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REVIEW PAPER

Impact of salt, drought, heat and frost stresses on morpho-biochemical and physiological properties of *Brassica* species: An updated review

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ABSTRACT Abiotic stresses seriously impact crop productivity and agro-morphological and biochemical properties of all *Brassica* species. It also decreases the yield of many important *Brassica* species by disturbing their normal growth and development. In this review, we have highlighted the latest reports about the impact of different abiotic stresses on different growth stages and other morpho-physiological processes of important *Brassica* species such as canola/rapeseed (*Brassica napus*), indian mustard (*Brassica juncea*), *Brassica oleracea* and *Brassica rapa*. Several researchers reported that abiotic stresses affect the important morpho-biochemical processes such as shoot and root length, shoot fresh and dry weight, proline and relative water contents, chlorophyll amount, antioxidant enzymes activity of important Brassica species. These stresses also disturb normal oxidative processes that lead to cell injury. The genetic modification approaches for the development of transgenic plants against these environmental extremes have been described. The present study will be useful to identify the best abiotic stress tolerant *Brassica* genotypes for further genetic engineering program and crop improvement programs.

Keywords: Abiotic stresses, *Brassica* species, Morpho-biochemical, Transgenic *Brassica* species

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INTRODUCTION

Abiotic stress affects the growth, development, yield and other physiological characters of different Brassica species. The effect on these characters is directly correlated with economically yield loss of crop plants. Various researchers conducted studies to screen the abiotic stress tolerant *Brassica* genotypes for further study in environmental stress affected areas. The detailed information about the effect of all sort of abiotic stresses on important *Brassica* species is given below:

Effect of salt stress on important properties of *Brassica* species

Salt stress is one of the major abiotic stresses that affects plant growth and its production (Allakhverdiev et al., 2000; Hasanuzzaman et al., 2017; Nejat & Mantri, 2017). About 20% of our cultivated lands and 50% of crop land are highly affected by salt stress (Lakhdar et al., 2009). It is estimated that more than 50% of our arable lands will be affected by this type of stress by the year 2050 (Wang et al., 2003). This stress can be determined at time when plant death occurs or when it badly affects its morpho-physiological process. However, the abiotic stress tolerance varies with plant species/sub-species. Therefore, development of abiotic stress tolerant varieties is so important (Zheng et al., 2009). Salt stress affects both the qualitative and

quantitative characters of important *Brassica* species such as canola (*Brassica napus* L.), Indian mustard (*Brassica juncea* L.), cabbage (*Brassica oleracea* L.) and turnip rape (*Brassica rapa* L.). The diploid nature of *Brassica rapa* is more sensitive to salt stress as compared to other polyploid species i.e. *B. napus* (Farhoudi et al., 2015; Kumar, 1995). The high salt concentration in soil and irrigation water decreases the germination rate of almost all *Brassica* species. Sometime plant germination can occur but shows stunted growth and poor development (Zamani et al., 2010). So, it is important to identify and characterize improved genotypes against these environmental extremes (Almodares et al., 2007; Islam & Karim, 2010).

Salt stress affects the N (nitrogen) uptake and its assimilation process in many plant species. The high level of salt affects various enzymes of *B. juncea* such as nitrite reductase (NiR), glutamine synthetase (GS), glutamate dehydrogenase (GDH) and asparagines synthetase (ASN) (Siddiqui et al., 2009). It also disturbs plant biomass, root and shoots length, CO_2 assimilation rate of *B. juncea* (Ahmad et al., 2012). The other morpho-biochemical and physiological processes such as growth rate, chlorophyll contents, leaf area index, flower abortion and N, K and P contents are also significantly affected in many *Brassica* species (Hayat et al., 2009).

Canola shows moderate level of resistance to salinity. But, its growth and productivity are highly affected by different salt concentraions (Lomonte et al., 2010). Salt affects the photosynthetic rate, growth and sodium (Na^+) ion accumulation and distribution in leaf area of two important canola genotypes (NYY 1 and BZY 1). The plant dry biomass, overall photosynthesis, Na^+ level and net water potential rates in leaf area were higher in genotype NYY 1 as compared to other genotype (BZY 1). However, the %Na^+ content in leaf symplast remained higher in genotype NYY 1. The moderate salt level (3 g/kg) has slight effects on the stomatal conductance. While high salt levels (6 and 9 g/kg NaCl) significantly affects the assimilation rate due to stomatal and non-stomatal limitations and leads leaf necrosis and stunted growth. The high salt resistant potential in genotype NYY 1 is due to low accumulation of Na^+ in shoot area confined Na^+ to the apoplast area thus lowering leaf toxicity. This is one reason that genotype NYY 1 shows more tolerance than that of BZY 1. Hence salt tolerance response varies with the type of genotype (Yang et al., 2012). The shoot, root fresh and dry weights of canola plants decreased with all salt stress levels (50, 100, 150 and 150 mmol) (Sergeeva et al., 2006). Similarly, the percent relative water contents 24 hours also decline with the increasing NaCl levels (0, 100, 150, 200, 250 and 300 mM) in many important canola cultivars. It means that water loss from leaves occur at high rate at elevated NaCl concentration (Dai et al., 2009).

Elevated salt concentrations (12 and 15 dSm^{-1}) significantly decreased the germination rate, root shoot length and seedling dry weight many folds of kohlrabi (*Brassica oleracea* var. *gongylodes*). While it showed good morpho-physiological performance at up to 9 dSm^{-1} NaCl (Biswas et al., 2016). Kandil et al. (2016) reported that salinity stress affects all the ten tested canola genotypes. However, the salt tolerance level varied among genotypes. The cultivar Screw 6 showed excellent morphogenic response for all quantitative traits like root/shoot length and root/shoot fresh and dry weights. While cultivar Screw 51 gave better seedling height, total chlorophyll contents and relative dry weight. However, these characters were highly affected at high NaCl concentration (1.8%). Umar et al. (2011) also observed different type of responses at different salinity levels of many imported *B. rapa* genotypes. The abiotic stress decreased the amounts of chlorophyll a, b and a+b up to several folds of *B. napus, B. juncea* and *B. rapa* genotypes (Alam et al., 2014).

Salt stress also affects the growth and total fatty acid (TFA) contents of many important *Brassica napus* genotypes. The plant biomass was decreased by 25 and 35% at high NaCl levels (100 and 150 mmol). The overall decrease in biomass occurred by 55% at very high salt stress (200 mmol) in all canola genotypes. The overall TFA value was decreased by 25% with increasing of salt stress from 0 to 200 mmol. It might be due to membrane lipid degradation at high stress level. More interestingly, the poly-unsaturated fatty acids decreased, while the mono-unsaturated fatty increased with the rise of salt stress. The oleic acid, palmatic acid, linoleic acid and linolenic acid optimum concentrations were significantly disturbed by saline condition (Bybordi et al., 2010). The increase level of degradation of important secondary metabolites (glucosinolates) occur with the increase level of salt stress, due to membrane damage/high relative electrolyte leakage. The high glucosinolates content was observed in *Brassica oleracea* L. var. *italica* after NaCl (40 and 80 mM) stress for two weeks. The same trends were also recorded for *B. rapa* after subjecting NaCl levels (20, 40 and 60 mM) for five days (Lopez-Berenguer et al., 2008). These abiotic stresses may change the defense mechanism of many important *Brassica rapa* germplasm (Steinbrenner et al., 2012). Salt stress affected the growth and other important enzymatic activity of three important canola genotypes (Consul, Zarfam and Okapi). The

growth decreased by several folds but the rate of Catalase (CAT) and Peroxidase (POD) increased many folds with the increase of salt concentration from 0 to 120 mmol. The cultivar Opaki showed more salt tolerance and maximum enzymatic activities; CAT (14.2 mgH2O2/g.pro/min)/POD (63.4 mgH2O2/g.pro/min) as compared to other two cultivars at 120 mmol NaCl (Farhoudi et al., 2015).

Salts stress severely affects different plant species at early germination and seedling growth stages by disturbing their various agro-morphological and physiological processes (Su et al., 2013). Torabi & Ardestani (2013) reported that salinity and drought stress affected the morpho-biochemical processes of important canola genotype Opaki at germination stages. The seeds were germinated at 0, -0.1, -0.2, -0.3, -0.4, -0.6 and -0.8 MPa NaCl and PEG-6000 concentrations. The maximum germination frequency (72%) was obtained at controlled condition (0 MPa) and it decreased up to 26.1% at -0.8MPa for NaCl and PEG. The 50% maximum germination value was estimated for 50.4 h at 0 MPa and increased to 62.5 and 123.7 h at -0.8 MPa concentrations. Salinity causes reduction in average yield, oil contents and other growth performance of many important *Brassica* species. It has adverse effect on plant morphology and other morpho-physiological processes (Su et al., 2013; Jan et al., 2016).

Impact of heat stress on morpho-physiological properties of *Brassica* species

High temperature stress disturbs normal plant growth and development, especially at the early stages of plant growth, which is one of the major problems in many cultivated areas of the world. The high heat stress retards the normal agronomical, morphological, biochemical and physiological processes of many different plant species and causes severe yield loss. It also affects many *Brassica* species including important canola oilseed crop at early growth stage. The increase in levels of ascorbate peroxidase and gene expression in canola hypocotyl occurs at high temperature. However, ascorbate peroxidase levels increased for a short period upon high temperature stress. The up-regulation of these proteins play key role in energy and metabolic processes and can help to provide maximum nutrients to early seedling at high temperature (Ismaili et al., 2015). The optimum temperature for *Brassica napus* germination is 28 °C and any temperature above this level retard its growth and development (Kaya et al., 2006). The effect of low to high temperature gradient on plants generally depends on some important factors like anti-oxidant enzyme concentrations, plant species/ cultivar used, type of organs, time period of exposure, magnitude of stress and growth stages (Lu et al., 2008; Zhang et al., 2015). Similarly, the proline content increases with rise of heat stress. Proline protects the proper protein structure from denaturing, stabilizes the cell membrane by interacting with phospolipid bilayer and maintains the osmotic pressure between cytoplasm and environment (Claussen, 2005). On the other hand, the decrease in chlorophyll content was recorded at unfavorable temperature (Gupta et al., 2013; Shah et al., 2015).

Temperature above 27 °C leads to floral sterility and yield loss of many economically important *Brassica napus* cultivars. The high heat stress at vegetative growth stage leads to low flower number in all three important *Brassica* species (*B. rapa, B. juncea and B. napus*). The yield significantly increased with the increase of flower number. The loss of yield was due to reduced seed size per flower. Therefore, heat tolerance genotypes are important to achieve maximum flower numbers and healthy seed size (Morrison & Stewart, 2002). The *B. carinata* shows poor germination and early seedling growth at high heat stress. Therefore, proper inter/intra-specific hybridization methods are important to develop new heat tolerant *Brassica* species. New alien genes introgression can be used for the improvement of many important *Brassica* species (Deol et al., 2003).

The flower and grain filling stage are more sensitive for temperature stress. It affects pollen viability, grain development, anthesis time and fertilization process. The high thermal stress at terminal growth stage affected normal photosynthesis process, transpiration rate, stomatal conductance, mean productivity and geometric mean productivity, and important yield characters of 43 important rapeseed germplasm. A 20% reduction in plant yield was recorded in many genotypes. The rapeseed mustard genotypes, BPR-549-9, BPR-540-6 and BPR-349-9 showed more heat tolerance at terminal growth stage and gave better yield and other morpho-physiological response than that of other accessions (Singh et al., 2014). The elevated level of temperature increased the transpiration rate and stomatal conductance, and decreased the water use efficiency and chlorophyll a content of Chinese cabbage (*Brassica campestris* subsp. napus var. pekinensis cv. Detong) (Oh et al., 2014).

Effect of frost stress on physiological properties of *Brassica* species

The frost stress is one of the key environmental extremes that affects the yield and other agronomic important characters of many crop plant species (Singh et al., 2008; Shah et al., 2016). The canola crop is very sensitive to frost stress especially at reproductive stages. The spring and winter temperature affect some of the important steps during the reproductive period like gametogenesis, pollination, fertilization and embryogenesiss (Angadi et al., 2000). The low temperature leads to few mature seeds formation due to poor pollen formation (Jinling, 1997). Frost stress at early seedling stages causes death of the whole canola plant. The damage of frost stress mainly depends on many important factors such as duration and extent of cold stress, different plant growth stages and moisture content. The seedling growth is significantly affected by high frost stress (−16 °C). The frost stress leads to wilting of leaves, bleaching, or in extreme cases can cause plant death. A significant level of difference in growth was found among spring, hybrid and winter types to cold stress. However, the response of hybrid and winter types remained the same (Fiebelkorn and Rahman, 2016). The wilting symptoms can cause loss of maximum water from cells. The blackened cotyledons and/or leaves of canola genotypes serve as indicator to frost damage. The canola is more sensitive at cotyledons stage than at three- to four-leaf stage. The slow growing seedling shows less susceptibility than that of rapid growing seeding canola genotypes (Sovero, 1993).

Effect of drought stress on morpho-physiological characters of *Brassica* species

Drought is one of the most drastic abiotic stresses that damages agricultural crops affecting its development, growth and production (Micheletto et al., 2007). Drought stress in plants may result some physiological disorders such as reduction in photosynthesis and transpiration (Sarker et al., 2005). The drought decreases the average production rate of different crop species (Robertson & Holland, 2004). Plants react to water stress through a number of developmental, functional and biochemical changes. The tolerant canola genotypes have more ability for adapting themselves under drought condition. The genetic diversity of cultivated *Brassica napus* relatives provides valuable genes for improving this tolerance (Hosseini & Hassibi, 2011).

Nasri et al. (2008) studied drought stress that caused a significant reduction in the number of seeds per siliqua, number of siliquae per plant, 1000-seed weight, seed yield, seed oil content, and oil yield of five rapeseed cultivars. Sinaki et al. (2007) observed that low water stress at flowering stage decreased seed yield, the biological yield, and the number of siliquae per plant of important rapeseed cultivars. Stroeher et al. (1995) reported that phenology of rapeseed affected seed quality characteristics such as protein and oil percentage and the quantity of glucosinolates under water stress condition. The main qualitative properties of rapeseed plants strongly affected by water deficit are oil and protein contents (Istanbulluoglu et al., 2010). Tesfamariam et al. (2010) found that the seed oil content of rapeseed plants was low due to water deficit at flower budding stage. Richards & Thurling (1978) observed variation in response to drought stress between and within species such as *B. rapa* and *B. napus*. They found that seed production and its components in different cultivars of *B. rapa* and, *B. napus* are significantly influenced by low water stress. Variation in drought patience cultivars or species has frequently attributed to differences in their time of ripening. Thurling (1974) suggested that *B. napus* may be more resistant to drought stress than that of *B. rapa* since it flowers later and stores less of its dry matter after flowering. Drought stress negatively affected many biological processes in plants including the reduction in photosynthesis, accumulation of dry matter, stomatal opening, and protein synthesis (Larcher, 2003; Ohashi et al., 2006). Drought causes disorganization of thylakoid membranes resulting in reduction in chlorophyll contents and the pigments (Ashraf & Harris, 2013).

Development of transgenic abiotic stress tolerant *Brassica* species

In nature, plants produced tolerance to both types of biotic and abiotic stresses but it is a very slow process and some time these extreme stresses affect plants negatively. The transgenic plants expressing transgene show more abiotic stress tolerance as compared to non-transgenic plants (Shinwari et al., 1998; Kasuga et al., 1999; Maqbool et al., 2002; Ali et al., 2016). Transgenic plants against biotic and abiotic stress can be produced through several gene transfer approaches using *Agrobacterium*-mediated transfer; this will enhance tolerance against drought, salinity and low temperature in *Arabidopsis thaliana* (Kasuga et al., 1999). Agarwal et al. (2006) described that with recent advances in molecular biology have shown that several genes are induced under abiotic stress condition. These genes have been isolated, characterized and transformed to plants under the presence of specific induced or constitutive promoters. The resulted transgenic plants showed tolerance to these extreme environmental conditions and played important role in the improvement of sustainable agriculture. Many efficient, quick, direct and indirect transformation protocols have been developed to wide range of plant species (Kumar et al., 2014; Shah et al., 2015; Jan et al., 2016). Various transgenic *Brassica* species has been produced against these environmental extreme that shows tolerance as compared to non-transgenic plant. The detailed information of these transgenic *Brassica* species against abiotic stresses is shown in Table 1.

Table 1 Transgenic *Brassica* species developed against abiotic stress through genetic modification

Transgenic Plant	Transgene	Against	References
Brassica napus	*BnSIP1-1*	Salt and Osmotic stress	Luo et al. (2017)
Brassica napus	Differentially expressed genes (DEGs)	Drought	Wang et al. (2017)
Brassica juncea	Glyoxalase I	Drought and salt stress	Rajwanshi et al. (2016)
Brassica juncea cv. Varuna	Lectin	Drought and salt stress	Kumar et al. (2015)
Brassica napus	*AtDWF4*	Drought and heat stress	Sahni et al. (2016)
Brassica napus Var. Wester	*DREB*	Salt stress	Qamarunnisa (2015)
Brassica oleracea var. botrytis	APX, SOD	Salt stress	Metwali et al. (2012)
Brassica napus	Vacuolar Na+/H+ antiporter*BnNHX1*	Salt stress	Wang et al. (2004)
Brassica napus	Vacuolar Na+/H+ antiporter*AtNHX1*	Salt stress	Zhang et al. (2001)
Brassica napus	*AtCBF1*	Frost stress	Jaglo et al. (2001)
Brassica napus	*BNCBF5/BNCBF17*	Frost stress	Savitch et al. (2005)
Brassica napus	*Coda*	Salt stress	Huang et al. (2000)
B. juncea	*Coda*	Salt stress	Prasad et al. (2000)
B. oleracea	*Beta*	Salt stress	Bhattacharya et al. (2004)
B. campestris	*Lea*	Drought and salt stress	Park et al. (2005)

CONCLUSION

The drought, salt, frost and high temperature stresses significantly affect the morpho-physiological processes of some important *Brassica* species. Development and identification of abiotic stress tolerant cultivars are important economic goals for our globe. The morphological and agronomical study of *Brassica* species performing under environmental extremes could lead the research and development of new stress-tolerant cultivars. The genetic engineering approaches play a key role for the development of improved transgenic

Brassica species against wide range of abiotic stresses. The present study provided updated information about the toxic effects of abiotic stress on important *Brassica* species, detailed information of abiotic stress tolerant and non-tolerant *Brassica* species/genotypes and transgenic approaches against these stresses.

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ORIGINAL PAPER

Farm management capacities contribute to sustainability of rural livelihoods amongst small farmers in district Layyah, Punjab, Pakistan

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Key Message This study reveals that about 98% of the respondents had farms, while 100% respondents had livestock assets for their livelihoods in district Layyah, Punjab, Pakistan. The study will help in the development of relevant sustainability policies.

ABSTRACT Punjab is one of the fertile provinces of Pakistan but poverty is prevailing especially in its rural areas. The main reasons for poverty in these areas include the lack of planning as well as implementation of policies. The present study was conducted in district Layyah, Punjab to investigate the sustainability of rural livelihoods among the small farmers. The results show that a majority of the respondents (68.33%) had their own land and 98 percent of the respondents had a farm. 41.66% were farming on the current farm for a period of 11-15 years. During this study, it was found that 87% respondents had electricity available for farming activities and 74.33 percent of respondents were using canal water to irrigate their land. A majority of the respondents (37.66%) were holding 1.1-2 ha of land and performing cultivation activities. As far as active membership of a community organization is concerned, about two thirds (65%) of the respondents held active membership in a community organization via different non-government organizations. After taking into account livestock and farming; 100 percent respondents told that they possessed these assets as their primary financial capital because the area was rural in nature and the targeted respondents were farmers by occupation. Agriculture loans were also found to be a source of income for a majority (61.66%) of the respondents. The findings of this study will be helpful for policy makers to develop policies that correspond to the realities of farming in the region.

Keywords: Farm, Layyah-Punjab, Management capacity, Small farmers, Sustainable livelihoods

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INTRODUCTION

Universally, more people are involved in farming than in any other industry and a vast majority of the world poor is reliant on agribusiness to earn their livelihood (Food and Agriculture Organization [FAO], 2004). The rural poor are unable to sustain themselves from agricultural earnings especially when they cannot access financial tools that would help them succeed. The utilization of accessible assets creates conflicts among farm individuals and the poor are more likely to be vulnerable to being deprived of these assets (FAO, 2000; Wisner et al., 2003). Among 1.3 billion individuals on the earth, about one third lives beneath the poverty line. It has been estimated that 678 million poor people of the world who keep domesticated animals in the developing nations account for 66 percent of the rural poor and they are considered as the most significant part of this huge population (International Livestock Research Institute [ILRI], 2000). The domesticated animals in the developing nations contribute more than 33 percent to the farming total national output and give a noteworthy food security to about 1 billion poor people in underdeveloped countries (Swanepoel & Moyo, 2010). The availability of different trainings helps the rural farmers to stop repeating failing practices,

and change their patterns of livestock husbandry over time (Elis, 2000). In the developing nations, the domesticated animals are kept in the house and plain land for sustainability (Herrero et al., 2010).

The rural household units in Pakistan are tied to farming as an occupation for livelihood and education of their children. Agriculture produces 20.9 percent of the national wage and uses 43.4 percent of total workforce of the nation. Moreover, this section of the economy provides raw material to local agro-based commercial schemes for example sugar, oil, calfskin etc. In Pakistan nearly 66 percent of the population is poor and is living in rural areas; likewise 80 percent of the world poor is spending their lives in rural areas (Ishaq & Memon, 2016). Considering the wages, it can be easily concluded that the household earnings are lower in rural areas than that of urban areas. There is 34 percent poverty ratio in rural areas whereas in urban areas it is 19.1 percent. Lack of access to the basic necessities is a serious issue for the rural people. Agriculture has long been a major contributor to Pakistan's economy and to sustain rural livelihoods (Buhtoo & Bazmi, 2007).

Punjab is one of the fertile provinces of Pakistan but poverty is prevailing especially in its rural areas. The main reasons for poverty in these areas include the lack of planning as well as implementation of policies. This is because the basic necessities of life like food, shelter, health and entertainment are not provided by the government. People have to rely on their own resources to acquire these things. The spending on these things means there will be no savings and this ultimately results in poverty because the spending is going on the nonproductive way. Layyah is one of the districts of Punjab where land is fertile and the major crops grown by the farmers are wheat, sugarcane, cotton, maize, vegetables and fruits. Due to prevailing poverty in rural areas of Layyah, the majority of the poor depend upon agriculture for earning their livelihood. Politics, economics, and social and cultural norms are the basic factors that affect livelihood. In addition to these factors, one has to determine the day-to-day activities of households. In rural areas of district Layyah, basic daily activity revolves around the farm activities as the poor farmers depend on small scale farming activities such as cultivation of crops, fodder, livestock, sugarcane, maize, cotton, rice, orchard and forests. The political instability and unequal distribution of resources has adverse effect on the income of a rural household. The main sources of political instability in the area are the persons called landlords locally they are known as "Zameen Dar" or "Malik" or "Mulla". These are those people who enjoy the powers within the local community and influence the decision of masses. Due to their own benefits, they influence others for the vote casting and choosing of their representatives. Moreover, ever-changing government creates the disturbance in the policies of the previous one. That's why; this is contributing factor towards political instability for a person who is unable to accommodate in a political elite class. The study area is ignored by this class in terms of basic necessities and infrastructure development.

The present study was conducted in district Layyah, Punjab Pakistan to investigate the sustainability of rural livelihoods among small farmers. We initially carried out this research study in the targeted area to investigate the strategies employed by small farmers to try to increase income, as well as the farm management capacities of small farmers for earning their livelihood. It is our hope that policy makers will use the findings of our study to develop community-centered rural development programs.

METHODOLOGY

Profile of research locale

For the purpose of investigation district Layyah was selected as a population center. District Layyah is located in the south of Punjab with three sub districts i.e. Layyah, Choubara and Karor Lal Esan. Small scale farms and day-labour are the standards for wage earning in the area under study. The area has been selected purposively for the study for the following reasons:

(1) Government of Pakistan declared it the poorest district after 1998 census.
(2) Multiple livelihood activities are being carried out by the local people of the district.
(3) Selected area is rural in nature.
(4) People have had the resources for the livelihood but in scattered form due to low awareness level.

Research design

The study was quantitative in nature to collect data from the respondents of three union councils of Layyah which includes Jaman Shah, Samtia and Choubara. The classifications consisted of small farms, livelihood sources and income of the participants. For the purpose of investigation, we used questionnaires as a tool for data collection. The investigator visited the targeted audience by himself and the data was collected in face to face setting for the purpose of on spot recording of the expressions of respondents for the avoidance of errors. A majority of male and female participants were relying on the small farms for their livelihood and earning.

Sampling technique

Due to the limitation of time and resources, sampling was done by the investigator. After going through different resources which were available with the investigator; the investigator decided a sample of 300 respondents. These respondents were engaged in different levels of small farm activities for their livelihood. While we recognized that including female respondents' views in the study would have been very beneficial but the realities of the local cultural and social norms dictated that we interviewed only the heads of households who were always males. We were unable to interview women to allow for meaningful separation of data according to sex.

A random sampling technique was employed for the selection of 300 respondents from three union councils of district Layyah. A list of all households was taken from the district election office and this voting list of respective union councils served as a sampling frame (Table 1). Accessing all respondents was very difficult for the investigator; the base line survey technique in the present study was used because the researcher had to focus on many small scale farmers. Discussion with service providers was also conducted. For this a total sample of N=35 was drawn and officials selected from veterinary and agricultural departments. Local representatives of banks providing loans to farmers for agriculture and non-governmental organization specialists were included for the purpose of knowing that what they think about the local farmers and their community and also what they think about the services of the organizations from the organizational perspective.

Table 1 Sampling distribution of targeted respondents

Union councils	Total population	Households	Sample
Jaman Shah	23,590	3370	100
Samtia	30,626	4375	100
Choubara	20,845	2978	100
Total	75061	10723	300

Pilot survey

For the present study a questionnaire was developed and tested to insure the workability of the questionnaire and whether it addressed the ground realities or not. Twenty small farmers were selected for the study. After considering the views of respondents and social settings, a few questions were revised to address those issues.

Data analysis

The questionnaire was used as a tool for data collection. Numbers and symbols were given to each item for the categorization of variables used in the study. Data was analyzed through SPSS by applying statistical techniques and procedures.

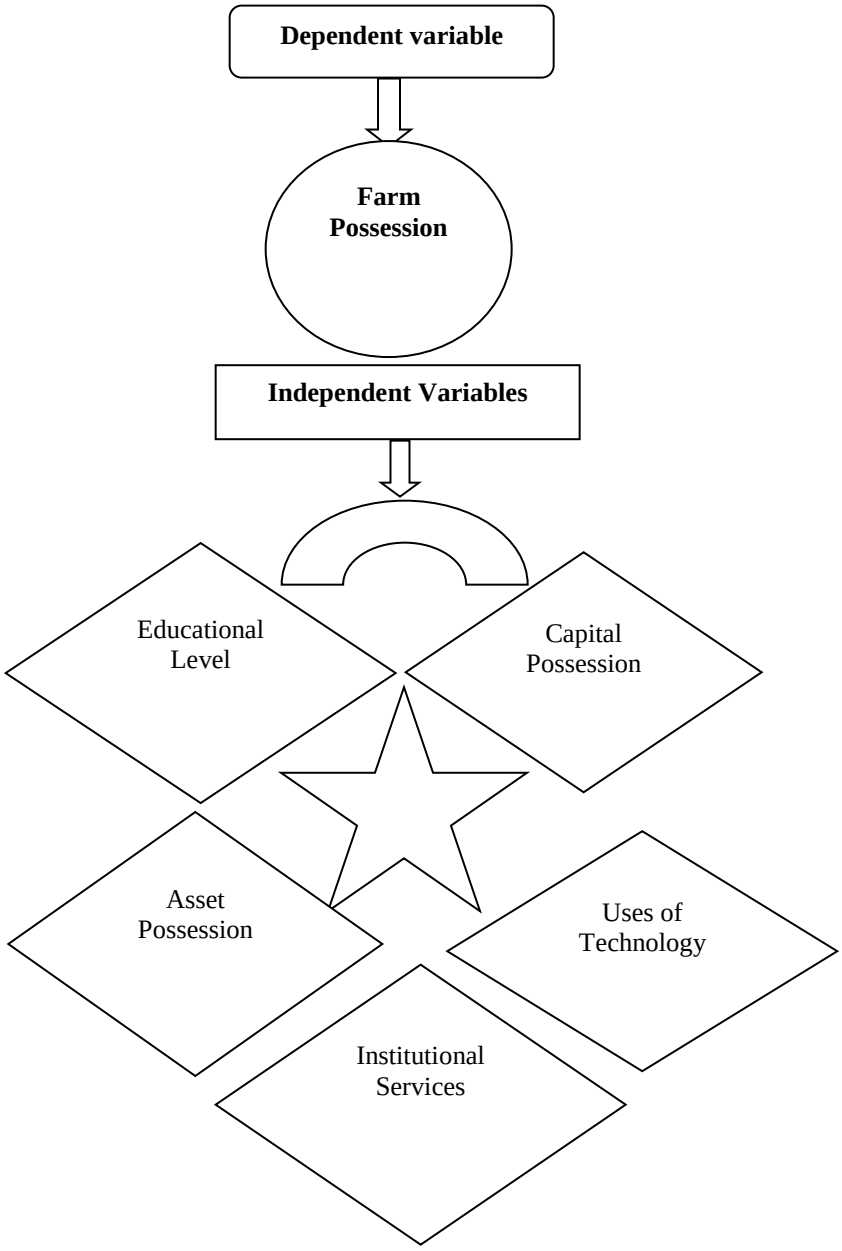

Fig. 1 Conceptual model

In conceptual model the variables used during investigation was listed categorically (Fig. 1). The investigation consisted of one dependent variable and five independent variables. The dependent variable was farm possession. The reason behind the respective dependent variable was to know the farm management capacity of the farmers. To find this the investigator targeted the respondents of the rural areas of district Layyah who had farms. Major independent variables used in this investigation having high impact on farm management were education level of household head, capital possession, asset possession, use of the latest technology and contribution of institutional services. Education level for farming was treated as the independent variable because this is the education which enables a farmer to know how to get the best out of available resources by managing them properly for the livelihood sustainability. Secondly in this study, the capital possession was further categorized into remittances, wages, pension, livestock, and farming and agriculture loans. The third variable used in this investigation was asset possession. Asset possession was

measured in section B of the questionnaire. Asset possession was further measured by categorizing it into natural and physical capital and human and social capital. Natural and physical capital was broken down further into land, tube well, forest and own house. Human and social capital was further categorized into technical and vocational skill, capacity to work, active membership of community organization and labor network for measuring the variable.

Use of the latest technology in section C of questionnaire was measured through questions like steps taken to enhance income, use of the latest technology, and use of developed breeds, money borrowing and migration. Finally, institutional services were included to know the impact of institutional services on the farm management and also to see if they contributed towards livelihood earning. This variable was measured in section D of the questionnaire through services of local agriculture extension officer and services from veterinary doctor and also the contribution of credit facilities.

RESULTS

Selected characteristics of the respondents

Data given in table 2 indicates the selected characteristics of the respondents. During this study, age of the respondents was divided into 4 parts. About 10% of the respondents were 21 to 30 years old. 25% respondents were 31 to 40 years age. A majority of the respondents (35.7%) were 41 to 50 years old. One fifth of the respondents (20%) were aged 51-60 years, while a minimum number of respondents were in the age group of above 60 years. Marital status of the respondents was also studied that shows that more than half of the respondents (about 66%) were married followed by 19% respondents who were widowed.

Table 2 provides information about the literacy level of heads of households. Results show that 54.33 percent of the respondents who were literate could write their names only, while 45.7 percent of the respondents were illiterate. This table also indicates the level of education of literate respondents. There were five categories for this question. Out of these five categories, the first category represented the primary level of education of respondents; results showed that 30.06 percent respondents were represented in this category. The second category was the eighth standard of education and 39.26 percent respondents were represented in this category. The third category was secondary level of education and 20.24 percent respondents were represented in this section, while 6.13 percent and 4.29 percent respondents were in twelve years of education and fourteen years of education categories, respectively. The size of households has also been presented in table 2. Results indicate that a majority (46 percent) had household sizes of 4 to 6 members. The family size of 25 percent of the respondents consisted of 7 to 9 members. The family size of 1.7 percent of the respondents was over 13 members. Results indicate that the main occupation of 55 percent of the respondents was agriculture followed by 25 percent respondents whose main occupation was that of tenant. This may be due to the reason that the study area is rural in nature and most of the people are related to cultivation of crops and growing of animals. Although a number of occupations are available in these areas besides farming such as dairy, animal rearing, carpenters, electricians, handicrafts, daily wage workers, selling and purchasing of crops but these are in minute quantity.

Farm activities of the respondents

Data in table 3 indicates the percentage distribution of respondents regarding their various farm activities. Results indicate that 68.33 percent of respondents had their own land, while 31.66 percent of respondents did not have their own land. The residents of this rural area prefer to have land for earning livelihood by growing crops because this is their only opportunity to earn livelihood. The people who did not own land were working on the land of others as a tenant or on lease. Results indicate that 98 percent of respondents had a farm. The purpose of investigation was to target the population who had farm to perform various farming activities. The respondents who owned land were asked what percentage of their land was actually in use. Then the highest number of respondents (294) told that they were cultivating all of their land for various agricultural operations.

Table 2 Selected characteristics of the respondents

Selected characteristics	Frequency	Percentage
Age		
21-30	30	10.00
31-40	75	25.00
41-50	107	35.66
51-60	60	20.00
60 and above	28	9.33
Marital status		
Unmarried	30	10.00
Married	198	66.00
Widowed	57	19.00
Divorced	15	5.00
Literacy status		
Literate	163	54.33
Illiterate	137	45.66
Education level of literate respondents		
Primary	49	30.06
Eighth standard	64	39.26
Matric	33	20.24
Twelve years of education	10	6.13
Fourteen years of education	7	4.29
Size of households		
1-3	52	17.33
4-6	138	46.00
7-9	75	25.00
10-12	30	10.00
Over 13	5	1.66
Occupation of household head		
Agriculture	165	55.00
Daily wages worker	45	15.00
Tenant	75	25.00
Government job	8	2.66
Private job	7	2.33

Table 3 Distribution of the respondents regarding their farms activities

Selected characteristics	Frequency	Percentage
Respondents having their own land		
Yes	205	68.33
No	95	31.66
Respondents cultivating all the land they owned		
Yes	294	98.00
No	6	2.00
Respondents regarding the duration of farming		
1-5 years	45	15.00
6-10 years	28	9.33
11-15 years	125	41.66
16-20 years	73	24.33
Above 20 years	29	9.66
Respondents' status for performing farm activities		
Performing full time farm activities	281	93.66
Performing part time farm activities	19	6.33
Respondents with respect to availing electricity		
Yes	261	87.00
No	39	13.00
Respondents with respect to availing canal water		
Yes	223	74.33
No	77	25.66
Respondents with respect to the area (cultivated)		
Up to 1 hectare	23	7.66
1.1 – 2.0 hectares	113	37.66
2.1 – 3.0 hectares	77	25.66
3.1 – 4.0 hectares	53	17.66
4.1 – 5.0 hectares	34	11.33
Respondents with respect to area (uncultivated)		
Up to 1 hectare	41	93.18
1.1 – 2.0 hectares	0	0.00
2.1 – 3.0 hectares	3	6.81
3.1 – 4.0 hectares	0	0.00
4.1 – 5.0 hectares	0	0.00

Table 4 Description of the respondents with respect to their possession of household assets

Type of capital	Frequency	Percentage
Natural and physical capital (respondents saying "Yes")		
Land	205	68.33
Tube well for irrigation	233	77.66
Forest	33	11.00
Own home	261	87.00
Natural and physical capital (respondents saying "No")		
Land	95	31.66
Tube well for irrigation	67	22.33
Forest	267	89.00
Own home	39	13.00
Human and social capital (respondents saying "Yes")		
Technical and vocational skills	161	53.66
Capacity to work	293	97.66
Active membership of community organization	195	65.00
Labor network	55	18.33
Human and social capital (respondents saying "No")		
Technical and vocational skills	139	46.33
Capacity to work	7	2.33
Active membership of community organization	105	35.00
Labor network	245	81.66
Financial capital (respondents saying "Yes")		
Remittances	5	1.66
Wages	6	2.00
Pension	3	1.00
Livestock	300	100
Farming	300	100
Agricultural loan	185	61.66
Financial capital (respondents saying "No")		
Remittances	295	98.33
Wages	294	98.00
Pension	297	99.00
Livestock	0	0.00
Farming	0	0.00
Agricultural loan	115	38.33

Table 5 Contribution of on-farm activities in the annual income generation for sustainable rural livelihoods

On-farm activities	Income generation from various assets (Pakistani Rupees)	Total income (Pakistani Rupees)
Crops	7,80,000	
Livestock	43,000	
Farm machinery	15,000	
Tube wells	13,000	12,35,000
Orchard trees	1,50,000	
Selling vegetables	78,000	
Fodder cultivation	27,000	
Poultry	1,29,000	

Data in table 3 also indicates the percentage distribution of respondents with respect to how long have they been farming. It is clear from the table that a majority of the respondents (41.66%) were farming on the current farm for a period of 11-15 years, while 9.66 percent respondents were farming for more than 20 years. Results reveal that 93.66 percent respondents were full time farmers and dedicated to farming activities, while 6.33 percent respondents were part time farmers. They are placed in the category of part time because a few of them were engaged in government or private jobs not directly involved with farming activities. Data in table 3 indicates the percentage distribution of respondents with respect to access to electricity. During this study, it was found that 87% respondents were accessing the public electricity grid for farming activities, while 13% respondents were not using the electricity facility. The reason behind not using the electricity facility was that the farmers had their own arrangement and a few responded that electricity was not available in their village. This table also indicates that 74.33 percent of respondents were using water from the canal system for irrigation, while about one fourth of the respondents (25.7%) were not using this facility because they had their own arrangement for water like tube wells, water pumps and peter engines for irrigation. As far as the cultivated area was concerned, a majority of the respondents (37.66%) were holding 1.1-2 ha land area and performing cultivation activities. About 93.18 percent respondents were holding up to 1 ha land for other purposes. On investigation respondents told the investigator that they built a house which they called *"chopaal"* or *"dera"* for the guests and some respondents told that they built stores for vegetables and crops which were rented to other farmers. Some whose land was beside the road had shops that they rented out.

Household assets of the respondents

Data regarding natural and physical capital has been shown in table 4 that demonstrates that more than two thirds of the respondents (68.33%) had their own land, while 31.66 percent respondents did not have their own land. Therefore, the people who did not own their land were working on the land of others as a tenant or on lease. During this study, it was found that 77.66 percent respondents had a tube well/ motor for irrigating their land, while 22.33 percent respondents did not have this asset. Those respondents who did not have this irrigating facility, borrowed water from a nearby tube-well on an hourly basis or take water from nearby canals through watercourses. When asked about forestry, a vast majority of respondents (89%) replied that they did not grow tree plantations but they grew trees alongside the watercourse in small quantities which they sold out when these trees grew up. A small number of respondents (11%) reported that they grew trees such as *Dalbergia sisso* (Sheesham wood) and eucalyptus locally known as sufaida, and this is a source of livelihood for their households. When asked about home-ownership, about 87 percent respondents told that they had their own homes, while 13% respondents did not own their homes. On investigation, the respondents said that they lived in the rented homes or living in houses on their owner's land in exchange for cultivating it.

Technical and vocational skill, capacity to work, active membership of community organization and labor network were categorized as part of the study. Results indicated that 53.66 percent respondents possessed sufficient technical and vocational skills to tackle the issues of keeping machinery working in the farm i.e. tube-well, tractor and electric equipment etc., while 46.33 percent of respondents did not have capacity to make repairs and maintain equipment. They were dependent on the skilled worker and laborers to do this work for them. On the question of capacity to work, 97.66 percent respondents had capacity to work, while 2.33 percent respondents did not have capacity to work because of their disability but their son or daily wage workers locally called as *"Dihari daar"* worked on the farm. As far as active membership of community organization is concerned, about two thirds (65%) respondents had active membership of community development through non-government organization (NGO's), while 35% respondents were not a member of any community organization. About 18.33% respondents had their labor network for working on different farms on a daily wage basis, while 81.66 percent respondents worked on their farm by themselves.

Data in table 4 also indicates the percentage distribution of respondents regarding their information on financial capital. On providing the information on financial capital, 1.66 percent respondents said that they earned through remittances, while 98.33 percent respondents had nobody outside the country and were unable to get the remittances. Only 2 percent respondents earned wages because they worked in any government or private office, while 98 percent respondents did not earn any non-agricultural wages. A small number of respondents (1%) was earning through pension, while 99 percent respondents did not earn

through pension. Agricultural loans were also found to be a source of income for the majority (61.66%) of respondents, while 38.33 percent of respondents reported that they did not access this funding source and instead arranged loans by private means i.e. from a local trader locally known as *"Aarhti"* or from friends or from relatives. They preferred this less formal method to meet their day-to-day expenses of farming.

Sustainable rural livelihoods from on-farm activities

Table 5 indicates the estimated contribution of different on-farm activities to the annual income generation for sustainable rural livelihoods. Results indicate that the farmers of this area were earning a total average of 12,35,000 Pakistani rupees through different farm activities (Table 5). It was evaluated that different crops (wheat, sugarcane, maize and cotton) were contributing about Rs. 7, 80,000 in income generating activities. Livestock was contributing about Rs. 43,000. Few farmers were rearing animals for domestic-purposes but the most of the farmers were using them to increase income. Farm machinery was contributing Rs. 15,000. Orchard trees including orange, mango, lemon and date palm were contributing about Rs. 1,50,000 in total earnings. Vegetables were contributing about Rs. 78,000 in the annual earning. Different vegetables were grown by the farmers for sale in the market. Farmers grew fodder for their own use as well as for sale (Table 5). Poultry was also a fruitful business for the local farmers in district Layyah. Although poultry was being raised on a small scale basis, it was contributing about Rs. 1,29,000 in the total farmer's annual income.

Raising of crops and rearing of livestock animals

During this study it was noticed that 100 percent respondents were raising crops. As the targeted respondents were farmers involved in the farming activities, the analysis of data showed that among 300 respondents, 245 were raising wheat. Further analysis showed that out of these respondents who were raising wheat; a majority of respondents (54.3%) were growing this crop on 1.1-2 ha of land. Secondly, out of 300 respondents only 139 were engaged in growing of cotton. This was determined to be due to local variations in soil fertility and difficulties associated with cultivating hard soils. More than half of the respondents (56.83%) were growing cotton on 1.1-2 ha area. Fruit orchards were grown in two union councils namely Samtia and Jaman Shah but due to lack of soil hardness in Choubara, fruit orchards could not be grown. Therefore, only 59 respondents out of 300 respondents carried out this activity. Among respondents who were growing fruit orchards; 89.83 percent were growing them on 1.1-2 ha land, while 10.16 percent respondents engaged in growing orchards on 2.1-3 ha land. Vegetables were grown by all the respondents. Among these respondents, a majority of respondents (65%) were performing this activity on up to 1 ha land area, 35 percent farmers were carried on this activity on 2.1-3 ha land area. Sugarcane is an essential crop for the farmers to grow because income from the sugarcane is very common in the area, while in Choubara, this crop cannot be cultivated due to lack of soil hardness and the remedy is to grow "Beet" in these areas. Therefore, out of 300 targeted respondents, only 161 respondents were carrying out this activity. So, 59.62 percent respondents were growing sugarcane on 2.1-3 ha land area followed by 28.57 percent respondents who were growing sugarcane on 1.1-2 ha land area. The crop gram (chick pea) was only grown by 100 respondents out of 300 respondents because this crop requires specific area and soil to grow. This crop can be cultivated on the land where land is desert in nature. About 56 percent respondents were growing gram on 3.1-4 ha land area followed by 35 percent respondents who were growing gram on 2.1-3 ha land area (Table 6).

Data about rearing of livestock animals has been presented in table 6 which reveals that 100 percent respondents were rearing animals. Farmers had animals for income generation but few of them were rearing the animals for domestic purposes. Farmers told the investigator that rearing of animals was an essential activity in rural areas. Presented data in table 6 indicates the percentage distribution of respondents regarding rearing of livestock animals, and the type of animals they had. Results indicate that 113 respondents kept buffaloes. Out of 170 respondents, 90.58 percent respondents had local breeds, while 9.41 percent respondents had improved breeds. Further investigation clarified that improved breeds of cows required special environment and cost. Small farmers were unable to afford the added expense for improved breeds. Regarding goats and sheep, it was found that all 300 respondents kept these animals. Results also showed that 100 percent respondents had local breeds of camels (Table 6). In response to the question regarding donkeys, 130 respondents said that they had donkeys and the analysis showed that 17.69 percent

respondents had local breeds, while 82.3 percent had an improved breed of donkey that is locally known as *"Khachar"* (a cross breed of donkey and horse). Further investigation showed that donkeys were used by the respondents for domestic work as well as for earning purpose providing services for the locally transportation of goods.

Enhancement of income for sustainable livelihoods of the respondents

Table 7 denotes the percentage distribution of respondents regarding steps taken to enhance their income for sustainable livelihoods. Results indicate that 100 percent of respondents told the investigator that they were taking steps to enhance their income at all levels. During this study, it was found that 80.33 percent of respondents relied on the use of the latest technology for agriculture and livestock, while 19.66 percent of respondents told that they did not use the latest technology but relied on old methods and explained the reason that they could not afford the price of developed technology. Results indicate that 94.33 percent respondents were shifting themselves from the use of conventional breeds to the latest developed breeds, while 5.66 percent respondents were not using developed breeds due to having a small number of livestock animals and they had the livestock on part time basis for domestic purposes only. Data regarding percentage distribution of respondents about the use of a bull for breeding of cattle has been shown in table 6 that shows that a majority of the respondents (45%) used any available bull for breeding the cattle followed by the respondents (30%) that used a bull from neighbours for breeding of cattle. Only 10 percent of respondents used artificial insemination for breeding of cattle. This was because of non-familiarity with the advantages of artificial insemination.

Data regarding borrowing of money for farm activity has also been presented in table 7 that indicates that 100 percent of respondents borrowed money for their farm activities. As far as the source for borrowing money is concerned, about 63.33% respondents were borrowing money for their farm activity from a wholesale dealer followed by the respondents (18.33%) who were borrowing money from agriculture banks as agriculture development loans. Data about percentage distribution of respondents regarding access to local agriculture officers for extension services indicates that 29.66 percent respondents had access to a local agriculture officer for extension services, while 70.33 percent respondents had no access to local agriculture officers. As far as using the credit facilities was concerned, 100 percent of respondents were aware of the credit facilities available in the area but only 18.33% of the respondents were using them. Data in table 7 indicates the percentage distribution of respondents regarding skills training. Results indicate that 74.33 percent respondents got trainings to improve their skills, while 25.66 percent respondents did not take any training. Respondents also said that non-governmental organizations have more opportunities regarding trainings than that of governmental institutions. The respondents who did not make use of trainings indicated that due to their day to day activities they were not able to attend any training. They also revealed that the duration of trainings was very long, and daily compensation rate was very low as compared to what they earned while working in the field.

Table 6 Description of the respondents with respect to raising of crops and rearing of livestock animals

Activities	Status of crops and livestock					
Raising of crops	Land occupied (hectare)					
	Up to 1	1.1 – 2.0	2.1 – 3.0	3.1 – 4.0	4.1 – 5.0	Total
Wheat	23 (9.4%)	133 (54.3%)	43 (17.6%)	31 (12.7%)	15 (6%)	245 (100%)
Cotton	34 (24.5%)	79 (56.83%)	26 (18.7%)	-	-	139 (100%)
Fruit orchard	-	53 (89.83%)	6 (10.16%)	-	-	59 (100%)
Vegetables	195 (65%)	105 (35%)	-	-	-	300 (100%)
Sugarcane	-	46 (28.57%)	96(59.62%)	8 (4.96%)	11 (6.83%)	161 (100%)
Gram	-	-	35 (35%)	56 (56%)	9 (9%)	100 (100%)
Rearing of animals	Local breed		Improved breed		Total	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Buffalo	113	100	-	-	113	100
Cow	154	90.58	16	9.41	170	100
Goats and sheep					300	100
Camel	11	100	-	-	11	100
Donkey	23	17.69	107	82.3	130	100

Table 7 Description of the respondents regarding the steps taken to enhance their income for sustainable livelihoods

Characteristics	Frequency	Percentage
Steps taken to enhance their income		
Yes	300	100
Use of latest technology for crops and livestock		
Yes	241	80.33
No	59	19.66
Conventional to latest developed breeds		
Yes	283	94.33
No	17	5.66
Bull used for breeding of cattle		
Own	45	15
From neighbours	90	30
Any available	135	45
Artificial insemination	30	10
Source of borrowing money for farm activity		
Agriculture banks	55	18.33
NGO's	38	12.66
Family and friends	17	5.66
Credit form wholesale dealer	190	63.33
Access to local agriculture officer for extension services		
Yes	89	29.66
No	211	70.33
Availing credit facility		
Yes	55	18.33
No	245	81.66
Getting trainings to enhance the skills		
Yes	223	74.33
No	77	25.66

DISCUSSION

Poverty reduction, rural development and sustainable rural livelihood are interlinked with each other and have remained as major aims of various democratic and military governments in Pakistan. The rural household units in Pakistan have been related to farming as a major occupation to sustain the rural livelihoods for a long period of time (Buhtoo & Bazmi, 2007). The present study was conducted to understand how the farm management practices of small farmers contribute to their sustainable livelihoods. It also describes the focus on the components and identification of livelihood sources by the small farmers with effective ways to improve these sources in district Layyah. Similar to our findings, Chaudhry (2009) examined the factors influencing rural poverty using Asian Development Bank data as essential source information about southern Punjab, Pakistan. Findings of the study demonstrated that rural poverty could be lessened by limiting the family unit size, reliance proportion, enhancing training, more female work power cooperation, high family support rate and enhancing resources. The study recommended that administration should give careful consideration for fundamental framework and market access facilities along with other socio-economic and demographic elements to alleviate rural poverty in remote regions of Pakistan. Jamali et al. (2011) investigated livelihoods in rural Sindh and described that the public sector organization had a significant contributing role through different interventions for the alleviation of poverty but the basic necessities like food and shelter were ignored and dealt as a corner stone having negatively affected on needy and poor people. Mobilizing people socially was one of the important factors that was carried out by the Sindh agricultural and forestry workers with different interventions of development. The most important aspect of this NGO was that they addressed and reached the people at ground level i.e. poor who were targeted but lack of budget and other technical aspects provoked the problems. Hence, the new technologies must have to be introduced by the NGOs for the improvement of crop production and avoidance of the fund provided by the government. This leaded to the arrangement of funds from the individuals who were rich.

Our findings coincided with the earlier proposition by Bahadur (2009) who investigated a relationship between socio-economic and spatial methodology for assessing rural production resources and the strategies of development in Asia's mountain region. An approach of farming system was used to know the livelihood and practices on farm in rural regions. A household survey was used for the collection of data on socio-economic conditions by selecting household farm randomly. This study explained that expansion in agriculture was unavoidable for the development at high level. For obtaining the development at all levels, 36 percent, 18 percent and 6 percent forests were converted into agricultural activities. Livestock and maize production was dominated in the villages where there was no arrangement of irrigation. Inorganic farming was common in villages which were below the hills. Difference in farming practices was due to the quality of land, availability of resources and environmental interventions. Nesamvuni et al. (2010) argued that the poor of rural areas always strived to enhance their livelihood and also faced difficulty towards food security. The major contribution towards livelihood earning in the rural areas was livestock for domestic needs and livelihood activities. In rural areas, gender was also the matter of concern as the women always exploited and underestimated in terms of contribution towards household income. For the development of rural areas, there was a need towards the institutional development regarding the women contribution acknowledgement and empowerment.

At policy and design level, consideration needs to be taken to identify critical components in a systems context to ensure sustainability of future projects. Funding of research projects is planned for shorter time periods than funding for long-term development projects. Such challenges were explored in relation to policy development that looks into creating a balance between livestock production and the consequence of its negative impact on the environment. The measurements of the negative impacts of livestock were confounded by the lack of cross-country indicators that were comparable across a range of socio-economic situations. Studies to establish appropriate livestock production systems should be a priority in developing countries to mitigate the negative impacts of greenhouse gases on the environment. Overall, the impact of livestock on human health and nutrition has been ignored, yet it offers opportunities for adding value to livestock interventions. Similarly, Rehman et al. (2008) explained that 15.8 percent households which were poor relied on the source of income other than agriculture. This group of researchers reported this after carrying the study on livelihood strategies and the factors affecting livelihood strategies in district Abbottabad, NWFP, Pakistan. The secondary income included the dependency on private and governmental services and other sources like remittances etc. Hence the improvement in the livelihood was only possible to

diversify the off-farm activities rather on-farm. Credit on easy term played a vital role to overcome the poverty in the study area.

CONCLUSION

The present study concluded that the farmers while employing various strategies for their livelihood neglected the new and developed techniques for farming and used only inherited techniques. It was further concluded that inputs (cost) by the farmers were high in terms of their social capital, financial capital and human capital. But because of the low awareness level, livelihood improvement and management were not in accordance with the resources employed. In case of farm management capacity of small farmer for the sustainability of livelihood, low education level and non-availability of resources for acquiring the capacity should be enhanced for the maximization of output and to sustain livelihood for the family.

RECOMMENDATIONS

1. As the land area of the district Layyah, Punjab Pakistan has fertile soil and broad range of land utilization for the productivity and earning of livelihood. Therefore, it has a scope for the farmers to maximize their production by different awareness programs and to enhance their skills towards utilization of the improved machinery and methods of cultivation and rearing.
2. Dairy farm development is one of the factors that can contribute significantly for the enhancement of income. This could be done with the help of local support organizations and the government institutions to link the farmers with the retailers of the area and secondly facilitate farmers by providing the improved breed of livestock that would assist the farmers in increasing production and household income.
3. Farmer income is dependent on the factors available for the production. It implies that more the human potential development, the more it will lead to increase the production for sustainable livelihood. Therefore, education and trainings should be provided in the respective fields with a special focus to build the production capacity of farmers by adopting the latest technology.

Author Contribution Statement Faria Ibad Mirza generated the idea and supervised the research. Rizwan Abbas conducted the research and wrote the manuscript. Anila Afzal analyzed the data and edited the manuscript.

Conflict of Interest The authors declare that they have no conflict of interest.

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ORIGINAL PAPER

Working efficiency of extension field staff with regards to integrated pest management of cotton in district D. G. Khan, Punjab, Pakistan

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Key Message This study evaluates the working efficiency of extension field staff with special reference to integrated pest management (IPM) of cotton in agricultural development of country and D. G. Khan region especially.

ABSTRACT In the agriculture sector, the success of any program and project depends upon the working efficiency of extension field staff (EFS). EFS are key stake holders and play crucial roles in the extension services, particularly in agriculture and rural development. Therefore, the present study was conducted to evaluate the working efficiency of extension field staff with special reference to IPM of cotton growers in district D. G. Khan. The results reveal that most of the respondents (44.2%) were under 35 years of age and about 80.80% of them were educated. A majority of the respondents (85%) had small land holding up to 12.5 acres. Less than half of the respondents (42.5%) reported that EFS provided extension services fortnightly. More than half of the respondents (56.7%) reported that EFS provided excellent information regarding resistant varieties. About 69.2 to 84.2% of the respondents reported that microorganisms, beneficial insects, buying and releasing beneficial insect and protecting beneficial insects were poorly addressed. Insecticidal soap and horticultural oil were the activities that performed poorly by the EFS as reported by a vast majority (90%) of the respondents. More than half of the respondents (56.7%) were of the view that the time involved was a big problem in applying IPM. The entire respondents (99.2 -100%) were of the view that IPM had positive impact on their crops. So the concerted efforts such as launching of IPM program for cotton crop in other districts of Punjab, Pakistan should be made with the aim of adopting cultural and biological control rather than chemical control.

Keywords: Agriculture extension, Cotton growers, Extension field staff, Extension services, Integrated pest management

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INTRODUCTION

In Pakistan, agricultural extension acts as a catalyst in agriculture and rural development because it brings innovations to the farming community for the improvement of its living standards. It provides a channel through which the farmers can solve their problems of research as well as revision of agricultural policies for the maximization of profits of rural areas (FAO, 2002a). It is the prime responsibility of the Agricultural Extension Department to transfer the latest agriculture technology and technical assistance to the farming community for improving agricultural production. In a previous research study, Urooba (2001) reported that inefficiency of extension services was the major cause of failure of self-sufficiency in agricultural products. Generally, government bodies have been trying their best to fill the yield gap of various crops launching a number of agricultural extension programmes in Pakistan (FAO, 2002b). This situation demonstrates clearly that production of various crops depends upon education, research and extension of agricultural innovations and technologies (National Rural Support Programme [NRSP], 1999). Today, agriculture in Pakistan is totally

different from that of the past owing to the shift from conventional to modern technology. The rate and direction of agriculture development is determined by the farmers' capacities to adapt the changing technologies. At national level, unsuitable extension policies, inadequate community development funds, dearth of accountability and high rural poverty are the major causes that have provoked the developing world to re-constitute the relevant policies of agricultural extension for rural development (Shah, 1998).

In Pakistan, the contributions of major crops like sugarcane, rice, cotton and wheat to GDP are 1, 1.3, 2 and 3.4%, while their share in agriculture value addition are 4.2, 5.4, 8.2 and 13.8%, respectively. But the yield of these crops is lower as compared to other countries because a huge gap has been produced between the actual and potential yield of the major crops. Until 2000, IPM was not established in Pakistan. The misuse of pesticides and their negative effects on the society has become a key element of agriculture development policy for sustainable development of the country (Guinee, 2002). According to a report by Central Cotton Research Institute [CCRI], (2012), cotton has become a major cash crop that contributes about 62% of the total foreign exchange earned by the major field crops in Pakistan. It provides the labour force for its cultivation and employment to 40% of industrial labour in textile industries. Moreover, cotton seed oil accounts for 60% of total edible oil usage. Agricultural productivity depends upon the availability of improved technology and its active dissemination. But high dissatisfaction has been found among the farming communities regarding the efficiency of the present extension system (Malik & Prawl, 1993). Dearth of qualified staff, outdated syllabi for agricultural subjects, deficiency of trainings, no use of audio visual aids, lack of timely information about the latest technologies are the major problems of extension services. Therefore, the impact of these factors should be appraised to improve the capability of extension field staff so that the sustainable agricultural production may be improved.

In spite of much emphasis laid on agricultural extension services in the dissemination of improved agricultural practices, the farmers are still in search of satisfaction regarding the performance of extension field staff. The farmers demand that EFS should work like a bridge between the research stations and farmers. EFS provide the latest technologies to the farmers to improve their crop production. Small farmers also expect equal services and opportunities, so EFS should provide them equal services irrespective of the client's social status and landholdings because in our country, a majority of farmers have small land holding capacity. Working efficiency is the accomplishment of a job with a minimum expenditure of time and effort. In this project the working efficiency of EFS was checked at first stage whether the farmers were aware about IPM practices in the study area and then the adoption level of those IPM practices was explored among the farmers. Hence, this study was planned first time to explore the working efficiency of extension field staff (EFS) in relation to IPM of cotton crop in district D. G. Khan, Punjab, Pakistan and then to assess the impact of adoption of IPM recommendations in cotton crop. Adoption rate of IPM practices is directly related to the working efficiency of EFS. The formula of efficiency = output/input so, adoption rate is the output of our efforts and it directly relates with the efficiency. The study was also intended to evaluate the effectiveness of extension method applied to promote the IPM of cotton crop and to measure the satisfaction level of the farmers about the trainings of IPM for cotton under FFS strategy. Basically, all these objectives including effectiveness of extension methods applied to promote IPM and the satisfaction of farmers with the extension strategies were considered to analyze the working efficiency of EFS. It is hoped that the findings of the study will be helpful for probing into the level of expectations and satisfaction of farming community towards the working efficiency of EFS with reference to IPM of cotton growers.

METHODOLOGY

The study was conducted in sub district D. G. Khan. The district D. G. Khan comprises of three sub districts; D. G. Khan, Taunsa and Tribal Area. Sub district Tribal Area and Taunsa are not cotton cropped areas so these have not been included in the study. Sub district D. G. Khan was selected purposefully for the present study.

Sampling procedure

The study area comprises of more than 0.5 million farmers so it was difficult to collect data from all of these farmers. Therefore, random sampling was adopted to collect the data from the field. In this study, a simple random sampling technique was used. Out of total 41 union councils of sub district D. G. Khan, 6 union councils were randomly selected for the present study. Two villages from each nominated union council were selected using random sampling technique. From each village, 10 cotton growers working with IPM of cotton with the collaboration of EFS were then selected randomly hereby making a total 120 cotton growers as a sample for the study.

Study tool

Structured interview schedule was constructed keeping in view the objectives of the research and with the consultation of supervisor. The questionnaire was developed in English language but was asked from the respondents in their local languages like Saraiki and Urdu. Interview schedule consisted of open and close ended questions which were asked directly from the respondents to collect the accurate and relevant data. Random sampling was done on lottery system at every stage of random sampling technique. A list of farmers using IPM technique was generated and respondent's selection was done on lottery system that is each respondent may gain an equal chance of selection.

Pre-testing

During this study, a pre-testing was done on ten respondents to check the accuracy and efficiency of the interviewing plan. Subsequently, some essential modifications were made to make the plan more appropriate, efficient, understandable and reliable. The data was collected from those farmers who were participating in an IPM cotton programme in the study area. The data was collected from FFS, IPM cotton yield enhancement project sub district D. G. Khan.

Data analysis

After the collection of the data, results of the study were analyzed through Statistical Package for Social Sciences (SPSS) in which frequency distributions, tabulations, and graphs were made.

RESULTS

Socio-economic features of the respondents

During this study, the socio-economic features of the respondents including age, education level, size of land holding (acres), land ownership, cropping area of cotton (acres), cropping area of wheat (acres) and cropping area of fodder (acres) related to IPM were studied. Patterns of change in human behavior relate to age and younger farmers tend to be more open to agricultural innovations than that of their elders (Butt et al., 2011). The respondents were asked about their age and their perceptions were tabulated in table 1. The data in table 1 reveals that most of the respondents (44.2%) were young (under 35 years), while 41.7% of the respondents were between 36-50 years (middle aged). Only 14.2% of the respondents were over 50. Education relates to the formal years of schooling and it enhances the learning ability, knowledge and wisdom of the farmers (Mirza, 1994; Okunade, 2007). The education process develops knowledge and other desirable qualities by means of formal schooling years. In this study, respondents were asked about their educational status and their responses have been depicted in table 1. The results show that most of the people living in the research area were educated (80.8%), only 19.2% respondents were uneducated. Amongst educated respondents, more than half (57.5%) had primary to secondary education followed by primary (15%). During this study, it was noticed that in rural areas, most of the families were sending their children to schools and thus the education growth rate was increasing at a high speed. Size of land holding relates to the land area cultivated by a farmer and it affects the adoption behavior of the farmer for the latest techniques of cultivation (Nawaz, 1989; McCown, 2002). Keeping in view the importance of size of land holding, respondents were asked about the size of their land and their responses were recorded in table 1. A majority (85%) of the respondents had

small land holding (up to 12.5 acres), while 11.7% of the respondents had medium land holding (>12.6 to 25 acres) and 3.3% of the respondents had large land holding (more than 25 acres) (Table 1). Land ownership refers to the mode of cultivating land (Idrees, 2003). In this study, three types of land ownership namely owner, owner-cum tenant and tenant were considered. Owners were those types of farmers who cultivated their own land. Owner-cum tenants were those types of farmers who farmed their own land and rented others' land. The tenants were those types of farmers who cultivated others' land on rent. The data about type of tenure have been presented in table 1 that shows that a majority of the respondents (80.8%) had their own land, while only 17.5% of the respondents were tenants and only 1.7% of the respondents were appeared as owner-cum-tenant. The data in table 1 also shows that an overwhelming majority of the respondents (90.8%) had small land holding (up to 12.5 acre) and cultivated cotton and wheat crops. Large numbers of respondents (70%) grew fodders and they also had small land holding. The respondents had mainly two seasonal crops. It also shows that D. G. Khan area is diverse in agriculture.

Source of information regarding IPM

A new agricultural technology can be adopted by the efficient sources of information (Rogers, 1962). In this study, farmers were asked about the sources of information regarding IPM and the data about their sources were displayed in table 2. An overwhelming majority (80-100%) of the respondents reported that they got information about IPM from extension field staff, local people, radio and newspaper respectively. More than half (60%) of the respondents had learned about IPM via television and only 21.7% of respondents got information about IPM from internet.

Frequency of visits by Extension Field Staff

The extension field staff plays a significant role in rural development. Acquaintance of farmers with EFS is two dimensional i.e. it provides interest to the farmers for extension activities on one side and interest to EFS in educational programs for the farmers on other side. The respondents were therefore, asked whether they knew EFS of their area or not. The respondents were asked about the frequency of extension visits and their responses are depicted in table 3. Less than half of the respondents (42.5%) reported that EFS provided extension services fortnightly. About one-fourth of the respondents (29.2%) were of the view that EFS provided extension services on a weekly basis, while 26.7% of the respondents replied monthly, only a small fraction of the respondents (0.84%) replied that they got extension services once a year.

Cultural operations regarding IPM related activities provided by EFS

Various agricultural practices including crop rotation, cultivation of alternate host, trap crops and selection of planting sites to make the environment less suitable for insect pests. The crop rotation minimizes the incidence and severity of various plant diseases, and suitable planting site affects the severity of insect attack. Keeping in view the importance of cultural operations, the respondents were asked about their perceptions about the cultural operations with respect to IPM of cotton and their responses are represented in table 4. The table shows that the information was excellent for more than half of the respondents (56.7%) regarding resistant varieties, while it was excellent for 58.3% of the respondents for planting the right plants at the right place. Furthermore, the information relating to rotating annual plants and intercropping was poor as reported by 44.8 and 50.8% of the respondents, respectively (Table 4).

Physical operations regarding IPM related activities provided by EFS

The physical barriers including row covers and trenches limit the entry of insects into the crop. Row covers can prevent the cucumber beetles to save the damage of cucurbits, while plastic lined trenches are used to disperse the Colorado potato beetles. Likewise, cold storage is also considered as a physical control that stops the development of insects on the stored grains. Therefore, the respondents were asked about the physical operations regarding IPM related activities provided by EFS and their responses are displayed in table 5 which reflects that 55.8-97% of the respondents preserved information regarding pruning, mulching, handpicking, trapping and light trap as poor category, while 22.5% of the respondents had information about pruning, trapping, hand picking and mulching that fell in the category "fair".

Biological operations regarding IPM related activities provided by EFS

A biological control or bio-control agent of insect, disease, and weed pests is an important practice of IPM. Owing to the importance of biological control, the respondents were asked about this and their responses are presented in table 6. About 69.2 to 84.2% of the respondents reported that microorganisms, beneficial insects, buying and releasing beneficial insect and protecting beneficial insects were poorly addressed, while very few respondents rated all the activities as fair, satisfactory, good and excellent (Table 6).

Chemical operations regarding IPM related activities provided by EFS

The chemical control of insect pests creates health issues, kills non-target species, and creates problems of leaching and accumulation of residues on food crops. The chemical controls can only be used if other methods are not adequate to control insect pests, and they must be labeled for a specific intended use. The results in table 7 showed that EPS did not provide information about efficient and effective use of chemicals to the farmers; therefore a majority of the respondents (90%) were poorly using insecticidal soap and horticultural oils on crops". Similarly, 62.5% respondents were poorly using synthetic insecticides, fungicides and molluscicides.

Application of various IPM techniques in the field

Respondents were asked about to assess cultural activities and their responses are given in table 8. Resistant varieties were frequently used by most of the respondents (42.5%) as cultural activities of IPM regarding cotton. It was found that planting of right plant at right place and other activities were frequently adopted by the respondents (45.8%). However, about one-third of the respondents were often rotating annual plants and intercropping as cultural activities (Table 8). Respondents were investigated to assess the rating of physical activities related to IPM of cotton. It is clear from the table 9 that all the physical activities related to IPM of cotton were mostly applied as reported by 46.7, 54.2 and 65.8% of the respondents. However, most of the farmer often applied the recommended physical activities (Table 9). Respondents were asked about the application of IPM of biological activity and their responses given in table 10 that indicate that protecting beneficial insects, releasing of beneficial insect, buying and releasing of beneficial insects, microorganisms and parasitic nematodes were rarely applied by 59.2, 54.2, 52.5, 52.5, and 50% of the respondents, respectively. Respondents were asked to assess the effects of chemical activity they applied relating to IPM, and their responses are displayed in table 11. The data reflects that more than half of the respondents (54.2 and 55.0%) rarely applied horticultural oil and insecticidal soap as an IPM measure to their crop. Further, botanical insecticides, and inorganic fungicides and insecticides were often applied as reported by about one-third (37.5%) of the respondents. Very few (0.7-10.8%) respondents adopted the entire chemical regimen on occasional to frequent basis (Table 11).

Reasons for non-adoption of IPM measures

Respondents' responses regarding the non-adoption of IPM measures are presented in table 12. About one-fifth of the respondents (21.7-23.3%) were of the view that lack of equipment and skills were the reasons of non-adoption of IPM measures for some times, while about 20% frequently reported lack of finances as the non-adoption reason. However about one-third (29.2%) recorded others reasons for non- adoption (Table 12).

Table 1 Socio-economic characteristics of the respondents

Socio-economic characteristics	Frequency	Percentage
Age (years)		
Up to 34	53	44.2
35-50	50	41.7
More than 50	17	14.2
Education level (years of schooling)		
Uneducated	23	19.2
Primary	18	15
Primary to Secondary	69	57.5
F.A./F.Sc.	6	5
B.A./B.Sc.	3	2.5
M.A./M.Sc.	1	0.83
Size of land holding (acres)		
Small (Up to 12.5)	102	85
Medium (> 12.5 to 25)	14	11.7
Large (> 25)	4	3.3
Land ownership		
Owner	97	80.8
Owner-cum tenant	2	1.7
Tenant	21	17.5
Cropping area of cotton (acres)		
Small (Up to 12.5)	109	90.8
Medium (> 12.5 to 25)	10	8.3
Large (> 25)	1	0.8
Cropping area of wheat (acres)		
Small (Up to 12.5)	109	90.8
Medium (> 12.5 to 25)	10	8.3
Large (> 25)	1	0.8
Cropping area of fodder (acres)		
Small (Up to 12.5)	84	70
Medium (> 12.5 to 25)	1	0.8
Large (> 25)	-	-

Table 2 Source of information regarding IPM

Information source	Respondents saying "Yes"		Respondents saying "No"	
	Frequency	Percentage	Frequency	Percentage
Extension field staff	120	100	0	0.0
Newspaper	97	80.8	23	20
Local people	120	100	0	0.0
Radio	116	96.7	4	2.3
TV	72	60	48	40
Internet	26	21.7	94	78.3

❖ Respondents gave multiple response because of various sources of information

Table 3 Description of extension visits of the respondents

Provision of Extension Services	Frequency	Percentage
Weekly	35	29.2
Fortnightly	51	42.5
Monthly	32	26.7
Yearly	01	0.8

Table 4 Rating of various cultural operations regarding IPM related activities provided by EFS as perceived by the respondents

Cultural Activity	Poor		Fair		Satisfactory		Good		Excellent		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Resistant varieties	-	-	02	1.7	21	17.5	29	24.2	68	56.7	120	100
Rotating annual plants	-	-	53	44.2	19	15.8	19	15.8	01	0.8	120	100
Intercropping	28	23	61	50.8	19	15.8	12	10	0	0	120	100
Planting right plant at right place	09	7.5	20	16.7	11	9.2	10	8.3	70	58.3	120	100

Table 5 Rating of information regarding IPM physical operations related activities provided by EFS

Physical activity	Poor		Fair		Satisfactory		Good		Excellent		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Hand picking	77	64.2	26	21.7	12	10	03	2.5	02	1.7	120	100
Pruning	67	55.8	19	15.8	29	24.7	05	4.2	0	0	120	100
Mulching	66	55	27	22.5	10	8.3	17	14.2	0	0	120	100
Trapping	89	74.2	24	20	07	5.8	0	0	0	0	120	100
Light traps	116	97	02	1.7	02	1.7	0	0	0	0	120	100

Table 6 Rating of information regarding IPM biological activities provided by EFS

Biological Activity	Poor		Fair		Satisfactory		Good		Excellent		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Beneficial insects	92	76.7	17	14.2	07	5.8	03	2.5	01	0.8	120	100
Protecting beneficial insects	101	84.2	12	10	05	4.2	01	0.8	01	0.8	120	100
Buying and releasing beneficial insects	96	80	11	9.2	09	7.5	03	2.5	01	0.8	120	100
Microorganisms	83	69.2	21	17.5	13	10.8	03	2.5	0	0	100	120
Parasitic nematodes	91	75.8	20	16.7	07	5.8	02	1.7	0	0	120	100

Table 7 Rating of chemical activity relating to IPM of cotton as perceived by the respondents

Chemical operations	Poor		Fair		Satisfactory		Good		Excellent		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Insecticidal soap	109	90.8	09	7.5	02	1.7	-	-	-	-	120	100
Horticultural oils	108	90	08	6.7	04	3.3	-	-	-	-	120	100
Botanical insecticides	25	20.8	66	55	16	13.3	10	8.3	03	2.5	120	100
Inorganic fungicides and insecticides	22	18.3	66	55	16	13.3	12	10	04	3.3	120	100
Synthetic insecticides, fungicides and molluscicides	75	62.5	17	14.2	09	7.5	11	9.2	08	6.7	120	100

Table 8 Rating of cultural activities as adopted by the respondents

Cultural activity	Rarely		Often		Occasionally		Sometime		Frequently		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Resistant varieties	0	0	0	0	11	9.2	18	15	51	42.5	80	66.7
Rotating annual plants	20	16.7	42	35	13	10.8	04	3.3	01	0.8	80	66.7
Intercropping	22	18.3	43	35.8	13	10.8	02	1.7	0	0	80	66.7
Planting the right plant in the right place	12	10	03	2.5	04	3.3	06	05	55	45.8	80	66.7

Table 9 Rating of various physical activities applied by the respondents

Physical activity	Frequently		Often		Occasionally		Sometime		Rarely		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Hand picking	56	46.7	16	13.3	08	6.7	0	0	0	0	80	66.7
Pruning	48	40	13	10.8	14	11.7	05	4.2	0	0	80	66.7
Mulching	45	37.5	18	15	06	05	11	9.2	0	0	80	66.7
Trapping	65	54.2	12	10	03	2.5	0	0	0	0	80	66.7
Light traps	79	65.8	0	0	01	0.8	0	0	0	0	80	66.7

Table 10 Rating of various biological activities applied by the respondents

Biological activity	Rarely		Often		Occasionally		Sometime		Frequently		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Beneficial insects	65	54.2	10	8.3	05	4.2	0	0	0	0	80	66.7
Protecting beneficial insects	71	59.2	05	4.2	04	3.3	0	0	0	0	80	66.7
Buying and releasing beneficial insects	63	52.5	09	7.5	08	6.7	0	0	0	0	80	66.7
Microorganisms	63	52.5	10	8.3	04	3.3	03	2.5	0	0	80	66.7
Parasitic nematodes	60	50	14	11.7	05	4.2	01	0.8	0	0	80	66.7

Utilization of extension methods by EFS for IPM of cotton

The respondents were asked about the extension methods used for educating farmers regarding IPM of cotton and the responses are presented in table 13. Data depicts that result demonstration, farm and home visits and field tour were effectively used methods by EFS as reported by 55.8, 55.8 and 54.2% of the respondents, respectively. Whereas, method demonstration and group methods were also effectively used by EFS reported by less than half of the respondents (47.5 and 46.7%). About 45.8 and 49.8% respondents reported good use of demonstration (result and method). A majority of the respondents (79.2, 90.8, 91.7 and 93.3%) reported poor use of magazine multimedia, cassette and brochure by the EFS to educate the respondents regarding IPM of cotton (Table 13).

Effectiveness of extension methods

The responses regarding the effectiveness of various methods on the bases of their effectiveness are displayed in table 14. Slightly above half (54.2, 55.0 and 55.0%) and less than half (45.8and 41.7%) of the respondents reported field tour, farm and home visits, result demonstration, method demonstration and group meeting were the excellent methods on the bases of their effectiveness. About 45 and 53.3% rated result and method demonstration as good in their effectiveness (Table 14). Newspaper was rated fair for its effectiveness by most of the respondents (42.5%). Furthermore, a majority of the respondents (78.3, 90.0, 91.7 and 92.5%) disclosed that magazine, brushers, multimedia, and cassette were poor extension methods on the bases of their effectiveness (Table 14).

Problems faced by the respondents in applying IPM of cotton

The farmers were polled regarding the problems for practical application of IPM in the field and their responses are shown in table 15. More than half of the respondents (56.7%) were of the view that time is a big problem in applying IPM. Most of the respondents (40%) and one-third of the respondents (34.2-35%) rated practicability, approachability, adoptability and difficulty in management as a serious barrier to them applying IPM. Further, more than half of the respondents (52.5-60.8%) rated practicability, difficult to manage adoptability and approachability were high problems for them (Table 15).

Impact of IPM technology

The respondents were further asked about the impact of IPM technology on their crop and data in this regard is presented in table 16. It is clear from the data that almost the entire respondents (99.2 -100%) were of the view that IPM had positive impact on their crops.

Table 11 Rating of chemical activities relating to IPM of cotton by the respondents

Chemical activity	Rarely		Often		Occasionally		Sometime		Frequently		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Insecticidal soap	66	55	12	10	02	1.7	0	0	0	0	80	66.7
Horticultural oils	65	54.2	08	6.7	06	05	01	0.8	0	0	80	66.7
Botanical insecticides	17	14.2	44	36.7	13	10.8	04	3.3	02	1.7	80	66.7
Inorganic fungicides and insecticides	18	15	45	37.5	11	9.2	05	4.2	01	0.8	80	66.7
Synthetic insecticides, fungicides and molluscicides	45	37.5	18	15	10	8.3	06	05	01	0.8	80	66.7

Table 12 Reasons for non- adoption of IPM measures by the respondents

Reasons	Rarely		Often		Occasionally		Sometime		Frequently		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Lack of skill	1	.8	0	0	2	1.7	28	23.3	9	7.5	40	33.3
Lack of equipments	0	0	0	0	5	4.2	26	21.7	9	7.5	40	33.4
Lack of finances	0	0	1	0.8	0	0	16	13.3	23	19.2	40	33.3

Table 13 Rating of various extension methods used by EFS for IPM of cotton

Extension method	Poor		Fair		Satisfactory		Good		Excellent		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Farm and home visits	0	0	01	0.8	16	13.3	36	30.0	67	55.8	120	100
Result demonstration	0	0	0	0	0	0	55	45.8	65	54.2	120	100
Method demonstration	0	0	0	0	05	4.2	59	49.2	56	46.7	120	100
Group meeting	01	0.8	06	5.0	27	22.5	29	24.2	57	47.5	120	100
Field tour	03	2.5	8	6.7	28	23.3	15	12.5	66	55.0	120	100
Newspaper	42	35.0	60	50.0	07	5.8	6	5.0	05	4.2	120	100
Magazine	95	79.2	16	13.3	0	0	05	4.2	04	3.3	120	100
Brusher	112	93.3	08	6.7	0	0	0	0	0	0	120	100
Cassette	110	91.7	07	5.8	03	2.5	0	0	0	0	120	100
Radio	24	20.0	45	37.5	46	38.3	05	4.2	0	0	120	100
Television	34	28.3	42	35.0	39	32.5	05	4.2	0	0	120	100
Multimedia	109	90.8	02	1.7	05	4.2	0	0	04	3.3	120	100

Table 14 Rating of extension methods on the bases of their effectiveness for IPM of cotton

Extension Method	Poor		Fair		Satisfactory		Good		Excellent		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Farm and home visits	02	1.7	02	1.7	14	11.7	36	30.0	66	55.0	120	100
Result demonstration	0	0	0	0	0	0	54	45.0	66	55.0	120	100
Method demonstration	0	0	01	0.8	0	0	64	53.3	55	45.8	120	100
Group meeting	09	7.5	0	0	28	23.3	27	22.5	56	46.7	120	100
Field tour	02	1.7	11	9.2	27	22.5	15	12.5	65	54.2	120	100
Newspaper	57	47.5	51	42.5	09	7.5	01	0.8	02	1.7	120	100
Magazine	94	78.3	19	15.8	06	5.0	01	0.8	0	0	120	100
Brusher	108	90.0	10	8.3	02	1.7	0	0	0	0	120	100
Cassettes	111	92.5	09	7.5	0	0	0	0	0	0	120	100
Radio	23	19.2	41	34.2	50	41.7	06	5.0	0	0	120	100
Television	31	25.8	41	34.2	40	33.3	08	6.7	0	0	120	100
Multimedia	110	91.7	04	3.3	05	4.2	01	0.8	0	0	120	100

Table 15 Rating of various problems faced by the respondents in applying IPM of cotton

Problem	Very Low		Low		Medium		High		Very High		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Lack of resources	03	2.5	0	0	08	6.7	45	37.5	64	53.3	120	100
Difficult to manage	01	0.8	0	0	10	8.3	68	56.7	41	34.2	120	100
Adoptability	0	0	01	0.8	07	5.8	71	9.2	42	35.0	120	100
Approachable	0	0	01	0.8	05	4.2	73	60.8	41	34.2	120	100
Practicable	01	0.8	0	0	08	6.7	63	52.5	48	40.0	120	100
Time consuming	01	0.8	37	30.8	01	0.8	13	10.8	68	56.7	120	100
Other (please specify)	116	96.7	02	1.7	0	0	0	0	02	1.7	120	100

Table 16 Impact of IPM technology adopted as perceived respondents

Impact	Negative		No impact		Positive		Total	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Impact on production	0	0	0	0	199	99.2	120	100
Impact on skills	0	0	0	0	120	100	120	100
Impact on finance	0	0	1	0.8	119	99.2	120	100
Impact on management	0	0	0	0	120	100	120	100
Impact on health	0	0	0	0	120	100	120	100
Impact on environment	0	0	0	0	120	100	120	100

DISCUSSION

In the agriculture sector, the success of any program and project depends upon the efficiency of the extension field staff (EFS). EFS are key stake holders and play significant roles in providing services for agricultural extension, therefore they are crucial for rural as well as agricultural development. IPM is considered with eco-friendly strategy and one can use it to minimize the risks to people and the environment. It focuses on a combination of various methods for prevention of pests in the long term that cannot work better alone. Approaches for managing pests and insects include the use of resistant cultivars, cultural methods, biological methods and habitat manipulation. The pesticides are only used when they are needed and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment. The IMP is also known as Integrated Pest Control (IPC) that controls pests with the aim of suppressing the pest population under the Economic Injury Level (EIL) for economic control through the integration of various methods (Perrings et al., 2001; FAO, 2012). The present study was conducted keeping in view the importance of IPM techniques for growing cotton in district D. G. Khan, Punjab, Pakistan. It has been reported that crop productivity for most of the crops in Pakistan is very low as compared with developed countries. This may be due to the limited access of farmers to the latest farming technology as well as poor services of agriculture extension departments.

Consistent to our findings, Mallah and Korejo (2007) evaluated cotton crop and farm level cotton production practices by surveying various parts of cotton growing districts of Sindh and observed that 50% of the farmers were able to identify the insect pests. Generally, the farmers sprayed their crop 3-4 times and in some cases 3-8 sprays were done mostly with hand sprayer. The main crop rotation; cotton-wheat-cotton was found in the study area. A study was conducted by Swinton and Day (2000) who reported that southern Punjab was a major cotton production region of Pakistan. The average yield of cotton was about 560 kg/ha. In this region, the demand for pesticides was continuously increasing. There was a dire need for alternate methods of pest management for sustainable and profitable cotton production. IPM was an appropriate method which can reduce or minimize the use of pesticides and cost of production as well. A similar study was conducted by Wilson and Tisdell (2001) who reported that the advancement of agricultural production processes increased the crop productivity and well-being of the rural areas. It also ensured self-sufficiency in food grains and fibre production. In southern Punjab, cotton has been known as white gold being a major fibre crop of the country. In cotton production, pesticides were intensively used to control the pests. The Public Health Officials were increasingly concerned about the adverse effects of the applications of pesticides by the farmers in cotton production. Pesticide applications not only generated negative externalities for health and environment, but also increased the economic cost of cotton producers.

Our study found that IPM is an economically sound and environmentally safe method that can significantly increase the production of cotton. These findings are in accordance with Anonymous (2002) who stated that the IPM system was economically viable. Sustainable agriculture involved the successful management of resources for agriculture to satisfy changing human needs maintaining the quality of the environment and conserving the natural resources. The world experience over the years has shown that the best way for the transfer of technology practice was through trainings of facilitators and Farmer Field School (FFS) activities, which formulated the core of cotton IPM programmes. Work (2002) reported that the extension department was equipped with some exogenously adopted tools of print media, field visits, audio-visual aids and the local needs had never been addressed. The socio-cultural environment of the province was not suitable for all of these tools for a variety of reasons. The print media was wrongly used as a technique in a farming community with more than 80% of the citizens being illiterate. The tribal culture was one of the major obstacles for making big gatherings from different villages and providing trainings at one time. It called upon huge funding and staff to provide farmers training in such cultural settings. Under such conditions, audio-visual aids had been reported as one of the most useful techniques and their best use in field conditions had shown improvement on the efficiency of EFS.

Our findings were in agreement with the previous research study by Feder and Savastano (2006) who found that if the opinion leaders were slightly superior to followers but not very superior in socio-economic status then they were also effective in disseminating the information and awareness about IPM technology among other farmers. The adoption of improved conservation practices increased the crop yield. During our study we found that the best way to accelerate the adoption of IPM technology was by means of education

and training of farmers about IPM. Coherent with our findings, Pilcher (2001) attempted to develop a standardized measurement tool to determine factors that contributed to IPM adoption for corn, soybean, and cotton production in Iowa and Texas but could be accessible to other commodities and regions. They developed a survey instrument from an IPM definition that represented the widest scope of strategies and determined 21 pest management tactics regarded by growers to be IPM oriented. From preliminary results, over 60 percent of participants identified three variables; scouting, economic threshold, and field records of pest population to be significant when implementing an IPM program. These three tactics were also found to be consistent with other literature regarding IPM measurement. Drost et al. (1996) surveyed over 900 growers in Utah and determined that for potato farmers, the adoption or rejection of an IPM program was determined based on time availability, market demand for commodities based on specific pest management approaches and real time IPM information. FAO (2006) also found that the FFS approach on IPM had the potential to provide farmers with the practical knowledge and skills to operate more effectively in a market oriented agricultural system and to enable optimum utilization of services offered by private providers.

In an earlier study Bartlett (2005) stated that the first FFS was introduced in Indonesia in 1989. It was a group based learning approach, which was used by NGO, government departments and some international agencies to promote IPM. At this time, millions of people participated in this type of learning. The author also discussed some organizational issues relating to leadership, human resources, policy making and competition among farmers. The calculation of cost and benefit ratio stressed the farmer to join the IPM FFS, the donors and government agencies also funded it because of its beneficial aspects. In conclusion, FFS was very beneficial for poor farmers living in rural areas. Guinee (2002) studied that FFS worked in reducing the use of pesticides and other chemical pest control measures by switching the farmers to IPM in the Netherlands. FFS also helped in controlling the environmental pollution and health problems caused by the pesticides. Through FFS, the technology transferred to farmers and they got a lot of knowledge about the biological pests control method and saved their pesticide expenses. The FFS approach on IPM had the potential to provide farmers with the practical knowledge and skills to operate more effectively in a market-oriented agricultural system and to enable optimum utilization of services offered by private providers (FAO, 2006).

CONCLUSION AND RECOMMENDATIONS

The study concluded that Extension Field Staff were making good progress in helping farmers in D. G. Khan, Punjab, Pakistan to better utilize Integrated Pest Management techniques in their cotton production operations. Extension field staff and local people were the major sources of information regarding IPM of cotton. More than half of the study respondents were under 35 years of age and more than half of this group had at least primary level education. A majority (85%) had small landholdings (up to 12.5 acres) and was owners of their land. The study found that education and age were both factors that guided respondents' appreciation of IPM methods and their ability to make use of training materials. The satisfaction level regarding chemical application was very low. Two-thirds of the respondents applied IPM techniques in the field, while one-third of the respondents were either not adopting the IPM technique in the field or were only partially adopting it. Demonstrations, farm and home visits and field tours were highly effective methods used by EFS as reported by 54.2 and 55.8% respondents, respectively. More than half of the respondents (56.7%) were of the view that IPM was very time-consuming and that this presented a barrier to its adoption. We recommend that Extension Field Staff focus their efforts helping farmers better understand the time constraints of IPM and how they can be more effective in using the method. Also they should focus on making sure cultural and biological controls are properly adopted so that the benefits of using IPM instead of chemical pest controls become well accepted. The extension field staff should utilize the extension method for the promotion of IPM technologies among the farmers. They should also consider launching the IPM program for cotton crops in other districts of the Punjab. The present study was conducted on a limited scale; therefore, future researchers may want to use it as a starting place for further research in other areas of the province. Areas such as the benefits of IPM on water quality and ways to better educate farmers in tribal areas are ripe for examination.

Author Contribution Statement Badar Naseem Siddiqui generated the idea, supervised the research. Muhammad Adeel conducted the research project. Waqar-Ul-Hassan Tareen wrote the manuscript. Adnan Rayit analyzed the data. Shah Fahd edited the manuscript. All the authors read and approved the manuscript to be published in Journal of Rural Development and Agriculture.

Conflict of Interest The authors declare that they have no conflict of interest.

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ORIGINAL PAPER

Ethnomedicinal uses of plants for blood purification in disitrict Swabi, Khyber Pakhtunkhwa, Pakistan

Rozina[1]*, Mushtaq Ahmad[1], Muhammad Zafar[1], Muhammad Qasim[2], Sheikh Zainulabidin[1]

Key Message The present study represents the first ethnobotanical study to record the indigenous knowledge of district Swabi about the use of sixty-six medicinal plants for blood purification.

ABSTRACT Medicinal plants act as a very important and accessible source of blood purification in the rural communities of district Swabi, Pakistan. Current study represents the first ethnobotanical study of district Swabi to keep the record of medicinal plants to be used as blood purification. Approximately, 190 informants including local people (88.95%) and local health practitioners (LHPs) (11.5%) were interviewed for ethno-medicinal data documentations using semi structured interviews. Quantitative ethno botanical indices like frequency citation (FC), relative frequency citation and family importance value (FIV) were used to analyze the data. Total 66 medicinal plants belonging to 41 families and 63 different genera have been reported as blood purifying plants. Results indicated that Zygophyllaceae, Asteraceae and Solanaceae are families with more number of species (each have 4 sub-species), herbs were documented as dominant life form (71%). Relative frequency citation value ranges from 0.11- 0.95 in the current study. *Azadirachta indica* A. Juss., *Fumaria indica* (Hausskn.) Pugsley, *Cuscuta reflexa* Roxb, *Mimosa pudica* Mill. and *Melia azedarach* are the mostly cited blood purifying plant species. Approximately 50 plant species were reported as blood purifying plant in district Swabi. The ethnobotanical information demonstrated in this study to be useful for a high level of diversity of medicinal plants. The study disclosed the popular knowledge of medicinal plants and their use for blood purification which is still alive in the study area. New medicinal plants reported will provide new research topics for chemical and activity studies.

Key words: Ethno botany, Blood purifying medicinal plants, Swabi, Pakistan

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INTRODUCTION

Medicinal plants are used for curing and healing throughout the history of human beings and have been transferred from generation to generation (Perumal et al., 1998; Pieroni & Quave, 2005; Perumal & Ignacimuthu, 2000; Napar et al., 2012; Jan et al., 2015; Qasim et al., 2016). About eighty percent population of the word relies on plant remedies for their primary health (Riaz Ullah et al., 2010). Medicinal plants are main sources to cure most of the diseases practiced by herbal pharmaceuticals (Hamayun 2005; Rehecho et al., 2011). Various surveys have been conducted in different communities of the world (Kargoglu, et al., 2008; Ratnam & Raju 2008; Jamila & Mostafa, 2014). In Pakistan, ethnobotany is maturing gradually, and it is receiving attention of the people for good health (Bhatti et al., 2001; Qureshi, 2002; Khan & Khatoon, 2004). In Pakistan, about 400–600 medicinal plants have been listed by various reporters being practiced traditionally by the herbalists (Gupta et al., 1999; Bhatti et al., 2001; Hamayun, 2005; Qureshi & Bhatti, 2009; Qureshi et al., 2009; Shinwari & Qaiser, 2011; Bahadur, 2012; Abbasi et al., 2013; Ahmad et al., 2014).

Ethnobotany refers to people and their forest interaction defining an area of ecology necessary for rural development (Beg, 1978). Plants can be considered as biological factories for the production of various medicinal compounds. A number of toxins, microbes and other dangerous compounds are introduced in the blood stream of our body by our diet and the external environment. The removal of these toxins from the blood flow by various medicinal compounds is known as blood purification (Suzuki & Hirasawa, 2016).

Cleansing of blood is a safe way to improve immunity, prevent heart diseases, improve overall health and fight cancer. Current study aimed at documentation of indigenous knowledge of the local people regarding blood purifying plants of district Swabi, Pakistan and its compilation by applying quantitative index information (QII), relative frequency citation (RFC) and family importance value (FIV) to compare ethnobotanical data.

MATERIALS AND METHODS

Study area

District Swabi is located at 34° 7', 48" North and 72° 28', 11" East of Khyber Pakhtoon Khwa province of Pakistan sharing boundaries with river Indus (Fig. 1). It has alluvial fertile soil supporting rich phytodiversity. However, original plant cover has been prohibited by extreme biotic and abiotic stresses. District Swabi has severe climate. Rise in temperature is observed from May to September. Frequent dust storms at night are detected during May and June. A high raise in temperature i.e. 41.5 °C happens in the month of June. Decrease in phytodiversity, increase in soil errosion and soil compactness are resultants of these factors (Lyaruu, 2010). Disorganized usage of vegetation caused degradation to phytodiversity (Chaughtai et al., 1989). The valuable medicinal plants and indigenous knowledge are losing day by day in the area. Several vegetation studies were conducted in the past in district Swabi and other parts of KPK, Pakistan (Hussain & Taj-Malook, 1984; Chaughtai et al., 1989; Hussain et al., 1995; Heinrich et al., 2009). Dominant plant species of district Swabi include *Dalbergia sissoo*, *Melia azedarach*, *Ziziphus nummularia*, *Acacia modesta*, *Morus nigra*, *Morus alba*, *Calotropis procera, Cynodon dactylon, Cyperus rotundus* and *Treibulis rerristris.*

Socioeconomic conditions of the area

Approximately 85 percent of the population depends on farming. The cash crop of Swabi is tobacco. Other important crops are sugarcane, maize and wheat. Citrus fruits grow well in this area along with apricot, peaches and watermelons. Swabi is considered as the second district of KPK with high literary rate (70%). Although there are government health care centers, still local people practice medicinal plant remedies for curing diseases. There are a number of herbalists or hakims whom are visited and trusted by local people for the treatment of diseases. Some of these are very experienced and professional.

Data collection

The study was conducted during 2014-2015 using the methods of Heinrich et al. (2009). The plant specimens (66) were collected from the selected site. During this study, 190 informants, 435 locals and 15 traditional healers were interviewed. Before starting interviews, informant consent (IC) was obtained. The plant specimens were collected, dried, preserved and mounted on herbarium sheets using techniques suggested by Jain and Rao (1977). Preserved specimens were then identified with the assistance of Dr. Mushtaq Ahmad, Associate Professor, Department of Plant Sciences, Quaid- i- Azam University Islamabad, Pakistan and Flora of Pakistan. Preserved specimens were collected in the Herbarium of Pakistan, Quaid-i-Azam University, Islamabad. Ethnobotanical data were collected through semi-structured interviews and free listing open ended questions with some key witnesses as reported by Ghorbani et al. (2011). The views were required to expressive knowledge about the plants in the area such as where they grew and how they were used. Edwards et al. (2005) method was used to design questionnaire containing both open and closed ended questions on the use and method of preparation of ethnobotanicals and socioeconomic characteristics (age, ethnicity, spiritual opinion, nationality, education and occupation) of the local people were conducted during 2014-2015. Other information like plant name (both local and scientific), respective family, living habitat, nature, habit and relative abundance were also documented.

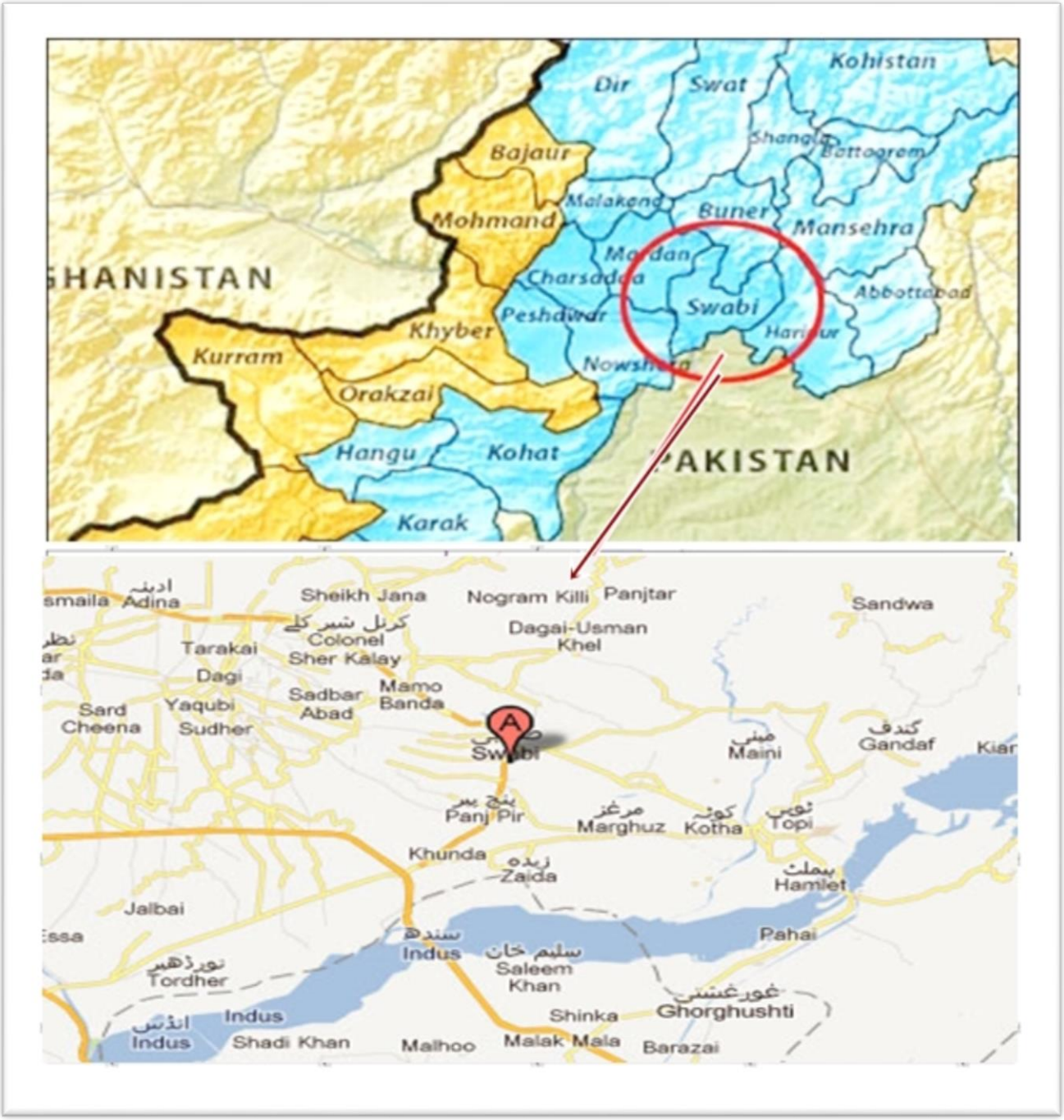

Fig. 1 Map of district Swabi

Botanical identifications

The local names of plants for identification were coordinated by local informants during the survey. Scientific names and classification was confirmed with the help of Flora of Pakistan (www.eflora.com), further name

correction was done by International Plant Name Index (www.ipni.gov.pk). Preserved specimens were deposited in the Herbarium of Pakistan, Quaid-i-Azam University, Islamabad.

Qualitative data analysis

The following parameters were used as qualitiative data:

Relative frequency citation (RFC)

Calculation of relative frequency citation was done with the help of following formula:
1. RFC=FC/N (0<RFC<1)
Every species had a certain local importance which was indicated by this relation. It was obtained by dividing frequency citation (FC) by the total number of informants participated in the survey (N). Where FC is the number of informants reporting species uses (Vitalini et al., 2013).

Family importance value (FIV)

FIV can be calculated to find out the informants harmony on the role of documented medicinal plant. Family importance value can be estimated by using formula given by Molares and Ladio (2009). Family importance value is computed utilizing the rule below:
2. FIV= FC (family)/N ×100
Whereas FC is the number of informants of the mentioned family and N is the total number of informants.

RESULTS AND DISCUSSION

Demographic data of informants

In current study, we interviewed a total of 190 informants comprising of local people (88.95%) and local health practitioners (LHPs) (11.5%) (Table 1) at different places randomly like homes, religious places (mosques etc.), fields and other meeting places like meeting rooms locally called as hujras or baitaks. Approximately, 57.89% of total informants were male and 42.11% were female. The less number of female informants was due to difficulty of access to them in various places, gender discrimination and other social restrictions. Some other reasons might be because females are generally involved in domestic life, while males perform the outside activities. In this study, the aged group of informants had more traditional knowledge about herbal remedies and liked to share it openly. Males were found to be more interested in sharing indigenous knowledge than that of females.

Considering the factor of age, it was classified into five groups (Table 1). The age group who was 50-60 years old contributed the highest indigenous knowledge (47.37%) followed by the second age group (40-50 years old) who shared 21.05% knowledge about ethnobotanicals, while the age group 30-40 years old shared only 18.42% of the total indigenous knowledge. Based on the education background, the highest indigenous knowledge (42.11%) about blood purifying medicinal plants was shared by illiterate people, while the highest educated group (higher education) shared only 2.63% of indigenous knowledge (Table 1).

Medicinal plant diversity

In the current study, a total of 66 blood purifying medicinal plants relating to 41 families and 63 different genera were documented (Table 2). Lameaceae, zygophyllaceae, asteraceae and solanaceae (each having 4 species) were most of the families used in this study followed by poaceae and rosaceae (each with 3 species) (Fig. 2). It has been observed that most of the plant species belonging to these families were easily accessible and abundant in the study area because of specific geographical distribution and their abundance. In previous studies family asteraceae was constantly reported in ethno-medicinal surveys in different parts of Pakistan (Sher et al., 2011; Bibi et al., 2014). The family asteraceae found as predominant in study area showed similarity with those described in previous literature (Blanco et al., 1999; Bano et al., 2012). Considering the growth/life form, the most dominant life form was that of herbs (71%) followed by trees (17%) and shrubs

(10%). In earlier ethno medicinal surveys, herbs were reported as dominant life form as these were generally employed in the chief source of medical specialty in several health maintenance systems (Murad et al., 2012). Ahmad et al. (2014) in their survey of Chail valley of Pakistan reported herbs as dominant life form. The common usage of herbs among indigenous people might be due to their abundance in various environments, easy availability, or more inexpensive at local grocery stores (Ayyanar & Ignacimuthu, 2005; Mukherjee & Wahile, 2006; Uniyal et al., 2006; Qureshi, 2012; Shah & Rozina, 2013).

Plant parts and their preparation for remedies

Various parts of plants were reported for blood purification during this survey (Fig. 3). The whole plant was reported to be the mostly used plant part followed by the leaves and the fruits. Generally, rural people use the whole plant for blood purification because they are herbaceous and can be picked up easily without any heavy work. Qureshi (2012) described the similar results and reported that the whole plant preparation for remedies is very common. However, any part or organ of a plant having active constituents and are pharmacologically active can be used as medicines (Verpoorte et al., 2002; Yesilada & Kupeli, 2007; Gurdal & Kultur, 2013; Ahmad et al., 2014). In the current study, no root part was found to be used as medicine in blood purification. The most dominantly used preparation is the decoction (27 reports) followed by the powder (20 reports) and infusion (10 reports) (Fig. 4). Our findings about the effects of widespread use of decoction and infusion were consistent with the results of Gurdal and Kultur (2013); Ahmad et al. (2014).

Quantitative ethnobotanical analysis

Relative frequency citations (RFC)

The RFC was calculated to determine the most commonly used medicinal plants for blood purification. Based on the RFC values, the most important plant species were *Azadirachta indica* A. Juss. (0.95), *Fumaria indica* (Hausskn.) Pugsley (0.79), *Cuscuta reflexa* Roxb (0.76), *Mimosa pudica* Mill. (0.53) *Melia azedarach* (0.52), *Mentha longifolia* L. (0.50), *Taraxacum officinale* F.H. Wigg (0.50), *Rosa indica* L. (0.47), *Cynodon dactylon* (L.) Pers. (0.45), *Lycopersicum esculentum* Mill. (0.45), *Aloe vera* (L.) Burm.f. (0.42), *Caralluma tuberculata* N.E.Br (0.42), *Allium sativum* L. (0.39), *Ziziphus nummularia* (Burm. f.) Wight & Arn (0.37), *Capsicum annuum* L. (0.35), *Punica granatum* L. (0.34), *Thymus serpyllus* L. (0.32), *Berberis lycium* Royle (0.29) and *Cymbopogon jwarancusa* (0.29) (Fig. 5; Fig. 6). The high RFC values reported the facts that these medicinal plant species were well recognized among the utmost number of sources. The plants having high RFC should be further evaluated phytochemical and pharmaceuticals to identify their active ingredients for drug discovery (Molares & Ladio, 2009). *Azadirachta indica* A. Juss., *Fumaria indica* (Hausskn.) Pugsley, *Cuscuta reflexa* Roxb, *Mimosa pudica* Mill. and *Melia azedarach* L. were the most popular plants in district Swabi that were reported by the majority of the informants.

Family importance value (FIV)

FIV was calculated to determine harmony among the informants on the role of medicinal plants. Based on the FIV values, the most important plant families were araliaceae (5), bombacaceae (5), molluginaceae (5), paeoniacea (5) and phyllanthaceae (5). The FIV of these five families was followed by apocynaceae (4.8), fabaceae (4.7), asphodelaceae (4.5), elaeagnaceae (4.3), myrsinaceae (4.2), polygonaceae (4.1), malvaceae (4), papilionaceae (4), salvadoraceae (4), zygophyllaceae (4), amaranthaceae (3.8), caryopyllacea (3.6), colchicaceae (3.6) and mimosaceae (3.4). Similar results were reported by Sher et al. (2011) from Chagharzai Valley, district Buner.

Table 1 Demographic data of the participants

Selected Characteristics	Categories	No. of persons	Percentage
Informants category			
	Local health practitioners	21	11.05
	Local people	169	88.95
Gender			
	Female	80	42.11
	Male	110	57.89
Age			
	Less than 20 years	0	0.00
	20-30 years	25	13.16
	30-40 years	35	18.42
	40-50 years	40	21.05
	50-60 years	90	47.37
Educational background			
	Illiterate	80	42.11
	Completed 5 years of education	10	5.26
	Completed 8 years of education	20	10.53
	Completed 10 years of education	20	10.53
	Completed 12 years of education	30	15.79
	Completed 16 years of education	25	13.16
	Graduate (Higher education)	5	2.63
Experience of the local health practitioners			
	Less than 2 years	40	21.05
	2-5 years	50	26.32
	5-10 years	40	21.05
	10-20 years	27	14.21
	More than 20 years	33	17.37

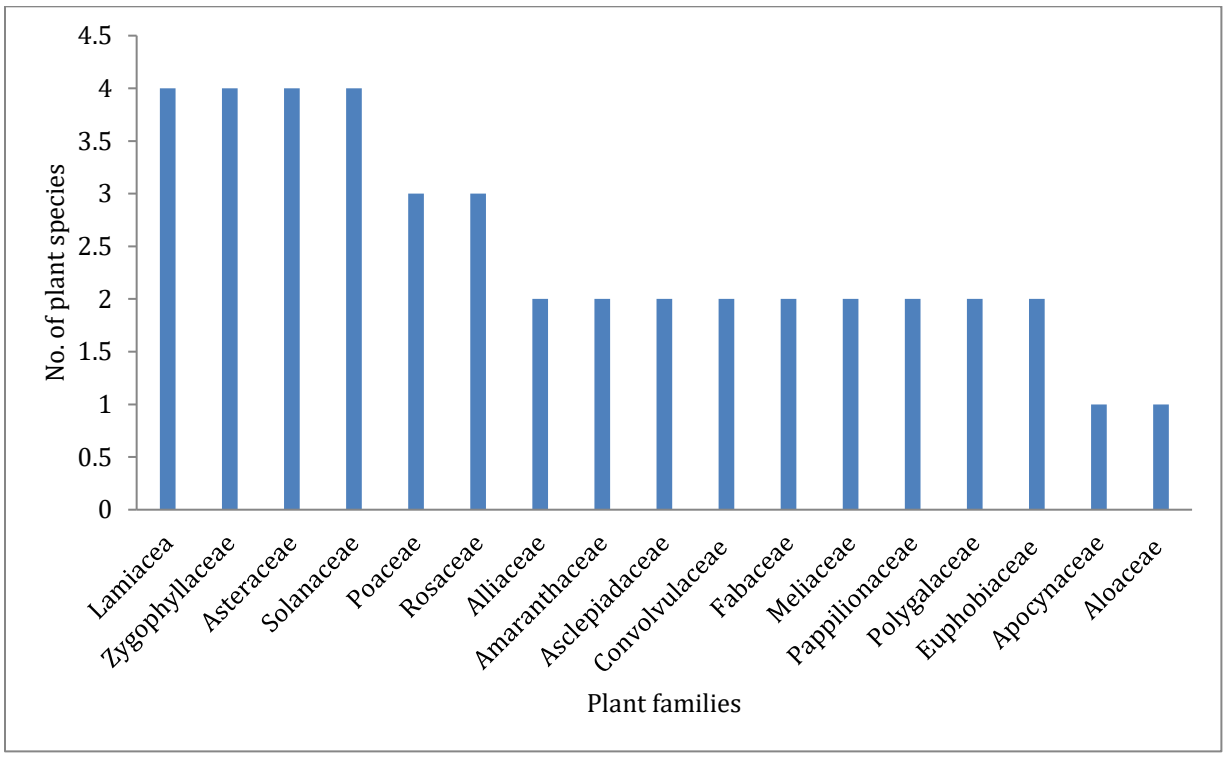

Fig. 2 Dominant families of medicinal plants in the study area

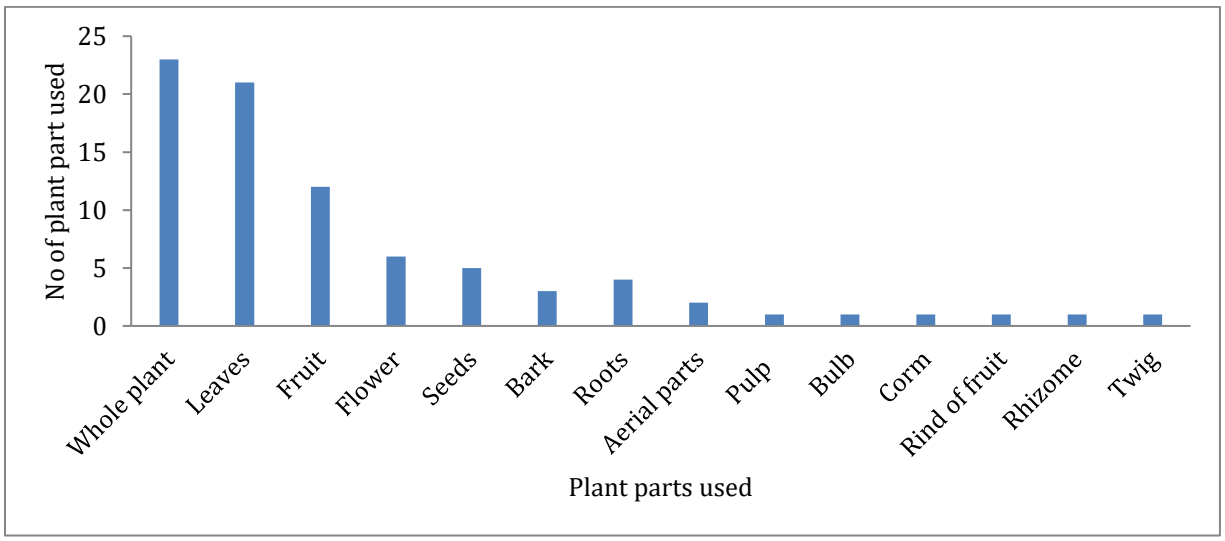

Fig. 3 Plant parts used for blood purification

Table 2 List of medicinal plants for blood purification found in Swabi, Pakistan

Plant species	Local name	Family	Habit	Mode of utilization	Part used	FC	RFC
Abutilon indicum (L.) Sweet.	Peeli buti	Malvaceae	Herb	Powder	Leaves and flowers	25	0.13
Achyranthes aspera Duss	Ghishkay	Amaranthaceae	Herb	Decoction	Whole plant	27	0.14
Acroptilon repens (L.) DC.	Alcohol, Sumbal	Asteraceae	Herb	Decoction	Whole plant	20	0.11
Agave americana L.	Kanwar Phara	Asparagaceae	Herb	Solid	Pulp	35	0.18
Ajuga bracteosa Wall ex Benth	Bootie, meaner, Qaimatgualla	Lamiaceae	Herb	Decoction	Leaves, Whole plant	26	0.14
Albizia lebbeck (L.) Benth.	Shirin	Mimosaceae	Tree	Decoction, Powder	Stem bark	29	0.15
Alhagi maurorum Medic.	Jawanha	Fabaceae	Shrub	Decoction	Whole plant	23	0.12
Allium sativum L.	Uga	Alliaceae	Herb	Extract	Bulb and leaves	75	0.39
Allium humile Kunth	Cherum	Alliaceae	Herb	Solid	Whole plant	50	0.26
Aloe vera (L.) Burm.f.	Quargandal	Aloaceae	Herb	Gel/extract	Leaves	80	0.42
Alternanthera pungens Kunth	Itsit Te Phakra	Amaranthaceae	Herb	Powder	Leaves	26	0.14
Anisomeles indica (L.) Kuntze(L.)	Sankhia	Lamiaceae	Herb	Decoction	Whole plant	27	0.14
Asphodelus tenuifolius Cav.	Piazi	Asphodelaceae	Herb	Powder	Whole plant	22	0.12
Azadirachta indica A. Juss.	Neem	Meliaceae	Tree	Decoction	Leaves	180	0.95
Berberis lycium Royle	Sumblu	Berberadaceae	Shrub	Powder	Root	55	0.29
Bombax ceiba L.	Sumbal	Bombacaceae	Tree	Decoction, powder	Flowers, roots, bark and seeds	20	0.11
Capparis decidua (Forssk.) Edgew	Karinh	Capparaceae	Tree	Solid fruit	Fruit, twig	33	0.17
Capsicum annuum L.	Shimla mirch	Solanaceae	Herb	Solid	Fruit	66	0.35
Caralluma tuberculata N.E.Br	Pamunkay	Asclepiadaceae	Herb	Chewed	Whole plant	80	0.42
Chrozophora plicata (Vahl) A.Juss. Ex Spreng.	Kharha vangai, Nilakari	Euphorbiaceae	Herb	Juice	Whole plant	25	0.13
Cichorium intybus L.	Kasini	Asteraceae	Herb	Powder	Whole plant	50	0.26
Citrullus colocynthis (L.) Schrad.	Kharengirirhi	Cucurbitaceae	Herb	Steam/Powder	Fruit	44	0.23
Citrus grandis Hassk	Chakotra	Rutaceae	Tree	Juice	Fruit	53	0.28

Colchicum luteum Baker	Qaimatguallay	Colchicaceae	Herb	Fried	Corm	28	0.15
Cuscuta reflexa Roxb	Maraz bootay	Convolvulaceae	Herb	Decoction	Whole plant	145	0.76
Cymbopogon jwarancusa	Lanjak	Poaceae	Herb	Decoction	Leaves	55	0.29
Cynodon dactylon (L.) Pers.	Khabbal gha	Poaceae	Herb	Decoction	Whole plant	86	0.45
Dalbergia sissoo Roxb.	Shawa, Shesham	Pappilionaceae	Tree	Extract	Leaves	30	0.16
Euphorbia prostrata J.Graham	Hazar dani	Euphobiaceae	Herb	Extract	Whole plant	47	0.25
Fagonia arabica L.	Karhkawa	Zygophyllaceae	Herb	Decoction	Whole plant	23	0.12
Fagonia cretica L.	Spelaghzai	Zygophyllaceae	Herb	Powder, Extract	Leaves, whole plant	26	0.14
Fumaria indica (Hausskn.) Pugsley	Papra, Murghipal, Shatira	Fumariaceae	Herb	Decoction, Juice	Aerial parts	150	0.79
Galium boreale Walter	_	Rubiaceae	Herb	Infusion	Flower	35	0.18
Glinus lotoides L.	_	Molluginaceae	Herb	Powder	Whole plant	20	0.11
Hedera nepalensis K.Koch	Prewata	Araliaceae	Herb	Juice	Leaves	20	0.11
Hippophae rhamnoides L.	_	Elaeagnaceae	Tree	Extract	Plant/fruit	23	0.12
Indigofera suffruticosa Mill.	Jantri	Papilionaceae	Herb	Decoction, infusion	Whole plant	20	0.11
Ipomea hederacea Jacq	Habbun-nil	Convolvulaceae	Herb	Powder	Seeds	22	0.12
Launaea nudicaulis Hook.f.	Thareeza	Asteraceae	Herb	Infusion	Whole plant	33	0.17
Lycopersicum esculentum Mill.	Tamatar	Solanaceae	Herb	Powder	Fruit	85	0.45
Melia azedarach L.	Dreik	Meliaceae	Tree	Juice	Leaves, seed, fruit	98	0.52
Mentha longifolia L.	Velanai	Lamiaceae	Herb	Infusion	Leaves, flowers	95	0.50
Mimosa pudica Mill.	chui mui	Leguminosae	Shrub	Juice	Leaves, flowers	100	0.53
Morus nigra L.	Tor toot	Moraceae	Tree	Solid	Fruit	40	0.21
Myrsine africana L	Khukan	Myrsinaceae	Shrub	Decoction	Leaves	24	0.13
Oxystelma esculentum (L.f.) Decne	Dudhani	Asclepiadaceae	Climber	Decoction, infusion	Whole plant	28	0.15
Paeonia emodi Wall.	Mamaik	Paeoniaceae	Shrub	Powder	Rhizome	20	0.11

Peganum harmala L.	Aspand	Zygophyllaceae	Herb	Powder	Seed	22	0.12
Phyllanthus emblica L.	Amla	Phyllanthaceae	Tree	Infusion	Fruit	20	0.11
Polygala erioptera DC.	Asmani Buti	Polygalaceae	Herb	Decoction, infusion	Whole plant	23	0.12
Potentilla nepalensis Hook	Mammarh	Rosaceae	Herb	Decoction, infusion	Roots	21	0.11
Potentilla supina L.	PushkunPhul	Rosaceae	Herb	Decoction	Leaves	24	0.13
Psoralea plicata Delile	Makka Buti	Fabaceae	Herb	Decoction, powder	Seeds	20	0.11
Punica granatum L.	Anar/ Daroona	Punicaceae	Tree	Solid fruit	Rind of fruit	65	0.34
Rhazya stricta Decne.	Aishar	Apocynaceae	Shrub	Powder	Leaves	21	0.11
Rheum australe D. Don	Chontal	Polygonaceae	Herb	Powder	Whole plant	26	0.14
Rosa indica L.	Gulab	Rosaceae	Shrub	Powder	Flower	90	0.47
Saccharum arundinaceum Retz.	Sarkanda	Poaceae	Herb	Juice	Stem, root	2	0.15
Salvadora oleoides Decne.	Pilu, Wan	Salvadoraceae	Tree	Decoction	Leaves	25	0.13
Silene inflata Sm.	Jangli gashoon	Caryopyllacea	Herb	Infusion	Whole plant	28	0.15
Taraxacum officinale F.H. Wigg	Zyar gulai	Asteraceae	Herb	Decoction	Root	95	0.50
Thymus serpyllus L.	Tumaro	Lamiacea	Herb	Decoction	Whole plant	60	0.32
Withania coagulans Dunal	Panirbank/Panirbad	Solanaceae	Herb	Infusion, Powder	Fruit and seeds	22	0.12
Withania somnifera (L.) Dunal	Panirbank/Panirbad	Solanaceae	Herb	Decoction	Fruit	21	0.12
Ziziphus nummularia (Burm. f.) Wight & Arn	Ber, Brunhi Unab	Rhamnaceae	Shrub	Decoction, Solid	Leaves, fruit, bark	70	0.37
Zygophyllum simplex L.	Lunak	Zygophyllaceae	Herb	Decoction, powder	Whole plant	30	0.16

FC = Frequency citation, RFC = Relative frequency citation. These plants have been reported by Yaseen et al. (2015); Parvaiz (2014); Amjad (2015); Kumar et al. (2014); Tene et al. (2007); Mosaddegha et al. (2012); Qureshi & Bhatti (2008); Shinwari & Khan (2000); Yabesh et al. (2014); Ahmad et al. (2014)

Table 3 Family importance values (FIV) of sampled families

S. No.	Family name	FIV*	S. No	Family name	FIV*	S. No	Family name	FIV*
1	Araliaceae	5	17	Caryopyllacea	3.6	33	Poaceae	1.8
2	Bombacaceae	5	18	Colchicaceae	3.6	34	Convolvulaceae	1.7
3	Molluginaceae	5	19	Mimosaceae	3.4	35	Alliaceae	1.6
4	Paeoniacea	5	20	Capparaceae	3.0	36	Punicacea	1.5
5	Phyllanthaceae	5	21	Asparagaceae	2.9	37	Rhamnaceae	1.4
6	Apocynaceae	4.8	22	Rubiaceae	2.9	38	Aloaceae	1.3
7	Fabaceae	4.7	23	Euphobiaceae	2.8	39	Meliaceae	1.0
8	Asphodelaceae	4.5	24	Moracea	2.5	40	Fumariaceae	1.0
9	Elaeagnaceae	4.3	25	Cucurbitaceae	2.3	41	Leguminosae	1.0
10	Myrsinaceae	4.2	26	Rosaceae	2.2			
11	Polygonaceae	4.1	27	Solanaceae	2.1			
12	Malvaceae	4.0	28	Asteraceae	2.0			
13	Papilionaceae	4.0	29	Lamiacea	1.9			
14	Salvadoraceae	4.0	30	Rutaceae	1.9			
15	Zygophyllaceae	4.0	31	Asclepiadaceae	1.9			
16	Amaranthaceae	3.8	32	Berberadaceae	1.8			

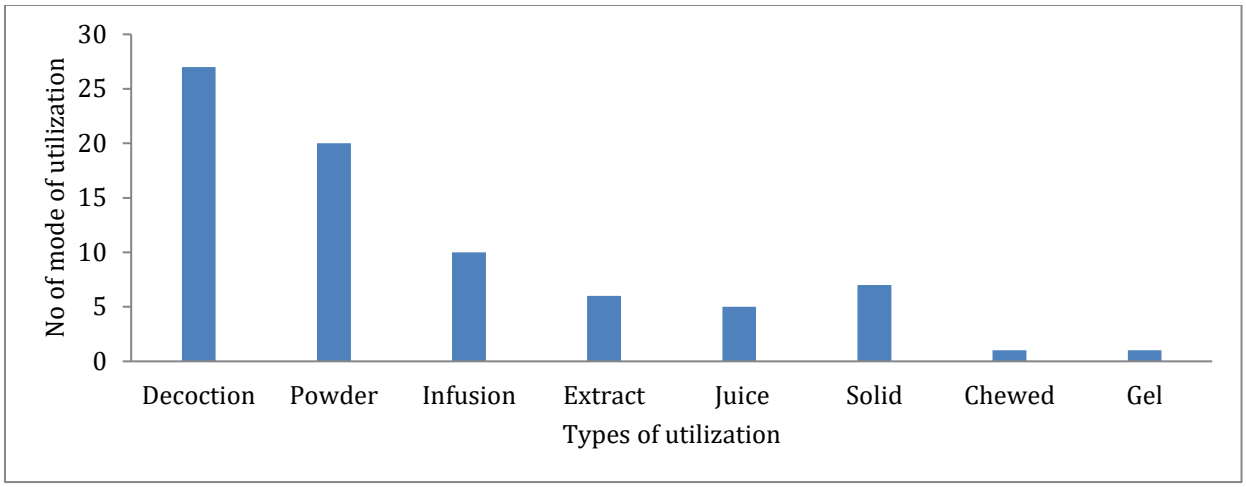

Fig. 4 Mode of utilization of medicinal plants

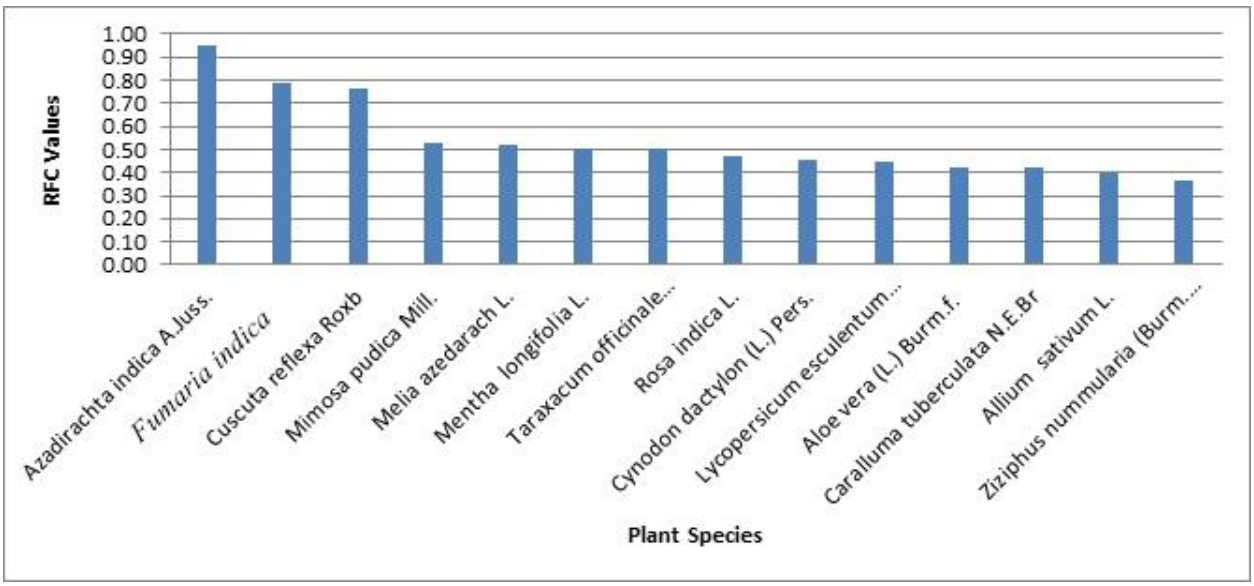

Fig. 5 The highest RFC values of some important medicinal plant

Fig. 6 Identification and collection of medicinally important plant species for blood purification in district Swabi

CONCLUSION

It is the first ethno medicinal study of traditional usage of blood purifying plants in district Swabi, Pakistan. The region is bestowed with medicinal plants and these plants are still commonly utilized for medicinal uses by people in their everyday lives. This study emphasized on the major role of herbal medicine for the blood purification. In aggregate, 66 plant species are covered. The highest RFC values ranked *Azadirachta indica* A. Juss. (0.95), *Fumaria indica* (Hausskn.) Pugsley (0.79), *Cuscuta reflexa* Roxb (0.76), *Mimosa pudica* Mill. (0.53) *Melia azedarach* (0.52) and *Mentha longifolia* L. (0.50). However, there is a gradual depletion of traditional knowledge about these plants in new generation. Hence it is important to document and reconstitute the rests of the ancient medical practices which exist in the region for future generations. Further strategies should be taken for conservation of these medicinal plants on priority. It will too provide various socioeconomic dimensions associated with the rural people.

Author Contribution Statement Mushtaq Ahmad generated the idea and supervised the research. Rozina conducted the research project and wrote the manuscript. Muhammad Zafar analyzed the data. Muhammad Qasim helped in survey and collecting information. Sheikh Zainulabidin contributed in plants collection and preservation. All the authors have read and approved the manuscript.

Conflict of Interest No conflict of interest is declared among the authors.

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ORIGINAL PAPER

Variations in meat chemical composition of some captive avian species

Shahid Javaid[1], Arshad Javid[2], Umar Farooq[2], Ujala Kiran[2] and Tabinda Akmal[2]

Key Message This study explores the potential of avian species for the production of quality food and it reports that the highest moisture contents (78.52%), crude protein contents (82.57%) and ash contents (5.34%) were recorded in the meat of the *M. gallopavo*.

ABSTRACT Increasing population of Pakistan puts a lot of pressure for more food production. Therefore, it is the need of the day to explore potential of avian species for the production of quality food and inclusion in existing meat resources. A study was conducted to analyze meat chemical composition of domestic pigeon (*Columba livia domestica*), wild pigeon (*Columba livia*), grey francolin (*Francolinus pondicerianus*), broiler chicken (*Gallus gallus domesticus*) and turkey (*Meleagris gallopavo*). During the investigation, interspecific variations in meat chemical composition were recorded. The highest moisture contents (78.52%), crude protein contents (82.57%) and ash contents (5.34%) were recorded in the meat of the *M. gallopavo*, while the highest fat contents (16.99%) were recorded in the meat samples of *C. livia domestica*. Monthly variations in chemical composition of meat were also recorded during this study. The highest moisture contents were recorded during the month of January, 2016 followed by February, 2016 and March, 2016. Similarly, the highest protein contents were observed during the month of March, 2016 followed by February, 2016 and January, 2016 months. The highest fat contents were recorded during March, 2016 followed by the months of February, 2016 and January, 2016. Maximum ash contents were observed during January, 2016 followed by the months of March, 2016 and February, 2016. It can be concluded from the present study that meat of the turkey, grey francolin and wild and domestic pigeons may also be utilized to fulfill the protein requirements and these species should be included into the existing poultry industry.

Keywords: Broiler chicken, Chemical composition, Pigeons, Protein content, Turkeys

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INTRODUCTION

Increasing human population demands more food sources, pressurizing poultry industry to enhance meat production. Furthermore, the consumers prefer organic food with quality nutrient profile, acceptable flavor and free from contaminants (Owens et al., 2006; Anjum et al., 2016). Meat of the animals is important components of human nutrition due to their nutritive values and these values are measured in terms of availability of quality proteins, carbohydrates, minerals, fats and fatty acids (Pearson & Gillet, 1996). The tissue and dietary proteins consist of two groups of amino acids, the essential amino acids and the non-essential amino acids. From the total 20 food amino acids, 10 are essential for infants and 8 for adults. Poultry meat is a source of quality protein and preferred by the consumers due to a number of attributes including easy to cook, nutritious, possessing organoleptic properties, high protein contents, low calories and enriched with essential amino acids necessary for the human health and growth (Panda, 1995). The characteristics of meat vary with species and are also influenced by the factors such as gender, diet and age of the animals

(Colmenero et al., 2001; Rule et al., 2002; Insausti et al., 2004; Leosdottir et al., 2005; Hoffman & Wiklund, 2006; Krystallis & Arvanitoyannis, 2006).

Meat of the pigeon is highly digestible and contains low fat contents than the meat of many other species (Gontariu & Buculei, 2009). Pigeons are effectively reared and used for sports, ornamentals, experimental purposes and for the production of meat (Rahman & Khatun, 1999). Bhuyan et al. (1999) documented that meat of the pigeon contains high protein and other nutrients than that of chicken meat. Moreover, the pigeons are mostly used for ceremonial purposes rather to meet protein requirements (Parkhurst & Mountuey, 2004). Demand for turkey meat is also increasing due to low fat and high protein contents. In addition, the meat of the turkey is categorized due to high mineral profile (Ribarski et al., 2001). Chemical composition of partridge meat shows that it contains 55.9-62.4% moisture, 25.2-29.1% protein, 1.6-5.6% lipids, 1.2-1.4% ashes and 70-234 mg/100g cholesterol showing its potential for production of special meat (Moro et al., 2006).

While considering health with growing human population, this is of utmost important to have knowledge about the foods of animal origin/sources providing good quality and quantity of nutrients specifically in terms of proteins and energy. Regarding it, special attention was given towards diversified avian breeds for the production of meat. So, more species have been added in the existing poultry industry like quail, turkey and ostrich. Therefore, meat is becoming popular among locales in Pakistan. Present study was therefore planned to find out monthly variations in meat chemical composition of some avian species along with finding out its nutritional value, as this is directly related with health.

MATERIALS AND METHODS

This study was conducted at Avian Conservation and Research Center, Ravi Campus, University of Veterinary and Animal Sciences, Lahore during January-March, 2016. Size of sample (n = 5) for each bird i.e. domestic pigeon (*Columba livia domestica*), wild pigeon (*Columba livia*), grey francolin (*Francolinus pondicerianus*), broiler chicken (*Gallus gallus domesticus*) and turkey (*Meleagris gallopavo*) was taken to study their chemical composition. Month wise variations in chemical composition of domestic and wild were also recorded from January, 2016 through March, 2016. The birds were cared and grown in controlled conditions closed to natural conditions for experiment purpose. The meat was taken from breast and thigh parts of birds for chemical analyses.

Determination of moisture contents and dry matter

Moisture contents and dry matter were determined through loss in meat weight on drying. The meat sample (5 g) was placed in cleaned and dried petri-dish. It was then oven dried at 103 ˚C for 24 h. After cooling in desiccator, petri-dish was weighed again and moisture (%) contents and dry matter were recorded using following formulae;

$$\text{Moisture contents (\%)} = \frac{\text{Wet weight of sample (W1)} - \text{dry weightof sample (W3)}}{\text{Weight of the sample (W2)}} \times 100$$

$$\text{Dry matter} = 100 - \text{Moisture \%}$$

Determination of crude protein

Meat sample (1 g) was taken in a Kjeldahl digestion flask (500 ml), 5 g digestion mixture (K_2SO_4 and $CuSO_4$) and 20 ml H_2SO_4 were then added into it. It was heated until the appearance of light green color. The mixture was cooled and 250 ml of sample was prepared using distilled water. After that, solution (10 ml) was taken and 10 ml NaOH solution (40% w/v) was added into it. Liberated ammonia was then collected in 10 ml of 0.01 N H_2SO_4 with 1 drop of methyl red as an indicator. The sample was titrated again with 0.01 N NaOH until light blue color appears.

Crude protein (%) was determined using the formula:

$$\text{Crude Protein (\%)} = \frac{V \times 0.00014 \times D \times 100 \times 6.25}{w \times A}$$

Where

"V" is volume of N/10 H_2SO_4 used; "0.00014" is nitrogen conversion factor; "D" is the quantity of digested and diluted sample; "100" is to get %age; "6.25" is to convert %age of nitrogen into crude protein; "6.25" is nitrogen % on dry matter basis; "w" is sample weight in grams; "A" is weight of diluted and digested sample

Determination of crude fat

Meat sample (3 g) was taken into a filter paper pouch, prepared through Whatman filter paper and the pouch was weighed. Soxhlet's apparatus was used to extract fats using petroleum benzene at temperature of 60-80 ºC. The extraction continued for 3-4 hours, the sample was then dried at 100 ºC for 30 min. It was the cooled and final weight of the pouch that was recorded. Fat contents (%) were recorded using following formula:

$$\text{Fat contents mg/100g of dried sample} = Wi - Wf$$

$$\text{Fat contents (\%)} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

Where

"Wi" is initial weight of sample (Before extract) and "Wf" is final weight of sample (After extract)

Determination of ash contents

Dried meat sample (2 g) was taken into the crucible. The crucible was then transferred to the muffle furnace and heated for 4-6 h. It was then cooled through desiccator and weighed. Ash contents (%) were recorded using following formula:

$$\text{Ash contents (\%)} = \frac{\text{Ash weight}}{\text{Sample weight}} \times 100$$

Statistical analysis

Meat chemical composition of domestic pigeon, wild pigeon, grey francolin, broiler chicken and turkey was recorded and DMRT was employed at 0.05 probability level to compare their mean values using statistical software SAS 9.1.

RESULTS AND DISCUSSION

During present investigation, average moisture contents from domestic and wild pigeons were recorded 68.73 ± 0.99% and 70.70 ± 0.67%, respectively. Protein contents of domestic pigeons were analyzed 69.41 ± 0.54%, while the same were recorded 74.65 ± 0.54% for wild pigeons on dry matter basis. The fat contents for domestic and wild pigeons were recorded as 16.99 ± 0.56% and 15.04 ± 0.83%, respectively. Ash contents of domestic and wild pigeons were recorded as 4.20 ± 0.34% and 4.47 ± 0.31%, respectively (Table 1). Apata et al. (2015) reported that fresh meat of the pigeon contains 67.20% moisture, 20.40% protein, 9.31% fat and 2.05% ash contents. The genetics, type of strain and environmental factors influence chemical composition of muscle fiber and aid in determining the quality of the meat (Listrat et al., 2016). High moisture contents 69.86% were recorded from domestic pigeon meat during January, 2016 followed by the months of February, 2016 and March, 2016. Similarly, high protein contents (70%) were recorded during the month of January, 2016 followed by February, 2016 and March, 2016. High fat contents (17.53%) were recorded during March, 2016 followed by the months of February, 2016 and January, 2016. Ash contents were high (4.56%) during January, 2016 followed by February, 2016 and March, 2016 (Fig. 1). High moisture contents (71.27%) were recorded from the meat samples of wild pigeons during the month of January, 2016 followed by the months of February, 2016 and March, 2016. The highest protein contents (75.22%) were recorded during the month of February, 2016 followed by January, 2016 and March, 2016. The highest fat contents (15.72%) were recorded during the month of March, 2016 followed by February, 2016 and January, 2016. Similarly, high ash contents (4.76%) were recorded in the month of January, 2016 followed by February, 2016 and March, 2016, respectively (Fig. 2). Unified meat with better water holding capacity determines the quality of the meat

(Picard et al., 2012), which in turn is affected by many factors including species, genotypes, nutrition and slaughtering and processing conditions. These factors also influence structure and chemical composition of the meat traits and intramuscular biological properties (Gagaoua et al., 2015).

During present study, average moisture contents (72.85 ± 0.67%) and crude protein (83.68 ± 0.52%) were recorded from the meat of grey francolin on dry matter basis. Similarly, fat contents (4.75 ± 0.27%) and ash contents (4.06 ± 0.10%) were recorded on dry matter basis in the meat of grey francolin (Table 1). Similar results were reported by Calik et al. (2015) who documented moisture contents (73.06%), crude protein (24.87%), fat contents 1.48% and ash contents 1.09% on wet basis. Monthly variations in chemical composition of meat of grey francolin were also observed during present experiment (Fig. 3). The highest moisture contents (73.51%) were recorded during the month of January, 2016 followed by February, 2016 and March, 2016. Similarly, the highest protein contents (84.17%) were observed from meat of *F. pondicerianus* during the month of March, 2016 followed by February, 2016 and January, 2016. The highest fat contents (5.05%) were recorded during March, 2016 followed by the months of February, 2016 and January, 2016. Maximum ash contents (4.16%) were observed during January, 2016 followed by the months of March, 2016 and February, 2016.

Average moisture contents (75.43 ± 1.12%) of broiler chicken were recorded during present study. Protein contents of broiler chicken were 79.98 ± 0.69% on dry matter basis, while fat contents (4.50 ± 0.57%) and ash contents (5.12 ± 0.13%) were recorded on dry matter basis (Table 1). Similar results were reported by Ali et al. (2007) who documented 75.47% moisture contents, 22.04% protein contents, 1.05% fat contents and 1.07% ash contents from the meat of broiler chicken on wet basis. Month-wise variations in meat chemical composition of chicken broiler were also recorded. In January 2016, the moisture contents (76.17%) were recorded higher than that of February, 2016 and March, 2016. Similarly, crude protein contents (80.72%) were also higher in January, 2016 than that of February, 2016 and March, 2016. In March, 2016 fat contents (5.07%) were higher as compared to February, 2016 and January, 2016. Similarly, ash contents (5.26%) were also higher in March, 2016 as compared to January, 2016 and February, 2016 (Fig. 4).

During present experiment, moisture contents of turkey meat were recorded as 78.52 ± 0.67%, protein contents 82.57 ± 0.57%, fat contents 2.75 ± 0.27% and ash contents 5.34 ± 0.22% on dry matter basis (Table 1). These findings are in line with Karakok et al. (2010) who reported that turkey meat contains moisture contents 73.12%, protein contents 24.38%, fat contents 1.19% and ash contents 1.43% on wet basis. Chemical variations in turkey meat from January, 2016 through March, 2016 were also observed during present experiment. The highest moisture contents (79%) were observed during January, 2016 followed by the month of March, 2016 and February, 2016. Protein contents were recorded maximum as 83.19% during January, 2016 followed by the months of February, 2016 and January, 2016. The maximum fat contents (3.03%) were recorded during March, 2016 followed by the months of February, 2016 and March, 2016, respectively. The maximum ash contents (5.57%) were recorded during the month of January, 2016 followed by February, 2016 and March, 2016 (Fig. 5).

Species-wise variations in chemical composition of meat were observed during present study. Moisture content varied significantly ($p<0.05$) between meat of domestic pigeon, wild pigeon, grey francolin, chicken broiler and turkeys. Significantly ($p<0.05$) higher moisture contents were recorded in turkey meat (Table 1). Omojola and Adesehinwa (2006) documented that low moisture ($p<0.05$) contents could be due to singeing operation. Apata et al. (2012) documented significantly higher ($p<0.05$) moisture and protein contents from stewed meat followed by roasted and fried meat.

Significant differences in protein contents of meat were recorded for meat of domestic pigeon, wild pigeon, grey francolin, chicken broiler and turkey (Table 1). Ali et al. (2007) reported significant ($p<0.05$) differences in crude protein, fat and total ash contents between the breast meat samples from the chicken. Crude protein and ash contents were significantly higher in chicken breast. Herkel (2016) reported significant ($p<0.05$) differences in crude protein and fat contents in pectoral muscles of turkey.

Fat contents of meat also varied significantly between domestic pigeon, wild pigeon and turkeys, while non-significant variations in fat contents were recorded between grey francolin and chicken broilers. Significantly higher ($p<0.05$) fat contents were recorded from meat of domestic pigeon, while the same were the lowest in meat of turkeys (Table 1). Omojola and Adesehinwa (2006) reported that significantly lower

($p<0.05$) fat contents from skinned carcass and it might be attributed to the removal of the skin with some of the under laying fat.

Non-significant variations in ash contents were observed between chicken and turkey meat however; turkey meat possessed slightly higher ash contents. Similarly, non-significant variations in ash contents were recorded for meat sample of domestic pigeon, wild pigeon and grey francolin (Table 1). Ali et al. (2007) recorded significantly higher ash contents from chicken breast as compared to the leg meat.

Table 1 Variations in chemical composition of meat of some captive avian species

Animal species	Moisture contents (%)	Crude protein contents (%)	Fat contents (%)	Ash contents (%)
Domestic pigeon	68.73 ± 0.99^{e}	69.41 ± 0.54^{e}	16.99 ± 0.56^{a}	4.20 ± 0.34^{b}
Wild pigeon	70.70 ± 0.67^{d}	74.65 ± 0.54^{d}	15.04 ± 0.83^{b}	4.47 ± 0.31^{b}
Grey francolin	72.85 ± 0.67^{c}	83.68 ± 0.52^{c}	4.75 ± 0.27^{d}	4.06 ± 0.10^{b}
Chicken broiler	75.43 ± 1.12^{b}	79.98 ± 0.69^{b}	4.50 ± 0.57^{d}	5.12 ± 0.13^{a}
Turkey	78.52 ± 0.67^{a}	82.57 ± 0.57^{a}	2.75 ± 0.27^{e}	5.34 ± 0.22^{a}

Means with different letters in a column are statistically significant $p<0.05$. DMRT was employed at 0.05 probability level. The values after ± demonstrate standard deviation.

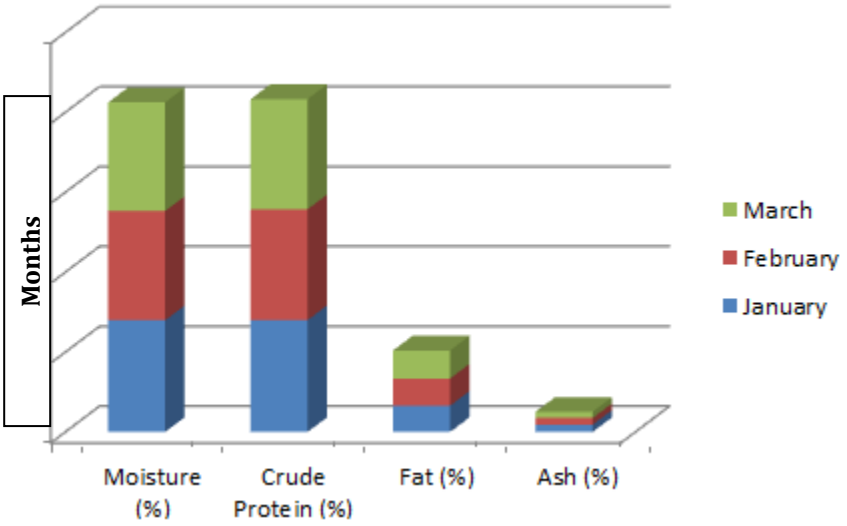

Fig. 1 Monthly variations in chemical composition of domestic pigeon meat

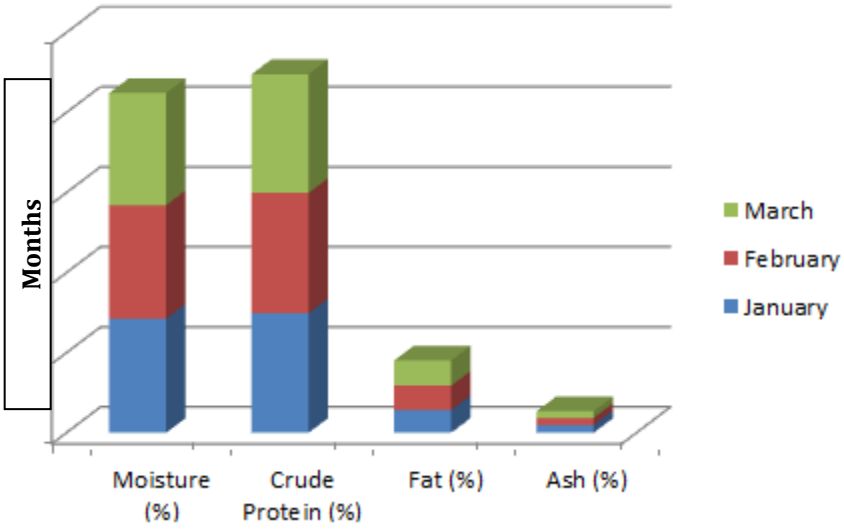

Fig. 2 Monthly variations in chemical composition of wild pigeon meat

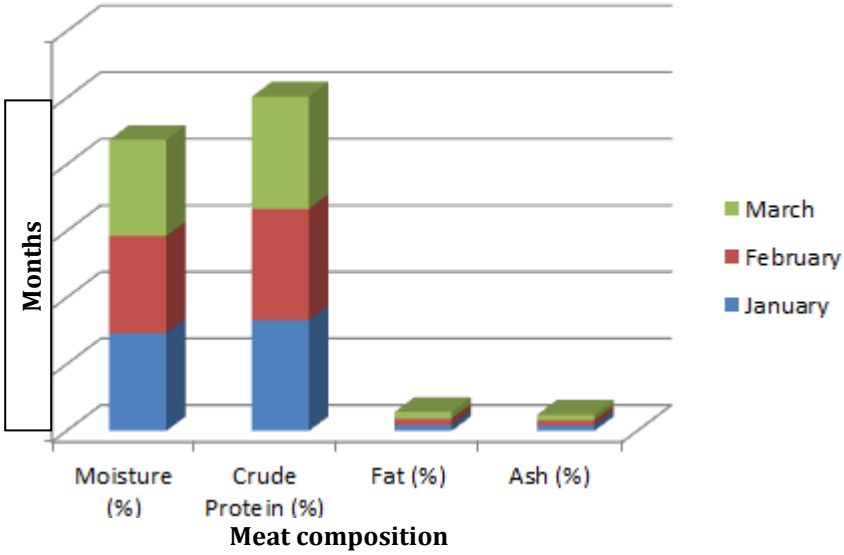

Fig. 3 Monthly variations in chemical composition of grey francolin meat

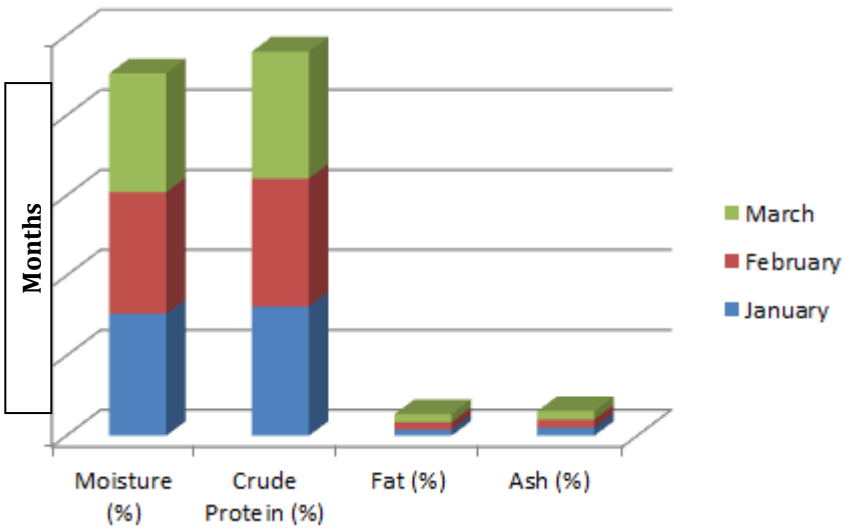

Fig. 4 Monthly variations in chemical composition of chicken broiler meat

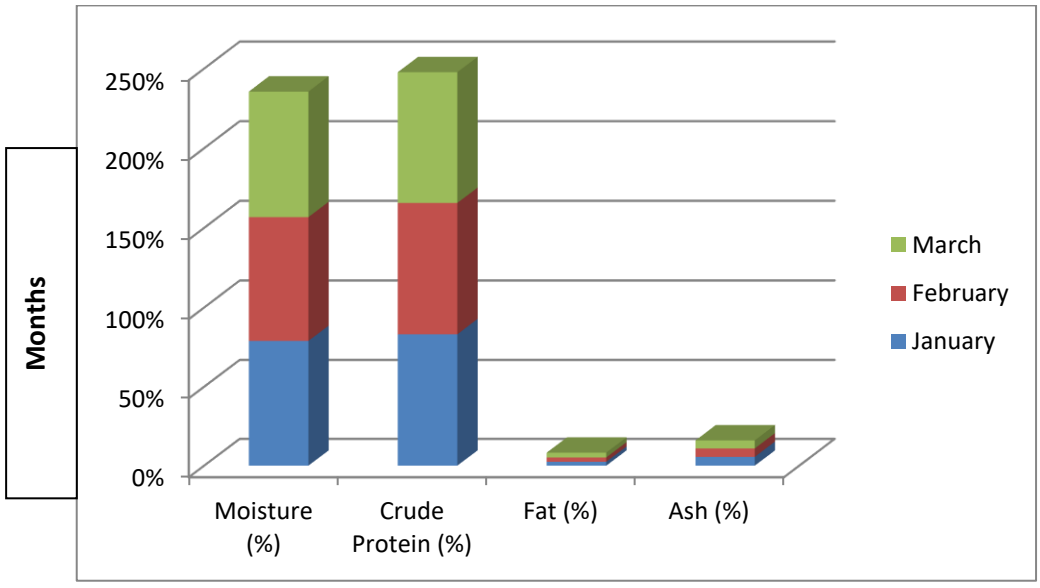

Fig. 5 Monthly variations in chemical composition of Turkey meat

CONCLUSION

It can be concluded from the present study that turkey meat contains higher moisture, protein and ash contents and lower fat contents than that of domestic pigeon, wild pigeon, grey francolin and chicken.

Authors Contribution Statement Shahid Javaid planned the experiment and refined the manuscript. Arshad Javid helped in statistical analysis of collected data. Umar Farooq collected data and executed the experiment. Ujala Kiran assisted in analysis and lab work. Tabinda Akmal helped in collection of data and rearing the birds.

Conflict of Interest The authors have mentioned no conflict of interest.

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ORIGINAL PAPER

Efficacy of quinolones and cephalosporins against antibiogram of *Escherichia coli* isolated from chickens

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Key Message This study evaluates the efficacy of quinolones and cephalosporins against antibiogram of *E. coli* isolated from chicken flocks and it reveals that these antibiotics were found to be effective against *E. coli*.

ABSTRACT Colibacillosis is an acute septicemia disease caused by *E. coli* producing considerable morbidity and mortality especially in poultry. Quinolones and cephalosporins have been used in treatment of various infections. Therefore, this study was designed to evaluate the efficacy of quinolones and cephalosporins against the antibiogram of *E. coli* isolated from chicken flocks. The 100 blood samples from liver and intestine were collected from different poultry vendors surrounding of Tandojam and Hyderabad, Sindh, Pakistan. The isolated organism was cultured on nutrient and blood agar media. The cultural, morphological and biochemical characteristics were observed for the confirmation of the isolated organism. The minimum inhibitory concentration (MIC) of different antibiotics against *E. coli* was performed by serially diluting antibiotics ciprofloxacin, metronidazole, cefipime as 0.4 µg/ml, 0.8 µg/ml, 1.6 µg/ml, 3.2 µg/ml and 6.4 µg/ml, 12.5 µg/ml, 25 µg/ml and 50 µg/ml, respectively. The mean zones of inhibition of ciprofloxacin, ofloxacin, enrofloxacin, norfloxacin, cefepime, ceftazidimine and cefoxitin against the antibiogram of *E. coli* were recorded as 14, 11, 12, 11, 11, 11, and 11 mm, respectively. MIC results indicated that ciprofloxacin was found to be more effective to inhibit the growth of *E. coli*. It was found that antibiotics of quinolones group namely ciprofloxacin, enroflaxcin and ofloxacin as well as cephalosporin group namely cefipime, ceftazidime and cefoxitin were found to be effective to isolate *E. coli*.

Keywords: Antibiogram, Cephalosporins, Chicken, *E. coli*, Quinolones

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INTRODUCTION

Pakistan is basically an agricultural country and livestock is considered to be an important sub-sector which contributes about 52.2% to the value addition in the agriculture sector and 11% in the total GDP (Khan et al., 2008). In Pakistan, poultry industry is developing during the last couple of decades and contributing in the increase of GDP. This sector not only produces meat and eggs but also provides large scale employment opportunities and source of income for the people (Government of Pakistan [GOP], 2014); Anjum et al., 2016). Microbial agents especially bacterial pathogens produce considerable health and production losses in poultry.

In Pakistan, colibacillosis is one of devastating diseases that causes heavy economic losses in poultry industry. This disease produces acute septicemia disease caused by *E. coli* with heavy motility particularly in broilers (Shah et al., 2004). *E. coli* were discovered by German Pediatrician and bacteriologist Theodor Escherichia in 1885. *E. coli* is widely distributed in nature and commonly found in normal intestinal tracts of man, animals and birds. It is a gram negative and rod shape bacterium, there are approximately 100 serotypes that have been recognized but *E. coli* strains 01, 02 and 078 are the most pathogenic causing severe infections in poultry and survive for longer time in poultry house. Usually, the organisms are present in the soil, water, dust, air, feed, litter, feathers and in open surfaces of the poultry farm (Holt et al., 1994). *E. coli* are not only harmful for poultry but also hazardous for other animal species as well.

E. coli can cause gastroenteritis, urinary tract infection, calf dysentery or "white scores" neonatal meningitis, mastitis, cystitis, metritis in cattle, sleeping foal disease in horse. It can cause peritonitis, pneumonia and in some cases it causes septicemia resulting animal death within 48 hours. It also causes enterotoxaemia in sheep and goats (Panduranga, 1996). In poultry, *E. coli* infected birds clinically show dullness, depression, elevated temperature, inappetence, diarrhea, hemorrhages and lesions on heart, intestines, proventiculous and gizzard (Cardona & Msoffe, 2009). There is growing concern to transmission and association of infections in humans. Recently, cephalosporin-resistant *E. coli* strains isolated from poultry exhibited phylogenetic relationship with the organism from human workers (Angela et al., 2016). The intestinal inhabitant commensally bacterial species poses a certain resistance against invasion and colonization of microbial agents (Pamer, 2016). The irrational use of antibiotics in veterinary practice is a great concern for treatment of bacterial infections. Also several microorganisms have acquired resistance to drugs, and decreases therapeutic options in clinical settings (Buffie et al., 2012).

Cephalosporins (β-lactum antibiotics; cefepime, cefotaxime, ceftriaxone and cefuroxime) are derived from fungus Acremonium. These antibiotics are commonly used in treatment of infection by gram negative bacteria i.e enterococci and *Streptococci pneumonia* (Palleres et al., 1993; Dahms et al., 1998). Cephalosporins induce their biological functions by interaction with bacterial enzymes and β-lactum (Flynn & Edwin, 2013). Quinolones (ciprofloxacin, ofloxacin, rifampicin, lincomycin, bacitracin, enrofoxacin, nalidixic acid and norfloxacin) are broad-spectrum antibiotics commonly used in veterinary medicine. It has been reported that these antibiotics lead to alteration, reduce accumulation and DN grease protection (Oliphant et al., 2002). In *E. coli*, quinolones target topoismerase IV for its antimicriobial action (Khodursky et al., 1995). Keeping in view the good therapeutic results of cephalosporins and quinolones against the gram negative bacteria, this study was designed to evaluate antimicrobial resistance/sensitivity of *E. coli* to quinolones and cephalosporins groups of antibiotics commercially available in market.

MATERIALS AND METHODS

Collection of samples, isolation and identification of the organism

The 100 blood samples of liver and intestine were collected from different poultry vendors in surrounding of Tandojam and Hyderabad, Sindh, Pakistan. The reference strain of *E. coli* was obtained from Department of Microbiology, University of Karachi. The samples were analyzed at Department of Veterinary Microbiology, Sindh Agriculture University Tandojam, Central Veterinary Diagnostic Laboratory, Tandojam, and Vaccine Production Unit, Tandojam, Hyderabad, Pakistan. The colonies of *E. coli* were used to obtain pure culture for the biochemical properties and sugar utilization efficiencies. The samples were cultured, isolated and identified using the methods described (Abro et al., 2016a, 2016b). The reference strain of *E. coli* was processed for confirming the similar cultural and biochemical characteristics.

Susceptibility test

The Muller Hinton agar (Difco) was prepared according to manufacturer's instructions and incubated at 37 °C for 15 min. Bulks of pure culture colonies were suspended in normal saline solution in order to match barium chloride standard for antibiotic sensitivity. Sterile swab was soaked in the suspended solution and culture was smeared on the medium. The colonies suspended swab was evenly applied on the surface of the medium and plates were incubated at 37 °C for 15 min. The antibiotics comprising of quinolones group; ciprofloxacin, ofloxacin, rifampicin, lincomycin, bacitracin, enrofoxacin, nalidixic acid, norfloxacin and Cephalosporins

group; cephradin, cefuroxime sodium, cefepime, cephalexin, ceftazidime and cefoxitin, cefotaxime, ceftriaxone and cefuroxime were used in this investigation. The antibiotic discs were applied on medium surface using disc dispenser and gently pressed with sterile forceps in order to complete contact with the surface of Muller Hinton agar. The plates were incubated overnight at 37 ^{o}C. The zone of inhibition was measured as a clear zone (free from growth around the disc = -) and a clear zone of inhibition formed against *E. coli*. The zone of inhibition produced by the drugs was measured from the center of disc to zone in millimeters.

Minimum inhibitory concentration (MIC)

This method is used to determine the minimum inhibitory concentration (MIC) of selected antibiotics. Muller Hilton broth was prepared in ten flasks, marked as 0.4 ug/ml. 0.8 µg/ml, 1.6 µg/ml, 3.2 µg/ml, 6.4 µg/ml, 12.5 µg/ml, 25 µg/ml, 50 µg/ml, 100 µg/ml and control (c). The medium was then incubated overnight to check sterility. Selected drugs (ciprofloxacin, metronidazole and cefapime) were added in above mentioned nine flasks according to the dilution mark on them and tenth was kept as a control. Forty test tubes measuring 13 × 100 mm plugged with cotton were sterilized in hot air oven at 170 ^{0}C for 2 h. The test tubes were grouped into four. Test tubes were then filled with medium containing antibiotic at the rate of 5 ml per tube. A single colony from *E. coli* incubated in the Miller Hilton broth; following the next day the organism was inoculated into the test tubes of each antibiotics group comprising of quinolones and cephalosporins. The test tubes were then incubated over-night and growth was observed. The minimum inhibitory concentration (MIC) of different antibiotics against *E. coli* was performed by serially diluting antibiotics as 0.4 µg/ml, 0.8 µg/ml, 1.6 µg/ml, 3.2 µg/ml and 6.4 µg/ml, 12.5 µg/ml, 25 µg/ml and 50 µg/ml, respectively.

RESULTS AND DISCUSSION

The data regarding mean size of inhibition of various antibiotics against *E. coli* is presented in Table 1. Higher zones of inhibition were formed by ciprofloxacin, ofloxacin, enrofloxacin, norfloxacin, cefepime, ceftazidimine and cefoxitin and their mean zones of inhibition was 14.0, 11.0, 12.0, 11.0, 11.0, 11.0 and 11.0 mm, respectively. Previously, it has been reported that organism is highly sensitive to these antibiotics (Rozina et al., 2004). However, earlier research observed that increase in resistance of *E.coli* to different antibiotics; oxytetracycline (97-100%), tetracycline (95-100%), neomycin (62-71%), trimethoprim (95-98%) and amoxicillin (50-65%). The exposure of *E. coli* was detected in chicken flocks of various poultry farms in Pakistan. The sensitivity of bacitracin against the isolated *E. coli* was observed resistant therapeutic in the control of *E. coli* infection. The findings of Ogunbanwo and Onilude (2004) are contradicted with the findings of our study. It was revealed in this study that *E. coli* showed complete resistance against bacitracin. While other antibiotics showed smaller zone of inhibition and were recorded as moderate or less effective against *E. coli*. However, it was observed that *E. coli* showed complete resistance against the lincomycin and bacitracin (Table 1). The efficiencies of enrofloxacin (73.96%) and amikacin (67.71%) had been reported highly active against *E. coli* isolated from broiler chicken. Although enrofloxacin was found to be more superior in the antibiotic activity than that of oxytetracycline and sulfadiment for control of morbidity and mortality caused by *E. coli* (Saha et al., 2003). *In vitro* antimicrobial testing of the isolated *E. coli* had been reported that 14 antimicrobial drugs revealed that 90% of the isolates of *E. coli* were sensitive to gentamycin and gentadox. They recorded that the organism was moderate sensitive (30-65%) to amoxicillin, sulfamethoxazole/trimethoprim, doxystin, chloramphenicol, enrofloxacin, furozolidine, norfloxacin, neomycin and ciprofloxacin. The findings of current research demonstrated that quinolones group; ciprofloxacin, enroflaxacin and ofloxacin effective against the isolated organism. Whereas, cephalosporin group; cefipime, ceftazidime and cefoxitin showed good efficacy against the organism.

Table 1 The mean sensitivity of *E. coli* against the various antibiotics observed during study

S. No.	Antibiotic used	Code	Zone of inhibition (mm)
A	**Quinolones**		
1.	Ciprofloxacin	CIP5	14
2	Ofloxacin	OFX5	11
3	Rifampicin	RD5	02
4	Lincomycin	MY10	R
5	Bacitracin	B10	R
6	Enrofoxacin	ENR5	12
7	Nalidixic acid	NA30	07
8	Norfloxacin	NOR10	11
B	**Cephalosporins**		
9	Cephradin	CE30	06
10	Cefuroxime sodium	CXM30	07
11	Cefipime	FEP30	11
12	Cephalexin	CL30	5.6
13	Ceftazidime	CAZ30	11
14	Cefoxitin	FOX30	11

R- Resistant i.e. no zone of inhibition

Table 2 The minimum inhibitory concentration of different antibiotic against *E. coli*

	Concentration of antibiotics (µg per ml media)									
Antibiotic	0.4	0.8	1.6	3.2	6.4	12.5	25	50	100	Control
Ciprofloxacin	-	-	-	-	-	-	-	-	-	+
Metronidazole	+	+	+	+	+	+	+	+	+	+
Cefipime	+	+	-	-	-	-	-	-	-	+
Amikacin	+	+	+	-	-	-	-	-	-	+

+ = Growth, - = No growth

The minimum inhibitory concentration (MIC) of different antibiotics against *E. coli* was performed by serially diluting antibiotics such as ciprofloxacin, metronidazole and cefipime as 0.4-50 µg/ml (Table 2). MIC results indicated that ciprofloxacin was found to be effective to inhibit the growth of *E. coli*. While the MIC of cefepime was found to be elevated concentrations of 0.4 µg/ml and 0.8 µg/ml of *E. coli*. In this study, ciprofloxacin showed better efficacy than that of cefepime against the isolated *E. coli*. Shuyu Wu et al. (2008) investigated in their conducted research on E. coli and found plate showed 74% effective for all strains and agreed within ± 1 log2 dilution when comparing MICs with Mueller-Hinton II media. Whereas, they noted significant variations for oxytetracycline and sulfamethoxazole against the organism. The description regarding minimum inhibitory concentrations of *E. coli* are in accordance with the previous reports (Saha et al., 2003; Shareef, 2004; Shuvu et al., 2008). Our findings demonstrated that the organism was highly sensitive to ciprofloxacin.

CONCLUSION

The antibiotics of quinolones group; ciprofloxacin, enrofloxacin and ofloxacin were effective to isolate *E. coli*. Whereas drugs belonged to cephalosporin group; cefipime, ceftazidime and cefoxitin showed good efficacy against the organism. The similar MIC results were obtained for antibiotic of quinolones and cephalosporin. The antibiogram of *E. coli* indicated that ciprofloxacin found to be effective antibiotic of quinolones and cephalosporin groups.

Author Contribution Statement Ranjhan Ali Lakho and Shahid Hussain Abro contributed in study conception and design. Ranjhan Ali Lakho, Shahid Hussain Abro and Muhammad Tarique Tunio contributed in acquisition of data. Mohsina Zubair, Rani Abro, Rahmatullah Rind contributed in analysis and interpretation of data. Riaz Ahmed Leghari and Kanwar Kumar Malhi contributed in drafting the manuscript. Ranjhan Ali Lakho, Muhammad Rafique Rind, and Asghar Ali Kamboh contributed in critical revision.

Conflict of Interest There is no conflict of interest

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