by Farayola *et al.* (2013) that poultry farmers had low knowledge level in handling of poultry birds.

4. Growing management/Daily-routine management. Also from Table 6, the results show that the knowledge level of youth farmers in growing management/daily routine management is low (mean score = 2.83), this result agrees with the result of Farayola *et al.* (2013) who concluded that poultry farmers had low knowledge level in poultry daily and special routine operations.

5. Litter management. It is evident from the results in Table 6 that the knowledge level of youth farmers in litter management is low (mean score = 2.47) this could lead to high mortality rate. The reason for this low mean could be the technicality involved in management of poultry litter, which according to Oyeyinka *et al.* (2011) account for most crises experienced in poultry production where upgraded knowledge for efficiency and effectiveness are required.

6. Vaccination and disease control. Results from Table 6 show that the knowledge level of youth farmers in vaccination and disease control is high (mean score = 3.93). This implies that the respondents were knowledgeable in vaccination and drug schedule for the birds. This result contradicts Farayola *et al.* (2013) that reported poultry farmers had a low knowledge level in vaccination and disease control.

7. Record keeping. It can be deduced from the results in Table 6 that the youth farmers' knowledge level in record keeping is high (mean score = 3.29), this result supports the result given by Farayola *et al.* (2013) that poultry farmers are knowledgeable in keeping records. To buttress this, Barnett *et al.* (2001), reported that record keeping and meeting production targets are good management practices that allow the identification and solution of problems in poultry farming.

8. Marketing of broilers. From the results in Table 6 it can be deduced that youth farmers had low knowledge level in marketing of their birds(mean score = 2.54). This might be the reason for their low-income rate, since they do not market their birds properly.

B. Skill levels of respondents in the standard practices or operations involved in broiler chicken production

1. Poultry house. It can be inferred from the results in Table 6 that youth farmers had low mean skill level in poultry housing (mean score = 2.54). This agrees with Farinde and Ajayi (2005) that reported that farmers had low skill level in construction of poultry house. This shows that they have not been housing their birds properly, which according to Torimiro *et al.* (2002) is one of the sources of economic losses in poultry business.

2. Equipment. From the results in Table 6 it can be inferred that the skill required in handling of poultry equipment by youth farmers is low (mean score = 1.96). This indicates that youth farmers are not skilled in handling the feeders and drinkers spaces required for different growth stages of birds. Since they were not knowledgeable in it, this type of result is expected. This shows that they lack the technical knowledge in handling of poultry equipment, hence need for training. This finding disagrees with the findings of Okeoghene (2013) who concludes that farm attendants were competent in handling of poultry equipment.

3. Management practices from brooding to two weeks old. Results in Table 6 show that the skill level of youth farmers in management practices from brooding to 2 weeks is high (mean score = 3.25). Having a low skill level in brooding of the birds can be catastrophic because management in the first four weeks of the chicks' life is by far the most valuable skill a poultry farmer must acquire because the birds are totally depend on them to meet their needs; therefore, adequate training is highly required.

4. Growing management/Daily-routine management. Results in Table 6 reveal that the skill level of respondents in growing management/daily routine management is low (mean score = 2.94). This finding concurs with the result given by Farayola *et al.* (2013) that conclude that most of the farmers do not adequately take to guidelines and principles that are required of the poultry business either daily or on special occasions.

5. Litter management. The results reveal in Table 6 that youth farmers had low skill level in litter management (mean score = 2.31). This finding is an indication that most of the respondents have been deviating from various precautions involved in litter management. Many of them may spend more money to buy drugs to cure the diseases caused by poor management of litter.

6. Vaccination and disease control. It can be inferred from the results in Table 6 that skill level of

youth farmers in vaccination and diseases control is high (mean score = 3.20). This implies that the respondents have been vaccinating their birds appropriately and adequately controlling disease. Many of them may not need to rely on veterinary doctors before they can administer drugs and vaccinate. This finding disagrees with Okeoghene (2013) who concludes that farm attendants were not competent in vaccination of birds.

7. Record keeping. The results from Table 6 show that the skill level of youth farmers in record keeping is high (mean score = 3.25). This implies that youth farmers keep records appropriately and as expected. This finding concurs with Farayola *et al.* (2013) that conclude that most of poultry farmers keep records appropriately and as expected.

8. Marketing of broilers. The skill level of youth farmers in the marketing of their birds is low (mean score = 2.91) as indicated in Table 6. This implies that they need adequate training.

In addition, since training aims at increasing the knowledge and skill of performance at a duty as stated by Ajayi (1995), it would be acknowledged that training should be organized and attended regularly for its effectiveness. Therefore, Laogun (1985) has earlier mentioned that the farmers' level of skill and knowledge need to be sought in order to know what to teach them for maximum production.

Table 6. Respondents' mean score of knowledge level, skill level and perception of importance of training in the standard practices or operations involved in broiler chicken production (n= 221)

Standard practices involved in broiler chicken production	Mean score	Knowledge level	Mean score	Skill level
Equipment	1.73	Low	1.96	Low
Litter management	2.47	Low	2.31	Low
Marketing of birds	2.54	Low	2.91	Low
Poultry housing	2.70	Low	2.54	Low
Growing management/ daily routine management	2.83	Low	2.94	Low
Management practices from brooding to two weeks	3.23	High	3.25	High
Record keeping	3.29	High	3.25	High
Vaccination and disease control	3.93	High	3.20	High

Source: Field survey (2016)

Training needs of youth in broiler chicken production

The results in Table 7 were used to identify the gap between the present knowledge and skill levels of youth farmers in standard practices or operations and the desired (standard) level so as to identify their training needs. As stated by Leagan (1971) that training need is the difference between what is and what ought to be, this infers that need led to a gap being created between two conditions, therefore, the present mean scores of both knowledge and skill levels of each operation is subtracted from the desired mean score. As earlier stated the range adopted to categorise them as high or low mean score is as follows: 0–3.05 (low) and 3.06–5.0 (high) according to Ajayi (1995).

It was evident from the result the respondents were highly in need of training in five standard practices involved in broiler chicken production, which are equipment, litter management, marketing of birds, poultry housing and growing management / daily routine management. This type of result is expected since they were neither knowledgeable nor skilled in them. This result support that of Farayola *et al.* (2013) which reported that poultry farmers were highly in need of training in poultry housing, daily and special operations and equipment but were in low need of training in record keeping.

Table 7. Training needs of respondents in broiler chicken production n= 221

Standard practices involved in broiler chicken production	What is (Mean scores)	What ought to be (Mean score)	Remark
Knowledge Level			
Equipment	1.73	5.0	High need
Litter management	2.47	5.0	High need
Marketing of birds	2.54	5.0	High need
Poultry housing	2.70	5.0	High need
Growing management/ daily routine management	2.83	5.0	High need
Management practices from brooding to two weeks	3.23	5.0	Low need
Record keeping	3.29	5.0	Low need
Vaccination and disease control	3.93	5.0	Low need
Skill Level			
Equipment	1.96	5.0	High need
Litter management	2.31	5.0	High need
Poultry housing	2.54	5.0	High need
Growing management/ daily routine management	2.94	5.0	High need
Marketing of birds	2.91	5.0	High need
Vaccination and disease control	3.20	5.0	Low need
Management practices from brooding to two weeks	3.25	5.0	Low need
Record keeping	3.25	5.0	Low need

Source: Field Survey (2016)

Training programme organized should base on trainees' actual needs. To reinforce this, Ajayi *et al*. (2008) as posited that training should be goal – specific; learner – oriented and designed to lift the trainee to a status of independent work in order for them to perform more efficiently, effectively and improve the quality of their output to increase their profit.

Correlation analysis showing linear relationship between some selected socio-economic characteristics of respondents and their training needs

The results in Table 8 show the Correlation Coefficient (r) with Coefficient (s), Determination (r^2) and it was deduced that at $p \leq 0.01$, there was a significant relationship between respondents' age (r = -4.411), household size (r = 0.272), years of experience (r = -0.384), number of broilers kept (r = -0.241), number of birds loss (r = 0.187), income during the last production cycle (r = -0.447), price range (r = -0.436), number of past training attended (r =-0.208) and their training needs in broiler chicken production. The positive correlation of household size of youth farmers and number of birds' loss indicated that the higher their household size and number of birds' loss, the higher their training needs in broiler chicken production.

Table 8. Summary of the results of Correlation analysis showing linear relationship between some selected socio-economic characteristics of respondents and their training needs

Variables	Correlation Coefficient (r)	Coefficient(s) Determination (r^2)	Decision
Age	-0.411**	0.168	S
Years of formal education	0.005	0.000	NS
Household size	0.272**	0.074	S
Years of experience	-0.384**	0.147	S
Number of broilers kept	-0.241**	0.058	S
Duration in reaching market weight	0.131	0.017	NS
Number of birds loss	0.187**	0.035	S
Income during the last production cycle	-0.447**	0.199	S
Price range	-0.436**	0.190	S
Cosmopoliteness	0.035	0.001	NS
Number of past training attended	-0.208**	0.043	S

** = r is significant at $p \leq 0.01$ level; NS = not significant; S = significant. Source: Field survey (2016)

Conversely, the negative correlation existing between age, years of experience, number of broilers kept, income during the last production cycle, price range, number of past training attended and their training needs in broiler chicken production indicated that the higher these variables, the less their training needs. The results could further be explained thus:

(i) there was a negative relationship between the age of the respondents and their training needs in broiler chicken production. This indicated that the higher the age of the respondents, the lower their training needs in broiler chicken production. This implies that the older the youth farmers become, the more their experience in broiler chicken production, hence the less the training they would require;

(ii) there was a weak positive relationship between household size of the youth farmers and their training needs in broiler chicken production. This indicated that the higher the household size of the youth farmers, the more their training needs in broiler chicken production. This implies that the larger the household size of the respondents become, the higher their responsibilities, hence the more the training they would require in order to expand their farm size so as to be able to meet the needs of the members of the household;

(iii) there was a negative relationship between years of experience of the respondents and their training needs in broiler chicken production. This indicated that the higher the years of experience of the respondents, the less their training needs in broiler chicken production. This implies that the higher the experience the respondents gathered during the production of broiler chicken, the better they would become, hence the less the training they would require;

(iv) there was a weak negative relationship between the number of birds kept by youth farmers and their training needs in broiler chicken production. This indicated that the higher the number of birds kept by youth farmers, the lower their training needs in broiler chicken production. The implies that the lesser the number of birds kept by youth farmers the more their major target of production is shifted from selling to consumption, therefore the lower the training required;

(v) there was a weak positive relationship between number of birds loss by the respondents and their training needs in broiler chicken production. This denoted that the higher the number of birds loss by the respondents the higher their training needs in broiler chicken production. This implies that youth farmers would embrace more training in broiler chicken production if they experience higher mortality rate than expected;

(vi) there was a negative relationship between income during the last production cycle of the youth farmers excluding their expenses and their training needs in broiler chicken production. This denoted that the higher the income during the last production cycle of the youth farmers, the lower their training needs in broiler chicken production and vice versa. This implies that the lower the income of youth farmers during the last production cycle, the more they would require training in order to boost their income;

(vii) there was a negative relationship between price range of selling birds by the respondents and their training needs in broiler chicken production. This denoted that the higher the price range, the lower their training needs in broiler chicken production and vice versa. This implies that the higher the price range the respondents were able to sell their birds, the lower their training needs in broiler chicken production would be because the higher the price range, the higher their

income would be, hence the lower the training required; and

(viii) there is a weak negative relationship between the number of past training attended by the youth farmers and their training needs in broiler chicken production. This indicated that the higher the number of past training attended by the youth farmers, the lower their training needs in broiler chicken production. This implies that the more training the youth farmers attended in the past, the lesser the training they would require.

Regression analysis establishing relationship between selected socio-economic of respondents and their training needs

The regression coefficients (B) with standard errors, standardized regression coefficients (β) and t-statistic values were presented in Table 9. The results in Table 9 show that of all the eight variables subjected to multiple regression only five variables were found to be statistically significant predictor. These variables include household size, number of birds' loss, years of experience, number of birds kept, income during the last production cycle, price range, and number of past training attended.

The multiple correlation coefficient (R) value for the regression was 0.662 indicating that a strong association exists between the combination of independent variables and training needs of youth farmers in broiler chicken production, R^2 value was 0.439 and adjusted R^2 value was 0.417 which means that the regression model accounted for 41.7% variation in training needs of youth farmers in broiler chicken production. The F-value was 20.697 and was significant at $p \leq 0.01$. The beta coefficient for the variables were household (0.202), number of birds loss (0.923), income (-0.322), price range (-0.268) and number of training attended in the part (-0.145). This indicated that the larger the household, the higher their training needs in broiler chicken production.

This could further be explained thus:

(i) the larger the number of birds loss, the higher their training needs in broiler chicken production;

(ii) the higher the income from broiler chicken production, the lower their training needs in broiler chicken production;

(iii) the higher the price range for selling the birds, the lower their training needs in broiler chicken production; and

(iv) the higher the number of past training attended, the lower their training needs in broiler chicken production.

Table 9. Results of regression analysis establishing relationship between selected socio-economic of respondents and their training needs

Model	B	s.e.	Beta	t	P
(Constant)	449.155	58.830		7.635	0.000
Age	-0.944	1.924	-0.034	-0.491	0.624
Household size**	20.951	5.572	0.202	3.760	0.000
Years of experience	-7.513	2.969	-0.152	-2.531	0.012
Number of broilers kept	0.134	0.089	0.114	1.497	0.136
Number of Birds loss**	4.241	0.923	0.257	4.596	0.000
Income during the last production cycle **	0.000	0.000	-0.322	-3.882	0.000
Price range**	-0.039	0.010	-0.268	-3.781	0.000
Number of past training attended**	-4.154	1.515	-0.145	-2.743	0.007

Multiple R-value = 0.662; R^2 value = 0.439; adjusted R^2 = 0.417; F value = 20.697 at $p \leq 0.01$; ** = significant at $p \leq 0.01$ level. Source: Field survey (2016)

Factors influencing the respondents' training need broiler chicken production (isolated factors influencing training needs of youth farmers)

The results in Table 10 show the principal component matrix extracted for training needs. Two groups of factors were isolated from the five variables with highly loaded components.

Factor I. Income factor. This factor was inferred of three variables from the first component. The variables were; price range (0.814), income (0.757) and number of birds loss (0.544). The price range of selling the birds by the youth farmers will determine their income, also, the higher the mortality rate, the lower their income. Therefore, training is needed in order to reduce the mortality rate of the birds. All these variables are important in determining the training needs of youth farmers.

Factor II. Training related factor. This factor was extracted from highly loaded variable such as number of training attended in the past (0.796) and household size (-0.593). The larger the household size of the respondents, the more training would be required to help them acquire more skill and gain more knowledge in broiler chicken production. The more the training attended in the past by the respondents, the more experience they would gain.

Table 10. Result of principal component matrix extracted for training needs showing correlation coefficient of highly loaded variables

Highly loaded variables	I	II	Percentage	Cumulative percentage
Price range	0.814		I (Income factors, 33.2%)	I (Income factors, 33.2%)
Income	0.757		II (Training related factor, 21.0%)	II (Training related factor, 54.2%)
Number of birds loss	0.544			
Household size		-0.593		
Number of training attended in the past		0.796		

I= Income factors; II= Training related factors

Contribution of extracted factors to the training needs of youth farmers. The results in Table 10 also show that income factors contributed 33.2% to the training needs of youth farmers while training related factors contributed 21.0% to the training needs of youth farmers. The high contribution of income factor may be due to the present of some variables like; price range, income and number of birds' loss, which were involved in the factor. The least contribution of training related factor may be because of interaction of the factor with the dependent variable (training needs). However, the total contribution of all the factors to the training needs of youth in broiler chicken production in Osun State, Nigeria was 54.2%.

Conclusion

The training needs of youth farmers were evaluated and the crucial factors associated with it were isolated. The two factors isolated were income and training related factors. Five variables household size, number of birds' loss, income during the last production cycle, price range and number of past training attended were identified to be very crucial to predict the training needs of the training needs of youth in broiler chicken production in Osun State. Areas of training needs identified include growing management/ daily routine management, vaccination and disease control, litter management and marketing of birds.

Extension agents should be inspired or motivated towards training of youth farmers on a regular basis. In addition, the factors mentioned above should be considered when planning and executing training for youth farmers. They should note the information sources in the community available to the youth farmers and utilize them adequately to disseminate improved information on broiler chicken production. The identified training needs of youth farmers should be given priorities in the design and implementation of training for them. This is ethical and will allow them to participate fully in the training programme.

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Conflict of interest

The authors declare that they have no conflict of interest.

Author contributions

M.O.O-O. – study conception/design/acquisition of data/ analysis and interpretation of data/drafting of the manuscript/critical revision of the final manuscript.
A.O.A. – design/sampling/critical revision of final manuscript.

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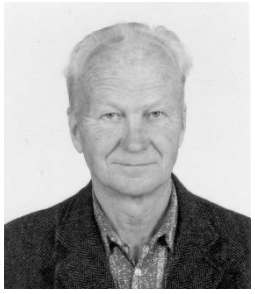
KALJU KASK – 90



Kalju Kask sündis 13. detsembril 1929. a Tallinnas elektriku peres. Koolitee algas Nõmme linna Rahumäe Algkoolis. Hiljem õppis ta Tallinna 10. keskkoolis (Nõmme Gümnaasium) ja lõpetas 1949. a kuldmedaliga. Erihariduse omandas Tartu Ülikooli põllumajandusosakonna aianduse osakonnas (1949–1951) ja hilisemas Eesti Põllumajanduse Akadeemia agronoomia teaduskonna aianduse erialal (1951–1955) ja lõpetas selle *cum laude.*

Praktiline töö aianduses algas Teaduste Akadeemia Tallinna Bioloogia Eksperimentaalbaasi aednikuna 1956. a ja jätkus 1957. a moodustatud TA Eksperimentaalbioloogia Instituudis teadurina. Aspirantuuriõpinguid (1961–1964) juhendas NSVLiidu TA V. Komarovi nimelise Botaanikainstituudi professor J. Konovalenko Leningradis. K. Kask kaitses bioloogiakandidaadi väitekirja teemal "Mõnede viljapuuliikide seemnete käsitlemine vahelduvate temperatuuridega ja selle mõju seemikutele" 1965. a Eesti NSV TA vastavas nõukogus. 1968. a sai ta vanemteaduriks instituudi geneetika sektoris. Uurimisvaldkonnaks oli tugevatoimeliste mutageenide uurimine taimedel. Juba 1956. aastal, asudes tööle aednikuna oli Teaduste Akadeemia president Johan Eichfeld andnud üle maguskirsi seemikud, nüüd lisandusid mutageenide kasutamise katsetesse veel aedõunapuu ja viltjas kirsipuu. Teaduste Akadeemia Eksperimentaalbioloogia Instituudis tegeles K. Kask mitmete kultuuride nagu aprikoosipuu, viltjas kirsipuu aretamise ning must aroonia, kibuvits, ebaküdoonia, astelpaju, aktiniidia, kreeka pähklipuu jt uurimisega. Saadud tulemused on kokku võetud doktoritöös "Eesti puuviljakasvatuse rikastamine uute kultuuridega", mille kaitses Läti Põllumajanduse Akadeemias 1974. a.

1970. a tehti K. Kasele ettepanek tulla tööle Eesti Maaviljeluse ja Maaparanduse TU Instituuti puuviljanduse osakonda Pollis, kus olid K. Kase ülesandeks õuna- ja pirnipuu sordiaretus ning sordiuurimise ja -aretuse töörühma juhtimine. K. Kask jätkas Aleksander Siimoni aretustööd õuna-, pirni- ja sarapuudega. Vormistas sordina õunapuud 'Tiina' ja 'Lembitu'. Ta valis A. Siimoni pirniseemikute hulgast järgnevatel aastatel väga populaarseks osutunud 'Pepi' algpuu. Vähem on levinud K. Kase pirnisordid 'Kadi' ja 'Polli punane'. Sarapuu seemikute valikul osutus 1978/79. a karm talv määravaks teguriks. Varem perspektiivseks osutunud 20 sarapuu seemikut külmusid lumepinnani, mistõttu tehti järeldus, et üle 40 aasta kestnud aretustöö ei andnud uusi sorte. K. Kase aretustöö maht oli kokku 40 000 õuna- ja 1000 pirniseemikut (Kask, 2010). TA Eksperimentaalbioloogia Instituudis alustatud mutageenide mõju uurimise katsematerjal 4200 õunapuusordi 'Antoonovka' seemikut, lisaks maguskirsi- ja viltja kirsipuu seemikuid toodi Polli. Nendest mutageenidega mõjutatud õunapuu seemikute hulgast pärineb sort 'Kaari' (2003). K. Kask valis A. Siimoni Longi aias kasvanud seemikute hulgast suureviljalised aretised L8, L9-2, L25 ja L28 ning kasutas neid edaspidises aretustöös lähtevanematena ristates aretisi omavahel, kuid ka sortidega 'Cortland' ja 'Tiina'. Saadud uue seemikute põlvkonna hulgast valis ta sordid 'Alar', 'Aule', 'Kallika', 'Katre', 'Krista', 'Madli', 'Liivika', 'Kaimo'. Sortide 'Cortland', 'Talvenauding', 'Tiina' ja 'Tellissaare' omavahelistest ristlusperekondadest valiti sordid 'Els', 'Kanti', 'Karamba', 'Katiliina', 'Kikitriinu', 'Kirki' ning Läti sordi 'Stars' vabatolmlemise seemikute hulgast sort 'Kastar'.

Viimane aretustsükkel hõlmab õunapuu kärntõvekindlaid seemikuid. Ristates kärntõvesse nakatuvat, kuid väga heamaitselist sorti 'Cortland' haiguskindla vormiga Nr 23 ta sai seemikute perekonna, kus osa isenditest olid kärntõvekindlad. Saadud 167 seemiku hulgast valis K. Kask salatiõunteks sobivad väikeseviljalised sordid 'Kuku', 'Ritika' ja 'Ruti'. Läti sordiaretaja Laila Ikase käest saadud kärntõvekindlate sortide vabatolmlemisest ja ristlustest saadud seemnete külvist 1988. a tärkas 875 taime. Neist valis K. Kask 20 perspektiivset aretist. 2018. a registreeriti sortidena taliõun 'Virve' (nimetatud kadunud abikaasa mälestuseks) ja sügissort 'Kalju'. Ta on aretanud maguskirsi sordid 'Johan', 'Karmel', 'Kaspar', 'Meelika', 'Mupi', 'Norri', 'Piret', 'Taki' ja 'Tontu'.

Aretaja on oma töö teinud, nüüd peavad sordid ise võistlema turukonkurentsis oma koha eest. Eriti väärtuslikud sordid muutuvad populaarseks. Õunasortidest on ärilistesse õunaaedadesse leidnud tee 'Krista', pirnisortidest 'Pepi' ja maguskirsisortidest 'Meelika'.

K. Kask on erakordselt viljakas kirjamees. Ta on üheksa raamatu autor või kaasautor. Publitseerinud ligi 1000 populariseerivat või aianduses nõuandvat artiklit. K. Kase kaastööd on avaldatud ajakirjades "Sotsialistlik Põllumajandus", "Maamajandus" ja "Maakodu", "Eesti Loodus" ja "Eesti Mets", aga ka välismaistes väljaannetes. K. Kase sulest on sadu artikleid entsüklopeediates (ENE ja EE) ja biograafilistes leksikonides. K. Kask on panustanud akadeemilise järelkasvu loomisele. Ta oli kümme aastat Tartu Ülikooli doktoritööde kaitsmise botaanika- ja ökoloogia nõukogu liige ning seejärel kümme aastat Eesti Maaülikooli samalaadse nõukogu liige. On juhendanud Heljo Jänese (Eesti) ja Laila Ikase (Läti) doktoritöid.

Eesti riik on hinnanud sordiaretaja tööd 1988. a ENSV teenelise teadlase tiitliga, 2009. a tunnustati teadus- ja arendustegevuse elutöö preemiaga. Eesti Maaülikool andis talle teenete medali 2004. a Põllumajandusministeerium kuldse teenete märgi 2010. a Akadeemiline Põllumajanduse Selts valis K. Kase auliikmeks 2005. a ja tunnustas elutöö preemiaga 2007. a Karksi vald valis K. Kase aukodanikuks 2010. a.

Eesti Vabariik tunnustas Kalju Kase teeneid valgetähe IV klassi ordeniga 2006. a.

K. Kase peres kasvas kolm last ja ta on vanaisa kuuele lapselapsele ning kahele lapsele on ta vanavanaisa.

Soovime juubilarile jõudu, tervist, erksat meelt ja nobedat sulejooksu!

Kolleegide nimel

Toivo Univer

PUUVILJANDUSTEADLANE ROBERT PIIR – 90

Robert Piir sündis 21. jaanuaril 1930. aastal Strelka külas Luuga rajoonis Leningradi oblastis talupoja lapsena. Pere tuli tagasi Eestisse elama, kui Robert oli veel laps. Samal ajal sai alguse ka tema huvi looduse, eeskätt taimede vastu.

Robert lõpetas 1950. aastal Tartu Meditsiinikooli. 1950–1951 töötas ta Rõuges velskrina, järgneval paaril aastal Tartu polikliinikus ja sõjaväehaiglas vanemröntgenitehnikuna. Elukutse sobis talle juba loomupoolest hästi, tingituna tema vastutulelikkusest, lahkusest ja heast kuulamisoskusest. Kuid pärast kolmeaastast töökogemust meditsiinivaldkonnas, otsustas Robert taimeteaduse juurde tagasi pöörduda. 1953. aastal lõpetas ta Tartu I Töölisnoorte Keskkooli, alustas õpinguid TÜ bioloogia osakonnas ning lõpetas viimase 1958. aastal. Seejärel suunati ta tööle Võrumaale Antsla Keskkooli õpetajaks, kus ta töötas kuni 1961. aastani. Samal aastal võttis Eesti Maaviljeluse ja Maaparanduse Teadusliku Uurimise Instituudi Polli katsebaasi juhataja professor Siimon ta teadurina tööle. Töökaaslaste sõnul on Roberti puhul tegu ausa, julge ja tööka inimesega. Üheks tema teadustöö aktiivsemaks perioodiks saab pidada aastaid 1962–1973, mille alguses loodi Roberti juhendamisel Polli katsebaasi tehnoloogialabor. Keemialaboratooriumi juhataja Koidu Kelt ja tehnoloogia labori juhataja Robert Piir analüüsisid kõiki Eestis sel ajal kasvatatud puuvilja- ja marjasorte. Teadustöös uuris ta veel puuvilja- ja marjasortide sobivust töötlemiseks, selleks valmistati hoidiseid, millele anti organoleptiline ja degustatsiooniline hinnang ning lisaks tehti füüsikalis-keemilisi analüüse. Töövõiduna võib nimetada maasikakeedise retsepti välja töötamist, mille puhul värvi esialgne intensiivsus säilib.

Oma vaba aja veetis Robert vabas õhus, käies pikkadel jalutuskäikudel ning kasvatades Pollis koduaias ravimtaimi ja vähelevinud puuvilja- ning marjakultuure. Tema loodushuvi jagas ka abikaasa, kellega koos käidi metsas seenel. Kuid lisaks aiandusehuvile jätkus ka aega musitseerimiseks, pilli mängimiseks tähtpäevadel ning Polli lasteaias ja kodudes näärivana mängimiseks.

Uurimisobjektidest olid Robert Piiri jaoks Pollis eriti südamelähedased pihlakaliigid ja -vormid. Ta rajas 1978. aastal Polli katsebaasi ühe täielikuma pihlaka sordikollektsiooni kogu Nõukoguse Liidus, kus oli ligi 20 pihlaka sorti ja vormi. Pihlakate paljundusmaterjali jagati harrastusaednike aedadesse aga ka aedadesse ja istandikesse välismaal, näiteks Lätis, Soomes, Rootsis ja USAs. Pihlakast sai alguse tõsisem huvi uute kultuuride vastu. Tema teeneks on uute puuvilja- ja marjakultuuride sortide ning liikide introdutseerimine Eestisse. Teadustöös hakkas ta uurima Eestis seni tundmata kultuure nagu astelpaju, söödav kuslapuu, toompihlakas, kuldsõstar, kirss-kontpuu, kukerpuu, pühvelpõõsas, laukapuu, sarik-hõbepuu. Uute kultuuride viljelemise ning andmete kogumisega tegeles ta enam kui 40 aastat. Pärast pensionile minekut 1992. aastal jätkas ta kirjutamistööd ning enamus tema uuritavatest materjalidest said avaldatud.

Ta on avaldanud üle 100 teadustrükise. Roberti huvialad on laiahaardelised, ta on avaldanud artikleid puutaimede puhkeperioodist, õuna-, pirni- ja ploomisortide sobivusest töötlemiseks, uute kultuuride viljade keemilisest koostisest ning uute puu- ja köögiviljakultuuride kasvatamisest. Lisaks muule on ta avaldanud kaheksa raamatut "Aiapidaja käsiraamat" (1974, üks autoritest), "Uusi puuvilja- ja marjakultuure" (1980, kaasautor K. Kask), "Puuviljad, marjad, tervis" (1997, kaasautorid K. Kelt, L. Lamp), "Pihlakas aias ja köögis" (2003, kaasautor T. Niiberg), "Astelpaju aias ja köögis" (2005, kaasautorid M. Jalakas, T. Niiberg), "Vähetuntud marjad aias" (2008), "Pihlakas" (2010), "Puuviljad ja marjad Eestis" (2010, üks autoritest). Veel on ta avaldanud artikleid ajalehtedes ja ajakirjades ning andnud oma panuse uute kultuuride kasvatamise propageerimiseks Eestis.

Robert tähistas sel aastal koos abikaasa Lehtega 52. pulma aastapäeva. Neil on kaks last, neli lapselast ning üks lapselapselaps.

Soovime juubilarile kogu südamest õnne!

Polli Aiandusuuringute Keskuse nimel,

Mailis Vinogradov

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