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Knowledge gap analysis of sugarcane growers in recommended sugarcane production technology in Khyber Pakhtunkhwa, Pakistan

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Abstract

Knowledge about innovation is the main ingredient of agricultural development and knowledge gap is at the crux of the yield gap. For this purpose, a study was carried out in two main sugarcane growing districts D.I.Khan and Mardan of Khyber Pakhtunkhwa province during 2018 to determine farmers' knowledge gap in fifteen recommended sugarcane production technology. Multistage sampling techniques were used and data were collected randomly from 285 sugarcane growers of districts D.I.Khan and Mardan through interview schedule. Knowledge gap index was used to measure the knowledge gap. The salient findings of the study showed that farmers had full knowledge gap in potash application and mechanical control of insects in both districts. The highest knowledge gap was found in disease control measures (85 and 97%), biological control measures of insects (79 and 77%) in districts D.I. Khan and Mardan, respectively. Similarly, district Mardan farmers had highest knowledge gap in cultural control of pest (63%), insecticides/doses (78%) and diseases identification (61%) as compared to district D.I. Khan. The knowledge gap index revealed that districts D.I. Khan and Mardan farmers had 49.91 and 52.79% knowledge gap in fifteen recommended sugarcane production technology. The main reasons of high knowledge gap might be due to lack of awareness and training program. The study suggested that awareness and training program should be organized for sugarcane growers especially in integrated pest management technology (IPM) in the study area.

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Introduction

Sugarcane (*Saccharum officinarm L.*) is an important and the second largest cash crop of Pakistan. Cane contributing 3.6 percent agriculture value addition and 0.7 percent in overall Gross Domestic product (GoP, 2018). It plays a vital role in the enhancement of socio-economic development of the country. Sugarcane is the major source of government revenue and fitches billions of rupees in the form of duties and taxes. Due to industrial advancement in recent years sugarcane is not only restricted to sugar production but also supply raw materials to other industries of the country (Iqbal and Iqbal, 2014).

Pakistan ranks 5th position in term of cane area and production and ranked 52nd in respect of per acre yield among the sugarcane growing countries of the world (FAO, 2016). Similarly, Pakistan ranks 8th in term of sugar production and consumption and 7th largest white sugar exporter of the world (PSMA, 2018). The sugar recovery is just 9-10% as compared to other countries of the world (Zaidi *et al.*, 2013). In Pakistan sugarcane yield is very low than potential yield due to poor management practices and post-harvest losses (Nazir *et al.*, 2013). The yield gaps between potential and on farm farmers exist in many countries of the world due to various factors. In Asian region the yield gap ranges from 17 to 50% except China which was 3.38% (Mondal, 2011). A huge gap exists between the improved practices and its adoption at farmers' fields which is reflected through poor yield (Tomar *et al.*, 2012). Lack of capital and inadequate knowledge and skills about the crop's agronomy contributed to low yield (Abura *et al.*, 2013). Cane farmers had lack of recommended knowledge about timely planting and planting techniques, diseases and pest management, improved varieties, cane seed treatment and nutrient management (Samantaray, 2017). The potential cane yield and sugar recovery can be increased if the modern technologies are transferred to the farmers farm (Gujar *et al.*, 2017).

Information plays an important role in farm productivity. Insufficient access to information may cause decline in estimated production (Ashraf *et al.*, 2015). In today's agriculture, knowledge is the main ingredient of agricultural development. As United States Agency for International Development (USAID) puts the knowledge gap is at the crux of the yield gap (Carlisle and Miles, 2013).

In order to sustain the sugar demand for internal consumption and export purpose, cane was cultivated in Pakistan on an area of 1.313 million hectares during 2017-18 as compared to last year area of 1.218 million hectares which showed 7.8 percent increase in cane area (GoP, 2018). Inter-provincial comparison of Pakistan reveals that Punjab is the leading province in terms of cane area and production and plays major role followed by Sindh and Khyber Pakhtunkhwa. Likewise, the cane yield per hectare of Khyber Pakhtunkhwa province is very low as compared to rest of the provinces (GoKP, 2018).

In Khyber Pakhtunkhwa, sugarcane is cultivated on 0.11 million hectares and covers 10.82% total sugarcane area of the country. Sugarcane is cultivated in 17 districts of Khyber Pakhtunkhwa contributing its role in sugar and *gur* production of the province (GoKP, 2018).

Although Public and private agricultural extension system has been continuously disseminated recommended sugarcane production technologies to cane farmers through various source of means. But still the cane farmers' especially small farmers do not have an access to right knowledge and skills. Many research studies about sugarcane production constraints, sugarcane economics and technical efficiency were already conducted in Pakistan, but study on knowledge gap was not found in Pakistan particularly in Khyber Pakhtunkhwa. Thus, present study has been designed with objective to determine farmers' knowledge and gap in recommended sugarcane production technology in the study area.

Materials and methods

Selection of the sites and samples

This study was conducted in Khyber Pakhtunkhwa

province during 2018. Multistage sampling procedures were used in order to cover the full spectrum of sugarcane growing districts of the province and to meet the study objectives. Districts, tehsils and union councils (UCs) were selected through multistage sampling procedures on the basis of sugarcane production whereas villages were selected randomly in the study area. Overall eight villages were randomly selected from eight union councils (UCs) in two tehsils of districts Mardan and D.I.Khan as presented in Table 1. Limenih and Tefera (2014) also applied similar procedures.

Sample frame

Selection of sugarcane farmers

In the study area out of total 1010 sugarcane farmers from the randomly selected eight villages, 285 farmers were selected through Sekaran (2003) sampling table. From the listed growers, 28 percent of sample was drawn from the sugarcane farmers of each village by using a proportional allocation sampling technique (Sajjad *et al.*,2012; Ali *et al.*, 2013) which is defined as:.

$$ni = \frac{Ni}{N} \times n \quad \text{..... (1.1)}$$

Where,

n_i = Number of sampled sugarcane growers in each village

N_i = Total number of sugarcane growers in i^{th} village

N = Total population in the sampled villages

n = Total number of sugarcane growers selected for the present study.

Data collection tools and procedures

This study was based on primary and secondary data. Primary data was directly obtained from 285 sugarcane farmers in the study area. For this purpose knowledge test was developed to measure knowledge gap. Hakeem and Dipak (2013) also applied similar approach. For measuring knowledge gap of sugarcane farmers knowledge test was prepared based on the recommended sugarcane production technology developed by the Sugar Crops Research Institute (SCRI) Mardan, Khyber Pakhunkhwa (Table 2). The sample sugarcane farmers were personally interviewed through a well-structured and pre-tested interview schedule. Primary data was randomly collected from the respondents at their farms, homes and their working places. While secondary data was collected from articles/studies, agricultural statistics, economic survey of Pakistan and internet etc.

Statistical analysis of the data

Knowledge gap

Knowledge gap refers to the difference in knowledge developed by Sugar Crops Research Institute (SCRI) Mardan regarding recommended cane practices and the knowledge possessed by the sampled sugarcane farmers. To measure the knowledge gap of sugarcane growers in fifteen different knowledge indicators such as farm yard manure (FYM), phosphorus (DAP), potash (SOP/MOP), nitrogen (Urea), Cultural control measures, Earthing-up, Weeding/hoeing, Mechanical control of insects, Biological control of insects, Herbicides/doses, Herbicides application stages/weeds identification, Insects identification, Insecticides/doses, Diseases identification and disease control measures were identified. For measuring knowledge gap, sugarcane management practice wise score was assigned such as 0= 'no knowledge', 1= 'partial knowledge' and 2= 'for complete knowledge' in the knowledge test. Overall score of the fifteen questions were thirty (30) score and each question carried two (2) score. The difference between achievable score and achieved score represented the knowledge gap of the respondents. This deviation was then articulated in percentage as the proportion to the farmer's achievable score (30). The knowledge gap was calculated by applying knowledge gap index. Kundu *et al.* (2013), Tomar *et al.* (2012), Ironkwe *et al.* (2008) and Kamruzzaman *et al.* (2001) also applied same Knowledge Gap Index (KGI) techniques. To determine the knowledge gap, the knowledge gap index (KGI) was used as:

$$KGI = \frac{Kp - ko}{kp} \times 100$$

..... (1.2)

Where as

KGI= Knowledge Gap Index

Kp= Maximum possible score of a farmers

Ko= Obtained knowledge score by a farmer

Results and discussion

Organic and inorganic fertilizer application

Farm Yard Manure (FYM)

The recommended application of rotten farm yard manure (FYM) is three to four trolleys acre^{-1} applied one month before to sugarcane field. The results exhibited in Table 3 that majority (71.3%) farmers of district D.I.Khan and 25.9% farmers of district Mardan had partial knowledge in respective technology while 74.1% farmers of district Mardan and 27.3% farmers of district D.I.Khan had complete knowledge.

Table 1. Distributions of sample sugarcane farmers by villages in the study area.

UCs	Villages	Total number of sugarcane farmers	Sampled sugarcane farmers
Tehsil Paroa (District D.I. Khan)			
Mahra	Mahra	170	48
Paroa	Paroa	150	42
Naivela	Jatta	150	42
Malana	Kat Shahani	65	18
Total		535	150
Tehsil Mardan (District Mardan)			
Khazana Dheri	Shiekh Yousaf	140	40
Babeni	Char Banda	130	37
Maho	Bakri Banda	125	35
Kandar	Sharif Abad	80	23
Total		475	135
G. Total		1010	285

Source: Agriculture Extension Department of districts D.I.Khan and Mardan.

It was remarkable that only (1.3%) farmers of district D.I.Khan and none of the sample farmers of district Mardan had no knowledge regarding recommended farm yard manure application to sugarcane field. The Knowledge gap index showed 37.0% knowledge gap in district D.I.Khan and 13.0% knowledge gap in district Mardan about recommended farm yard manure application to sugarcane field. The reasons of high knowledge gap in district D.I.Khan might be that the farmers had large land holding and mostly they concentrate on in-organic fertilizers while the farmers of district Mardan were mostly tenants and resources poor farmers due to which they mostly concentrate on organic fertilizers and applied their own livestock manure. Gujar *et al.* (2017) found that 71.67 percent trained and 41.67 percent un-trained farmers had complete knowledge whereas 28.33 percent trained and 58.33 percent un-trained farmers had partial knowledge regarding manure and fertilizer application. Patel and Vyas (2014) reported that that 62 percent technological gap exist in application of farm yard manure (FYM) in sugarcane crop. Jaiswal and Tiwari (2014) observed 60.38 percent knowledge level regarding compost/FYM application to cane crop.

Phosphorus Fertilizer (DAP)

The recommended phosphorus fertilizer (DAP) application is 1 to 2.5 bags acre^{-1} applied before cultivation in furrows and then covered with thin layer of soil along. The findings found that majority (72.7 and 85.2%) farmers of districts D.I.Khan and Mardan had partial knowledge whereas (27.3 and 14.8%) farmers of districts D.I.Khan and Mardan had complete knowledge respectively. The Knowledge gap index showed 37% gap in district D.I.Khan while farmers of district Mardan had 43% knowledge gap in phosphorus fertilizer (DAP) application. The main reason of the medium knowledge gap in phosphorus fertilizer application in the study area might be due to lack of awareness and communication gap of farmers with agriculture services providers (ASPs). Patel and Vyas (2014) found that 70 percent technological gap exist in application of basal fertilizer in cane crop.

Table 2. Recommended sugarcane production technology in Khyber Pakhtunkhwa.

S.No.		Organic and inorganic fertilizer application
1	Farm Yard Manure (FYM)	Three to Four trolley per acre rotten FYM apply one month before sowing
2	Phosphorus (DAP)	Depends on fertility of land Phosphorus fertilizer (DAP) Ranged from 1 to 2.5 bags per acre apply before sowing in furrows
3	Potash fertilizer (SOP/MOP)	Depends on fertility of land Potash fertilizer (SOP/MOP) ranged from 1.25 to 2 bags per acre apply before sowing in furrows
4	Nitrogen (Urea)	Depends on fertility of land Urea ranged from 1.5 to 3 bags per acre apply in three different timings during sugarcane growing seasons Autumn Cultivation Apply 1/3 urea in the starting month of November and the rest two doses will apply in the month of March and in the end of April during earthing up Spring Cultivation Urea first dose apply in the Month of April, Second dose in the month of May and third dose apply in the month of June during earthing up
		Integrated pest management (IPM)
5	Cultural Control of Pest	-Harvest the sugarcane near the soil upto 1-1.5 inch. -- Earhting up regularly - Ratoon cover with soil layer in May-June. -Disease free and resistant varieties -Disease effected sugarcane up rooted -Crop rotation -Seed treatment - Use clean implements etc.
6	Earthing-up	-Earthing up till control of weed - Spring crop earthing up will be complete upto end of June -Autumn the earthing up will be completed from March to April
7	Weeding/Hoeing	Hoeing started after first or second irrigation and continue the hoeing till control of weed
8	Mechanical Control of Insects	Use light traps at night time (March to October) for control of Insects
9	Biological Control of Insects	The recommended biological control for insects in cane crop is applied 6-8 Trichogramma cards per acre after 15 days interval from April to September.
10	Diseases Control measures	-Disease free and resistant varieties -Disease affected cane up rotted -Crop rotation -Seed dressing -Use clean implements
		Chemical control measures
11	Herbicides/ doses	Chemical Control of Weed - Gezapexcombi 80WP@ 1-1.5 kgs per acre - Ametryn + Atrazine @ 1kg per acre - Krismat 75 WG@ 400 gram per acre after cultivation
12	Insecticides/ doses	Basodine 10 G @ 8-10 kgs per acre -Diazinon 10% @ 8 kgs per acre -Furadan 3% @ 5-12 kgs per acre -Folidol 50% @ 500-700 ml per acre -Thiodan granular @ 7 kgs per acre - Lorsban 40 EC @ 1-2 liter per acre etc.
		Pest identification
13	Herbicides application stages/ weed Identification	The recommended stage for control of weeds is 40-45 days after sugarcane cultivation when the weeds have 3-4 leaves stages.
14	Insects Identification	Top borer, Stem borer, Root borer, Gurdaspur borer, White Fly, Bugs, Thrips, Mites (Red mite and White mite), Termites
15	Diseases Identification	Whip smut, Red Rot, Ratoon Stunting Disease, Mosaic, Red Stripe, Wilting, Nematodes

Source: Sugar Crops Research Institute (SCRI) Mardan.

Jaiswal and Tiwari (2014) found 64.23 percent knowledge level of the sample respondents about Phosphorous application in sugarcane crop.

Potash Fertilizer (SOP/MOP)

The recommended application of potash fertilizer (SOP/MOP) is 1.25 to 2 bags acre^{-1} applied pre

planting/sowing for sugarcane crop in furrows. The farmer knowledge was estimated on the basis of recommended potash fertilizer application. The results indicated that all of the sample respondents of districts D.I.Khan and Mardan had no knowledge regarding application of recommended doses of Potash fertilizer (SOP/MOP) in sugarcane and the entire sample respondents of both districts had full knowledge gap regarding recommended doses of potash fertilizer application in cane crop.

The genuine reason of full knowledge gap about the potash fertilizer application might be due to lack of awareness, trainings of farmers about the role and importance of potash fertilizer on cane quality and production in the study area.

Table 3. Practices wise knowledge and gap of sugarcane growers by districts.

S.No.	Technology	D.I.Khan				Mardan			
		No Knowledge	Partial Knowledge	Complete Knowledge	KG Index (%)	No Knowledge	Partial Knowledge	Complete Knowledge	KG Index (%)
	Organic and inorganic fertilizer application								
1	FYM	2(1.3)	107(71.3)	41(27.3)	37	0	35(25.9)	100(74.1)	13
2	Phosphorus (DAP)	0	109(72.7)	41(27.3)	37	0	115(85.2)	20(14.8)	43
3	Potash (SOP/MOP)	150(100)	0	0	100	135(100)	0	0	100
4	Nitrogen (Urea)	0	40(26.7)	110(73.3)	14	0	40(29.6)	95(70.4)	15
	Integrated pest management (IPM)								
5	Cultural Control of pest	42(28)	96(64)	12(8)	60	46(34.1)	77(57)	12(8.9)	63
6	Earthing-up	0	0	150(100)	0	0	0	135(100)	0
7	Hoeing	0	0	150(100)	0	0	0	135(100)	0
8	Mechanical Control of insects	150(100)	0	0	100	135(100)	0	0	100
9	Biological Control of insects	113(75.3)	11(7.3)	26(17.3)	79	95(70.4)	18(13.3)	22(16.3)	77
10	Disease control measures	105(70)	45(30)	0	85	127(94.1)	8(5.9)	0	97
	Chemical control measures								
11	Herbicides/ doses	33(22)	72(48)	45(30)	46	47(34.8)	59(43.7)	29(21.5)	57
12	Insecticides/ doses	41(27.3)	87(58)	22(14.7)	57	75(55.6)	60(44.4)	0	78
	Pest identification								
13	Herbicides application stages/ weed Identification	8(5.3)	78(52)	64(42.7)	32	21(15.6)	83(61.5)	31(23)	47
14	Insects Identification	24(16)	95(63.3)	31(20.7)	48	19(14.1)	80(59.3)	36(26.7)	44
15	Diseases Identification	20(13.3)	130(86.7)	0	57	28(20.7)	107(79.3)	0	61

Source: Field Data.

Nitrogen Fertilizer (Urea)

The recommended nitrogen (urea) application is 1.5 to 3 bags acre^{-1} applied in three different timings during growing season of cane crop. The data exhibited that the majority (73.3 and 70.4%) farmers of districts D.I.Khan and Mardan had complete knowledge while (26.7 and 29.6%) farmers of districts D.I.Khan and Mardan had partial knowledge regarding urea application in sugarcane crop.

The knowledge gap index showed that (14 and 15%) knowledge gap in districts D.I.Khan and Mardan about nitrogen application to sugarcane crop. The defined reason of low knowledge gap of farmers in the

research area about nitrogen application might be due to farmer awareness through various means of well publicities such as electronic/poster advertisement and their easy availability, low price and its quick responses. Jaiswal and Tiwari (2014) identified 64.61 percent knowledge level of the sample respondents in nitrogen application in cane crop. Kumar *et al.* (2017) found that 67.50 percent respondents were partially known followed by fully known (30%) about balance doses of fertilizers application in cane crop.

Table 4. Knowledge Gap Categorization of the sugarcane growers by districts.

Knowledge Gap	D.I.Khan		Mardan		Overall		Std. Dev.
	Frequency	Percent gap	Frequency	Percent gap	Frequency	Percent gap	
High (Up to 11.56 Score)	26 (9.12)	67.05	24 (8.42)	65.69	50 (17.54)	66.40	3.356
Medium (Between 11.57-17.65 Score)	87 (30.52)	50.80	93 (32.63)	52.32	180 (63.16)	51.59	4.836
Low (More than 17.66 Score)	37 (12.98)	35.76	18 (6.31)	37.96	55 (19.30)	36.48	4.644
Overall	150 (52.63)	49.91	135 (47.37)	52.79	285 (100)	51.27	10.173

Source: Field Data Figures in parenthesis are percentage Mean 14.62 Std. Dev.3.052

Integrated pest management (IPM)

Cultural measures for pest control

The farmers' knowledge was measured in respect of cultural measures for pest control. The recommended techniques for cultural measures for pest control are harvesting sugarcane crop near the soil, earthing up regularly, ratoon cover with soil layer in May-June, resistant varieties, crop rotation, intercropping, seed treatment, use clean implements etc. The results showed that majority (64 and 57%) farmers of districts D.I.Khan and Mardan had partial knowledge while (34.1 and 28%) farmers in districts Mardan and D.I.Khan had no knowledge respectively regarding cultural measures for pest control. In district D.I.Khan (8.9%) farmers and district Mardan (8.0%) farmers had complete knowledge regarding cultural measures for pest control. The knowledge gap index revealed 63% and 60% knowledge gap in districts Mardan and D.I.Khan about cultural control of pest. The major reasons of high knowledge gap in both districts about cultural measures for pest control might be due to lack of awareness and training regarding latest and updated techniques about cultural practices for pest control in the study area.

Earthing-up

The earthing-up is very important step for control of weeds, insects, disease and prevent the crop from lodging and other natural calamities. The recommended earthing up practices for spring crop should be completed upto June and for autumn crop this should be completed from March to April. The farmers' knowledge regarding earthing up to sugarcane crop was measured on the basis of recommended earthing up practices. The results indicated that all of the sample farmers of districts D.I.Khan and Mardan had complete knowledge regarding recommended earthing up practices in sugarcane crop. The knowledge gap index showed that both districts farmers had full knowledge about recommended earthing up practices in the study area. Reason of full knowledge of farmers about the recommended earthing up practices to sugarcane crop is very common due to farmers' awareness about the importance and role of earthing up and their expertise in traditional knowledge transferred from their fore fathers. Jaiswal and Tiwari (2014) found 84.80 percent knowledge level of the sample respondents in earthing-up of cane crop.

Hoeing

The recommended hoeing practice for control of weeds is started after first or second irrigation up to 6 weeks after cane setts sowing (DAS). All of the sample farmers of districts D.I.Khan and Mardan had complete knowledge regarding weeding at various

stages in sugarcane crop. The knowledge gap index revealed that the sample farmers of districts D.I.Khan and Mardan had no knowledge gap in respect of recommended weeding/hoeing practices in the study area. The general reason and expertise of the sample farmers about weeding/hoeing practice might be due to their full awareness about the weeding importance and role. Our study results are dissimilar to Abura *et al.* (2013) who reported that majority of the sample respondents did not know the recommended number of weeding in sugarcane crop. Patel and Vyas (2014) found 60 percent technological gap regarding weeding and inter-culturing practices in cane crop.

Mechanical control measures of insects

The farmer knowledge was depicted on the basis of mechanical control of insects by using light trap at night time during March to October. It was remarkable that all of the sample respondents of districts D.I.Khan and Mardan had no knowledge regarding mechanical control of insects through light trap. The knowledge gap index showed that both districts farmers had full knowledge gap regarding mechanical control of insects. The main reason of full knowledge gap about insects control through light trap might be due to unawareness and training of farmers and low interest of agricultural extension department about the dissemination of such type technology in the study area. Kumar *et al.* (2017) found that 45 percent respondents partially known followed by 43.75 percent unknown about the light and pheromone trap in cane crop.

Biological control measures

The recommended biological control for insects in cane crop is application of 6-8 Trichogramma cards acre^{-1} after 15 days interval from April to September. The farmers' knowledge was measured on the basis of suggested techniques. The results exhibited that sample farmers of both districts had wide knowledge gap in respect of biological control of insects. The results showed that majority (75.3 and 70.4%) farmers of districts D.I.Khan and Mardan had no knowledge regarding biological control of insects. The ratio of complete knowledge was (17.3 and 16.3%) in districts D.I.Khan and Mardan while (13.3 and 7.3%) farmers of districts Mardan and D.I.Khan had partial knowledge in the study area. The knowledge gap index of biological control measure showed (79 and 77%) knowledge gap in districts D.I.Khan and Mardan respectively. The major reason of low knowledge of farmers about the biological control of insects might be due to lack of awareness and training of farmers and the ignorant of the agricultural departments about the dissemination of biological measures for insects' control. Karamidehkordi and Hashemi (2010) reported that all of the sample respondents had no experience about biological methods to control pest.

Diseases control measures

The farmers' knowledge was measured in respect of cultural control measures for sugarcane diseases control. The recommended techniques for diseases control measures are to select and cultivate disease free and resistant varieties, disease affected sugarcane up rooted from the crop, crop rotation, seed treatment, use clean implements etc. The farmers knowledge was determined on the basis of diseases control measures through cultural practices. The data showed that overwhelming majority (94.1 and 70%) farmers of district Mardan and district D.I.Khan had no knowledge, while 30% farmers of district D.I.Khan and 5.9% farmers of district Mardan had partial knowledge. Knowledge gap index showed that district Mardan farmers had 97.0% knowledge gap and district D.I.Khan farmers had 85% knowledge gap regarding disease control measures. The major reason of high knowledge gap might be due to lack of awareness and farmers training regarding disease control measures in the study area. Jaiswal and Tiwari (2014) found 38.65% knowledge level about disease control in cane crop.

Chemical control measures

Herbicides

Herbicides and doses

The sample farmers' knowledge was measured on the basis of recommended herbicides and their doses applied for control of weeds in sugarcane crop. In

Market, various brands of weedicides are available. The recommended herbicides along with their appropriate doses for control of weeds in sugarcane crop on the prior recommendation of the research institutes are presented in Table 2. The results revealed that majority (48 and 43.7%) farmers of districts D.I.Khan and Mardan had partial knowledge while (30 and 21.5%) farmers of districts D.I.Khan and Mardan had complete knowledge whereas 22% farmers of district D.I.Khan and 34.8% farmers of district Mardan had no knowledge about herbicides and application of proper doses. The knowledge gap index showed 46% knowledge gap in district D.I.Khan and 57% knowledge gap in district Mardan. The reason of high knowledge gap in herbicides and application of proper doses were depended upon the sample farmers' technicality, education and also based on agricultural services providers (ASPs) expertise in the study area. Jaiswal and Tiwari (2014) reported that the sample respondents had 48.84 percent knowledge level about weed control in cane crop. Karamidehkordi and Hashemi (2010) found that the farmers did not know the full characteristic of how to apply the herbicide.

Insecticides

Insecticides and doses

To control insects in sugarcane crop the farmers mostly rely on pesticides dealers and agricultural department. The recommended prescription for control of insects is based on agricultural departments. So, the farmers' knowledge was measured on the basis of insecticides and their proper doses application in sugarcane crop is presented in Table 2. The findings showed that majority (55.6%) farmers of district Mardan had no knowledge about insecticides and proper doses application. It was remarkable that 27.3% farmers of district D.I.Khan had no knowledge regarding insecticides and application of proper doses while (58 and 44.4%) farmers of districts D.I.Khan and Mardan had partial knowledge in this aspect whereas only (14.7%) farmers of district D.I.Khan had complete knowledge and none of the sample farmers of district Mardan had complete knowledge on this aspect. The knowledge gap index showed (78 and 57%) of the knowledge gap in districts Mardan and D.I.Khan farmers respectively. The major reason of high knowledge gap might be due to lack of awareness and dependency on agricultural services providers (ASPs) and agriculture department. Gujar *et al.* (2017) revealed that majority (63.33%) of the trained farmers had complete knowledge followed by partial knowledge 36.67% whereas 30% of un-trained farmers had complete knowledge and majority (70%) of un-trained farmers had partial knowledge regarding plant protection. Patel and Vyas (2014) identified that 81% technological gap exist in plant protection in cane crop. Jaiswal and Tiwari (2014) found that the sample farmers had 46.34% knowledge regarding insect control in cane crop. Kumar *et al.* (2017) reported that 63.75% respondents were partially known whereas 20% respondents did not know the recommended doses of pesticides in cane crop. Karamidehkordi and Hashemi (2010) observed that 26% farmers were aware about the appropriate time of pesticide application and 32% knew the correct method of pesticide application, the farmers applied pesticides 80-90% according to suggestion of experts.

Pest identification

Herbicides application stages and weeds Identification

The recommended stage for control of weeds is 40-45 days after sugarcane cultivation when the weeds have 3-4 leaves. The data showed that majority (61.5 and 52%) farmers of districts Mardan and D.I.Khan had partial knowledge, while 42.7% farmers of district D.I Khan and 23% farmers of district Mardan had complete knowledge. Only negligible number (5.3%) farmers of district D.I.Khan and 15.6% farmers of district Mardan had no knowledge regarding narrow, broad and sedges types of weeds identification and their application on right stages. The knowledge gap index showed that sample farmers of district Mardan had 47% knowledge gap and farmers of district D.I.Khan had 32% knowledge gap about weeds identification and their application on right stages. The reason of high knowledge gap in respect of

herbicides application stages and weed identification might be due to lack of awareness about weed identification and control in right stage. Rao (2000) reported that 20% loses from pathogens, 30% from insects whereas 45% loses in crops production occurring from various type of toxic weeds infestation due to which sample farmers fail to identify and control these weeds in right stage and time.

Insects identification

The knowledge of farmers was recorded on the basis of insects' identification either the farmers can identify the insects that attacked on their sugarcane crop. The results revealed that majority (63.3 and 59.3%) farmers of districts D.I.Khan and Mardan had partial knowledge while 26.7% farmers of district Mardan and 20.7% farmers of district D.I.Khan had complete knowledge and only (16%) farmers of district D.I.Khan and 14.1% farmers of district Mardan had no knowledge regarding insect identification in cane crop. The knowledge gap index showed that 48% knowledge gap in district D.I.Khan and 44% knowledge gap was found in district Mardan in respect of insects identification. The major reasons of high knowledge gap about insects identification in sugarcane crop might be due to lack of entomological training and awareness. Karamidehkordi and Hashemi (2010) reported that more than fifty percent (50%) of the farmers identified the pest with wrong name.

Diseases identification

The farmers' knowledge was measured on the basis of disease identification either the farmers can identify the disease that attacked on their sugarcane crop. The results revealed that majority (86.7 and 79.3%) farmers of districts D.I.Khan and Mardan farmers had partial knowledge respectively, while 20.7% farmers of district Mardan and 13.3% farmers of district D.I.Khan had no knowledge. It was astonishing that none of the sample farmers of both districts had complete knowledge regarding diseases identification in cane crop. The knowledge gap index showed 57% gap in district D.I.Khan and 61% gap in district Mardan in respect of identification of cane diseases. The major reasons of high knowledge gap regarding diseases identification were might be due to lack of pathological training and awareness of farmers in the study area.

Knowledge gap categorization of the sugarcane farmers

The knowledge gap of the sample respondents were categorized into three groups such as high, medium and low on the basis of their score obtained. Those sample respondents got upto11.56 score ranked as high knowledge gap followed by medium knowledge gap obtained score between 11.57 to 17.65 and low knowledge gap was above 17.66 score in the study area. The data exhibited in Table 4 that majority (32.63 and 30.52%) farmers of districts Mardan and D.I.Khan had medium knowledge gap whereas 12.98% farmers had low knowledge gap and 9.12% of the sample respondents had high knowledge gap in district D.I.Khan respectively. While in district Mardan 8.42% farmers had high knowledge gap and only 6.31% farmers had low knowledge gap. The overall finding reveals that majority (63.16%) farmers had medium knowledge gap followed by low knowledge gap 19.30% and high knowledge gap of 17.54% in the study area. The knowledge gap index revealed 49.91% knowledge gap in district D.I.Khan and 52.79% knowledge gap in district Mardan. The overall knowledge gap was found 51.27% in the study area about recommended sugarcane production technology in the study area. Our finding regarding medium knowledge gap is almost similar as compared to Gujar *et al.* (2017) who found that 58.33 percent of the respondents had medium level of knowledge followed by low 28.33% and high 13.34%. Patel and Vyas (2014) reported that 65 percent of the sample respondents had medium level of knowledge and technological gap in sugarcane.

Conclusion

Salient findings of the study showed that sugarcane farmers had full knowledge gap in potash application and mechanical control of insects. Maximum knowledge gap was found in diseases control measures, biological and cultural control of insects.

Similarly, farmers had highest knowledge gap in phosphorus fertilizer, herbicides/doses, herbicides application stages/weed identification, insecticides/doses, insects and diseases identification in the study area. Most of the farmers had medium knowledge gap regarding recommended cane production technology in the study area. The results further revealed that farmers of district Mardan had more knowledge gap as compared to farmers of district D.I.Khan. The knowledge gap that exist in recommended production technologies were the major causes of low cane yield specially in district Mardan. The study suggested that awareness and training program should be organized for sugarcane growers in integrated pest management practices especially in mechanical control of insects, diseases control measures, biological control of insects and cultural control of pest. Agriculture extension department technical staff frequently visits should be conducted to farmers' field to updated sugarcane growers knowledge about improved sugarcane production technology.

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