Association of Agricultural Machineries and Nitrogen Application with Sugarcane Crop at Selected Districts of Khyber Pakhtunkhwa Province: Pakistan

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Abstract

This study was initiated to find out association of agricultural machinery and nitrogen application in sugarcane crop at two selected districts (Mardan and Charsadda) of Khyber Pakhtunkhwa province. A sample of 336 sugarcane growers was drawn through multistage sampling. An interview schedule was used to solicit responses from growers. It was found that 74, 25 and 2 per cent respondents used a hired tractor-drawn cultivator and engine driven rotovator as main agricultural implements in soil preparation. Their average yields were 65.01 and 57.55 t ha^{-1}. The sugarcane growers were using wooden ploughs had the highest average yield 74.52 t ha^{-1} and used the most fertile land 'silt loam'. They applied 220-270 kg ha^{-1} of Nitrogen to achieve relatively high yield (around 100 t ha^{-1}). Those who used recommended methods of agricultural machinery by advice of agricultural extension department achieved 114.01 t ha^{-1} yield while those who depended on their own resources to access information got only 58.67 t ha^{-1}. It is concluded that the use of recommended inputs, farming fertile land, and using better techniques for land preparation led to increased sugarcane yield. The government extension service and NGOs should create greater awareness about recommended input rate and soil preparation techniques among sugarcane growers.

Keywords: Types of agricultural machineries, sugarcane crop, agricultural extension, multi-level extension techniques, nitrogen application

Introduction

Agriculture is a major part of the Pakistan economy. In 1947 (when independence was granted), agriculture contributed 53% of the gross domestic product (GDP). While in 2013, it is recorded 21.4%. The share of the workforce employed in agriculture has also declined (from 66% to 45%) over the same period (Anon., 2014).

The total geographical area of Pakistan is 79.61 million hectares, of which Khyber Pakhtunkhwa (KP), Province is 10.17 million hectares. Of the total area of KP province, only 1.87 million hectares are used for cultivation. Pakistan generally, and KP in particular depends on a canal system for irrigation and agricultural production. Agricultural poduction is dominated by crops such as Sugarcane, Wheat, Maize, Tobacco, Vegetables and Fruit Sugarcane is a kharif crop which means

cultivation activities in KP province start from October to November and harvesting from April to June respectively. Sometimes harvesting of these major crops overlaps with land preparation for the next crop (Anon., 2014).

Agricultural mechanization is an important input in agricultural production. It increases productivity of labour and has the potential to improve cropping intensity and productivity by helping achieve timely crop establishment, introducing effective cultural practices, efficient harvesting and reduced postharvest losses. It also results in considerable savings of fodder and feed through a reduction in the bullock population. Thus, a transition from subsistence to commercial farming can be achieved through diffusion of modern, efficient, cost-effective mechanization technologies into animal powered farming systems. The efficient use of scarce agricultural resources coupled with accelerated agricultural mechanization is important in developing countries (Anon, 2005).

The adoption of agricultural mechanization is somewhat selective in Pakistan and currently only those operations are mechanized for which there are constraints of labour or power or a combination of both. Overall, the effects of farm mechanization are generally positive. The experience in countries that went through the transformation from animal power in agriculture to mechanization is that it has both increased on-farm income and labour productivity and also generated the opportunity for off-farm employment in manufacturing, supply/servicing of agricultural machinery, supply of other inputs, and post-harvest handling of increased agricultural production. The most popular forms of mechanization occurring in Pakistan now are bulldozers for land levelling, powered pumps on tube wells for irrigation, as well as tractors for cultivation, wheat threshers, sprayers, and trailers. Mould board and disc ploughs for deep tillage have gained popularity (Anon, 1988) in contrast to many more mechanized countries were minimal tillage and conservation agriculture are now widely used.

The uptake and losses of the nitrogen described in a first ratoon sugarcane (*Saccharum officinarum* L.) crop in Queensland, Australia where urea was applied on the soil surface or drilled 3 – 4 days post-harvest. A micrometeorological method was used to measure ammonia volatilization. For N recovery in plants and soil (depth of 140 cm) mass balance was used in macro plots with 15 N labelled urea at 166 and 334 days after the application of fertilizer. Most of the nitrogen uptake from soil and fertilizer by plants occurred till day 166. The use of nitrogen efficiency (recovery of labelled nitrogen in sugarcane) was very low. During the final sampling (day 334), the efficiencies of surface and sub-surface treatment was 18.9% and 28.8% respectively. The tops, leaves, stalk and roots in the sub-surface treatment consisted significantly more fertilizer nitrogen than corresponding parts in the surface treatment. After final sampling (days 334), The total recoveries of nitrogen fertilizer for the plant-trash-soil system shows significant losses of nitrogen in surface treatment 59.1% and sub-surface treatment 45.6% of applied nitrogen. Drilling the urea into the soil instead of applying it to the trash surface reduced ammonia loss from 37.3 to 5.5% of the applied Nitrogen. Subtracting the data for ammonia loss from total loss suggested that losses by leaching and de-nitrification combined increased from 21.8 and 40.1% of the applied Nitrogen as a result of the change in method of application. While the treatment resulted in increased de-nitrification and/or leaching loss, total Nitrogen loss was reduced from 59.1 to 45.6%, (a saving of 13.5% of the applied Nitrogen), which resulted in an extra 9.9% of the applied Nitrogen being assimilated by the crop. (Prasertsak et al., 2002).

Nitrogen fertilizers management is increasing important in sugarcane production as essential to decreasing environment impact of nitrogen worse. The research study introduces new method for nitrogen management as nitrogen replacement system. The system depend on soil nitrogen to “buffer” difference in crop nitrogen requires and nitrogen fertilizers supply to individual ten sugarcane crops, and aligns nitrogen application with actual sugarcane production over the long term rather than potential production. In 11 experiments, conducted in a wide range of environments over two to five crops, cane and yields being more in the

nitrogen replacement treatment were same to those get with growers conventional nitrogen management, with the trend to over successive crops for yields to increase relative to conventional management. The location where experiment starts for 15 at least 4 years, this trend resulted in cumulative sugar yields being higher in the nitrogen replacement treatment. Average application of nitrogen was 35% lower in the replacement treatment, and nitrogen lost to the environment was approximated to be 50% lesser. Soil nitrogen buffering was enough to maintain sufficient nitrogen supply to crops even when yields were up to 30% more than expected. Thus, it is not supported to nitrogen fertilizers applications to most probable 20 sugarcane yields, which are hardly adapted in practices. The results of the research show that the ecologically based nitrogen replacement system has potential to provide more environment outcomes without significantly decreasing sugarcane production, and potentially other semi perennial crops in the tropic and sub-tropic regions. Further evaluation of the system will be beneficial, and there is scope for determining more location specific values of parameters in the 3 systems. However, care must be taken to evaluate the system over sufficient time period (e.g. .2 crops) so that productivity improvement moves in the nitrogen replacement system can be stated (Thorburn et al., 2010).

The introduction of agricultural machinery and used of nitrogen are an important aspect of agricultural development and more profitable. According to many experts, mechanized farming and recommended doses of nitrogen are cost effective, less time consuming, and more profitable. However due to topography and the nature of soil types and conventional farming system in some parts of Pakistan, particularly in Khyber Pakhtunkhwa, agricultural mechanization is either not possible or uneconomical.

The main objectives of the research study are spelled out to study the impact of agricultural mechanization, recommended inputs and suitable dose of nitrogen application on sugarcane yield in study area and to develop suggestions and recommendations for future policy makers in Pakistan regarding appropriate use of agricultural machinery and the optimal level of inputs in mechanized cane production.

Materials and Methods

Out of a total 29 districts in Khyber Pakhtunkhwa province, sugarcane is cultivated in six districts namely Mardan, Charsadda, Peshawar, Dera Ismail Khan, Malakand, and Swabi. According to the Khyber Pakhtunkhwa Bureau of Statistics, the major areas for sugarcane cultivation are Mardan and Charsadda districts. Therefore, these two districts were purposely selected for this research as shown in Table 1.

Table 1 Area (ha), production (t/ha) and yield (t/ha) of sugarcane in Khyber Pakhtunkhwa Province in Pakistan

Districts	Area	Production	Yield
Charsadda	34593	1502268	43.42
Mardan	30436	1420448	46.67
Dera Ismail Khan	13565	575674	42.43
Peshawar	11106	576850	51.94
Malakand	4670	175529	37.58
Swabi	4336	170161	39.24

Source: Khyber Pakhtunkhwa Bureau of Statistics, 2013

A mutli-stage sampling method was used to select the required sample of farmers to interview. In the first stage of sampling, two tehsils (the sub-division below district) namely Takhatbhi and Tangi from Mardan and Charsadda districts respectively were randomly selected. From each selected tehsil, five union councils (next lower sub-division) namely Saro Shah, Madey Baba, Pir Saddi, Mian Issa and Lundkhwar were randomly selected from Takhatabhi while Koza Behram Deheri, Gundhera, Abazi, Hisara Nehri and Sherpao from Tangi were likewise selected from Mardan. From each selected union council, one village was chosen including Ferozshah, Akbarbad, Qutabgarh, Miangano Killi, Gulmera, Dobandi, Payan, Tangi Abazi, Gumbati

and Hisara Nehri, About 15% of sugarcane growers in each village were randomly selected. The method of selecting the 336 respondents is set out in Table 2. There was no need to select replacements for any of the randomly chosen farmers because no farmer who was asked declined to participate in the survey.

This research was based on primary as well as secondary data. A well designed interview schedule was used in the field by the researcher to collect primary data for years 2012 and 2013 from the sample of growers while secondary data were collected from published and un-published sources. The interviews with sugarcane growers took place at a convenient place, like the farmer's home or local community center (Hujra).

Using the questionnaire, the researcher collected information regarding age of respondents in categories 15-25 years (Youngest), 26-35 years (Young), 36-45 years (Middle aged), 46-55 years (Older) and more than 56 years (Oldest). The interview questionnaire is attached as an appendix to this article.

Table 2 Procedure for selection of sample

Districts	Tehsils	Union Councils	Villages	Sugarcane growers
Mardan	Takhatbhai	Saro Shah	Ferozshah	302 (45)[1]
		Madey Baba	Qutabgargh	224 (34)
		Pir Saddi	Akbarabad	217 (33)
		Mia Issa	Miangano Killi	232 (35)
		Lund-khawar	Gulmera	237 (36)
Charsadda	Tangi	Koz Behram Dehri	Dobandi	200 (30)
		Gandhera	Payan	180 (27)
		Abazi	Tangi Abazi	195 (29)
				160 (24)
		Sherpao	Hisara Nehri	289 (43)
Total				2,236 (336)

This study also gathered information from respondents about their educational status and whether they were literate or illiterate. Educational status categorized as Primary, Middle, Secondary School Certificate, College Certificate, university Graduate or Post-graduate. The researcher asked about the tenure of the respondents' farms such as whether they were owner-operators who cultivated their own land, owners-cum tenants (who rented land in addition to their own land, tenants (who cultivated land on a seasonal arrangement), lease holders (with long term access to land), or sharecroppers (who operated on the basis of sharing both inputs and outputs, usually in the range of a 50-50 or 60-40 split between the owner and the sharecropper). Size of land was categorized as up to 5 acres (approximately 2 hectares, smallest), 6-10 acres (2.42-4.04 ha, small), 11-16 acres (4.45-6.47 ha, middle-sized), 17-21 acres (6.88-8.50 ha, large), and 22 acres and above (8.90 ha, the largest farms). Information about the length of time the farmers had been cultivating sugarcane was also gathered with respondents reporting whether they had cultivated sugarcane for the past 5 years, for 10, 15, or more than 15 years.

The respondents used various technologies including bullock-drawn wooden ploughs, small hand-held rotovator, and tractor-drawn cultivators for land preparation. The respondents provided information about nitrogen fertilizer applied to their sugarcane in the form of "bags per acre" which the

[1] The 15% of sugarcane growers who were sampled is indicated by numbers in brackets

researcher needed to convert into kg per hectare. The farmers also applied a range of nitrogen fertilizers (DAP, Urea and Ammonium Nitrate as well as Farm Yard Manure) from which the total nitrogen applied was estimated. The researcher also recorded the source of agricultural information accessed by respondents which included using their own resources (Self), approaching the Agricultural Extension Department, and gaining knowledge from fellow farmers/friends and relatives).

To determine the farmer's yield of sugarcane accurately for this research, the researcher collected all of the cane from about 0.1 hectare (0.36 acre) from each sugarcane farm and took it to the

local market to be weighed on the local agent's scales. These agents buy sugarcane from the growers and sell it to the mills. The yield of cane from the whole farm could then be estimated taking into account how representative the sampled area was of the rest of the farm.

Computer programs such as Excel and SPSS were used to analyze the primary data from the sample of sugarcane growers. These computer programs were also used for paired t-test, chi-square test, and to calculate percentages.

Results and Discussion

Age

Age is one of the main factors which determines the response of individuals to different circumstances during various stages in their lives. All rational decision making processes are also affected by age as well as by other factors.

Table 3 shows that out of the total 336 respondents, 236 (70%) belonged to the age group 36-45 years. Therefore, most sugarcane growers were young and middle aged. Moreover, agriculture in Pakistan is currently going through a transition from traditional practices to mechanization so it is an industry that needs information about modern and scientific farming techniques. Although young sugarcane growers have less experience in agriculture, and may not know how to operate agricultural machinery, they are generally the pioneers in the adoption of new technologies consistent with the view expressed by writers such as Rogers (1983). The government and other organizations should provide information about agricultural machinery to sugarcane growers of all age groups but concentrate especially on the younger ones.

Table 3 Distribution of respondents by Age

Districts	Villages	Ages (Years)				Total
		26-35	36-45	46-55	56 and above	
Mardan	Gulmera	7(19)	23(64)	5(14)	1(3)	30(100)
	Miagano Killi	10(29)	18(51)	7(20)	--	35(100)
	Akhber Abad	12(35)	16(47)	6(18)	--	34(100)
	Qutabgarh	7(21)	23(70)	3(9)	--	33(100)
	Feroz Shah	1 (3)	37(81)	7(16)	--	45(100)
Charsadda	Dobandi	7(23)	23(77)	--	--	30(100)
	Payan	4(15)	23(85)	--	--	27(100)
	Tangi Abazai	1(3)	26(90)	2(7)	--	29(100)
	Hisara Nehri	6(14)	29(67)	8(19)	--	43(100)
	Qumbati	1(3)	18(75)	5 (21)	--	24(100)
Total		56(17)	236(70)	43(13)	1(0.2)	336(100)

Source: Adopted from Khan. F and M. Z. Khan, 2015

Note: The values in parentheses are percentages

Table 4 Distribution of Respondents by type of Machinery used for land preparation

Districts		Type of Agricultural Machinery			Total
		Bullock pulled Wooden plough	Engine driven Rotovator	Tractor drawn Cultivator	
Mardan	Gulmera	--	2 (6)	34 (94)	36 (100)
	Miagano Killi	1 (3)	--	34 (97)	35 (100)
	Akhbar Abad	--	--	34 (100)	34 (100)
	Qutabgarh	5 (15)	4 (12)	24 (73)	33 (100)
	Feroz Shah	1 (2)	13 (29)	31 (69)	45 (100)
Charsadda	Dobandi	--	10 (33)	20 (67)	30 (100)
	Payan	--	3 (11)	24 (89)	27 (100)
	Tangi Abazi	--	26 (90)	3 (10)	29 (100)
	Hisara Nehri	--	--	43 (100)	43 (100)
	Qumbati	--	24 (100)	--	24 (100)
Total		7 (2)	82 (25)	247 (74)	336 (100)

Machinery used for land preparation

The sugarcane growers in Mardan and Chassada districts used various types of agricultural machinery to prepare the land for sugarcane. During the collection of primary data, the researcher observed that sugarcane growers used bullock pulled wooden ploughs, small engine-driven rotovators, and tractors with cultivators for land preparation prior to planting the sugarcane crop. Both rotovators and tractors were hired rather than owned by the farmers which was the case with bullocks.

Table 4 shows that out of a total of 336 respondents, only 7 farmers used the bullock for land preparation prior to planting sugarcane. They were followed by 82 (24%) of respondents who hired small hand-held rotovators to use as their primary tillage machinery. However, the over- whelming majority of 247 farmers (74% of respondents) used a hired tractor and cultivator for farming activities. From Table 4, it is clear that some farmers are still using traditional methods and simple technology. The research by Khan, 2012 showed that 60% of farmers in Dera Ismail Khan, Malakand and Charrsadda districts of Khyber Pakhtunkhwa province used only tractors for land preparation.

According to NCAER (1980), the production increase from using the farmer's own or hiring a tractor and field equipment ranged between 4% and 55%. The yield of cane from fields cultivated by custom hired equipment was less those where the farmer owned a tractor because of recommended use of inputs and improvements in operations. Thus production records indicated improvements in yield due to recommended use of chemical fertilizer and irrigation appear to be associated with the use of modern agricultural machinery. It is therefore important for farmers to get information about modern agricultural practices and adopt that technology in the field.

The average yield of sugarcane for 2012 and 2013 years by type of agricultural machinery is presented in Table 5.

Table 5 Average yield (t/ha) of sugarcane 2012 and 2013 by type of agricultural machinery

Types of machinery	Average yield of 2012 and 2013	Number of respondents	Std deviation
Bullock pulled plough	74.52	7	27.039
Rotovators	57.55	82	34.746
Tractor-drawn Cultivators	65.01	247	23.144
Total	63.99	336	26.668

Table 5 shows the average cane yield from 7 respondents who used a bullock-drawn plough was 74.52 t/ha followed by 247 respondents who used a tractor drawn cultivator for land preparation and achieved an average yield of 65.01 t/ha while there were 82 respondents with an average yield of 57.55 t/ha who were using rotovators as their primary cultivation machinery. Unfortunately, there was only a small number of respondents usin the bullock plough in the sample indicating the mechanization of land preparation in these districts is well advanced and there can be less confidence in the average yield of the small group of farmers who are still using traditional land preparation methods. The annual sugarcane report of (Raja, 2015) revealed d that yield of sugarcane would increase with use of better quality cane varieties and suitable techniques for sugarcane cultivation in Pakistan. This should lead to re-thinking the use of rotary cultivators for land preparation as they are the group with the lowest yields although there is also scope for the farmers using tractor-drawn cultivators to improve yields as well.

Time taken for cultivation is an important difference between the three methods of bullock pulled wooden plough, rotovator, and tractor-drawn cultivators. Table 6 presents the period of time (hours/ha) in categories for the range of machines used to prepare soil for sugarcane planting.

Table 6 shows that the seven farmers using bullocks required more than seven and a half hours per hectare for basic cultivation. Likewise, the majority of farmers using cultivators also required more than seven and half hours per hectare to cultivate their sugarcane. By far the majority of farmers (247 out of 336) used a hired tractor and cultivator for land preparation for sugarcane, while the range in time for tractor drawn cultivators extended from two and half hours per hectare to more than seven and half hours per hectare. So there can be a substantial saving in time for land preparation using the tractor. However, these are hired tractors and the time taken for land preparation is often excessive

Table 6 Use of time (hours/ha) for machines to prepare soil for sugarcane planting

Types of agricultural machines	Time used for land preparation (hours)				Total farms
	Two and half	Five	Seven and half	More than seven and half	
Bullock pulled plough	--	--	1(14)	6(86)	7(100)
Engine driven rotovator	--	--	4(5)	78(95)	82(100)
Tractor-drawn cultivators	16(7)	34(14)	72 (29)	125(51)	247(100)
Total	16 (5)	34 (10)	77 (23)	209 (62)	336(100)

Note: The numbers in brackets are percentages.

There was a difference in cane yields between the three methods (bullock plough 75 t/ha, tractor cultivation 66 t/ha, and rotovator 58 t/ha. Therefore, greater attention to land preparation and longer time inputs into bullock-powered cultivation seems to pay off in higher cane yields as those farmers appear to pay more attention to their land preparation. However, there may be other factors, such as soil fertility, higher rates of fertilizer, or more irrigation water that explain these differences. Incidentally, there was little difference in the area of sugarcane cultivated under the three methods. Table 7 reports the area cultivated by each type of machinery.

Table 7 Area cultivated by each type of machinery (ha)

Type of agricultural machinery	Land area for sugarcane cultivation (ha)					Total
	Up to 2	2.01-4.00	4.01-6.00	6.01-8.00	8.01 and above	
Bullock pulled plough	7 (100)	--	--	--	--	7 (100)
Engine driven rotovator	60 (73)	8 (10)	7 (9)	6 (7)	1 (1)	82 (100)
Tractor drawn cultivators	232 (94)	14 (6)	--	--	1 (0.4)	247 (100)
Total	299 (89)	22 (6)	7 (2)	6 (2)	2 (0.6)	336(100)

Note: The numbers in brackets are percentages

Table 7 shows that all of the seven farmers using bullocks for cultivation had small farms (<2 hectares). While the majority of farmers using the other methods also had small farms, there was a small number of farms spread across the other size categories. Some of these larger farmers had other farmers share-cropping on some of their land so that small rotovators were still able to prepare what appears to be quite a large area.

Yield of sugarcane is obviously affected by soil type. There were four soil types represented in the survey: silt loam, clay loam, sandy loam, and waterlogged loam with mean yields of sugarcane from the farmers surveyed ranging from 77 t/ha for silt loam, 55 t/ha for clay loam, 37 t/ha for sandy loam and 38 t/ha for waterlogged loam. Table 8 shows the association of soil types with sugarcane yield.

Table 9 shows that all of the seven farms cultivated by bullocks were located on silt loam, the most fertile land while the farms using a rotovator were spread across all soil types. Those farms using a hired tractor for cultivation were confined to the silt loam and the clay loam soil types.

Table 8 Association between average yields (t/ha) of sugarcane with types of soils

Types of soil	Average yield (t/ha) 2012 and 2013	Number of respondents	Std. deviation
Silt loam	75.52	177	27.273
Clay loam	55.37	109	18.198
Sandy loam	37.52	26	11.701
Water logged loam	38.53	24	10.649
Total	63.39	336	26.668

Table 9 Use of agricultural machineries by soil types

Type of Soil	Types of Agricultural Machinery			Total
	Bullock driven	Rotovator	Cultivators	
Silt loam	7(4)	22(12)	148(84)	177 (100)
Clay loam	--	10(9)	99 (91)	109 (100)
Sandy loam	--	26(100)	--	26 (100)
Water logged loam	--	24(100)	--	24 (100)
Total	7(2)	82(24)	247(74)	336 (100)

Note: The numbers presented in brackets are percentages

Cost is one of the important factors in sugarcane production. Table 10 shows that only 7 farmers used traditional methods for land preparation (wooden ploughs pulled by bullocks) while most farmers (247 out of a total of 336 farmers) used modern cultivation techniques (hired tractors) for land preparation at a maximum cost of $US148 per hectare. The farmers were generally unable to drive a tractor, or to finance the purchase of one, so that hiring a tractor and cultivator, and thus implementing modern technology in farming practices, was a frequent outcome. The results of research by (Habib et al., 2014) revealed that costs of land preparation, and money spent on DAP and urea were highly significant factors affecting yield of sugarcane (significant at 1% level).

The cost of custom hiring a tractor and cultivator is based on an hourly rate which combined with the wide range in times used to cultivate the same area led to a wide range in costs per hectare as shown in Table 10. The average cost to cultivate one hectare of land for sugarcane using a rotary cultivator was $US 20.5 per hectare while for a tractor-drawn cultivator, the comparable cost was $US 24.7 per hectare.

Table 10 Cost of machinery for land preparation prior to sugarcane crop ($US/ha)

Type of Machinery	Cost per ha (US $)												Total
	0	1-49	50-54	55-69	70-74	75-81	82-86	87-99	100-104	105-109	110-123	124-148	
Bullock Pulled plough	7 (100)	--	--	--	--	--	--	--	--	--	--	--	7 (100)
Engine driven rotovator	--	--	3 (37)	--	21 (26)	57 (70)	1 (1)	--	--	--	--	--	82 (100)
Tractor drawn cultivators	--	5 (2)	113 (46)	1 (0.4)	100 (41)	21 (9)	--	1 (0.4)	1 (0.4)	2 (1)	2 (1)	1 (0.4)	247 (100)
Total	8 (2)	4 (1)	116 (35)	1 (0.3)	121 (36)	78 (23)	1 (0.3)	1 (0.3)	1 (0.3)	2 (1)	2 (1)	1 (0.3)	336 (100)

Note: Cost of ploughing with the bullock has been assumed to be zero. While there is no cash outlay for the farmer to use his own bullock, there are opportunity costs for feed, and capital costs associated with keeping the animal for farm work that are hard to assess.

Nitrogen is a necessary nutrient for growth of any crop. Figure 1 shows the association between different levels of Nitrogen applied by the farmers and yield of sugarcane. The regression line in the graph shows that sugarcane growers achieved a maximum yield of 110 t/ha with 220 kg/ha of applied Nitrogen. While excess use of Nitrogen fertilizer above 250-260 kg/ha appears to have an adverse effect on yield of sugarcane. The excess nitrogen applied is not cost effective for sugarcane growers and can cause pollution of the ecosystem. The large amount of excess Nitrogen measured in marine or other water sources from irrigation channels which pollute the environment should be avoided. Like the Earth's water, nitrogen compounds cycle through the air, aquatic systems, and the soil, but unlike water, these compounds are being injected into the environment in ever increasing quantities. In doing so, we are altering the global nitrogen cycle, causing possible grave impacts on biodiversity, adding to global warming, adversely affecting water quality, with possible detrimental effects on human health, and even the rate of population growth in developing nations (Scott Fields, 2014)

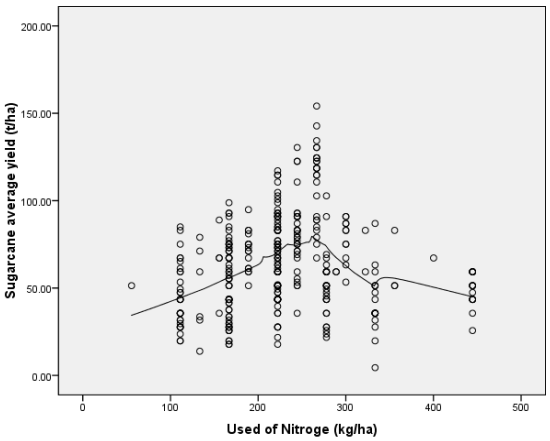

Figure 1 Association between applied nitrogen (kg/ha) and sugarcane yield (t/ha)

However, the research by (Ullah et al., 2011) concluded that there is substantial scope for increasing yield of sugarcane by the use of appropriate inputs and improved management practices and some farmers in the study area are using less than the optimum/recommended levels of inputs, possibly because they were unaware of the optimum level to use. The use of recommended levels of inputs and adoption of other improved farm practices can increase the yield of sugarcane to more profitable levels.

Figure 2 shows that farmers using hired tractor-driven technology are mostly using suitable 120 P_2O_5 and 150 K_2O kg/ha) as the most suitable rate of fertilizers for cane yield with the best cost benefit ratio. rates of Nitrogen between 167-222 kg/ha applied to their sugarcane crops.

For farmers using both rotovators and bullock-pulled ploughs, the range in nitrogen applications was much wider, from 56 to 444 kg N/ha. In the research reported by (Khan, 2005), five test treatments were applied in an experiment at the Nuclear Institute of Agriculture, Tando Jan Sindh, Pakistan. These were: i. 0 Nitrogen, 0 P_2O_5 and 0 K_2O kg/ha; ii. 150 Nitrogen, 80 P_2O_5 and 100 K_2O kg/ha; iii. 200 Nitrogen, 120 P_2O_5 and 150 K_2O kg/ha; iv. 250 Nitrogen, 160 P_2O_5 and 200 K_2O kg/ha; and v. 300 Nitrogen, 200 P_2O_5 and 250 K_2O kg/ha. The results of their research showed that yields of 107-109 t/ha, were obtained from treatments 3, 4, and 5 respectively. The authors further identified treatment iii (200 Nitrogen kg/ha, 120 P_2O_5 and 150 K_2O kg/ha) as the most suitable rate of fertilizers for cane yield with the best cost benefit ration.

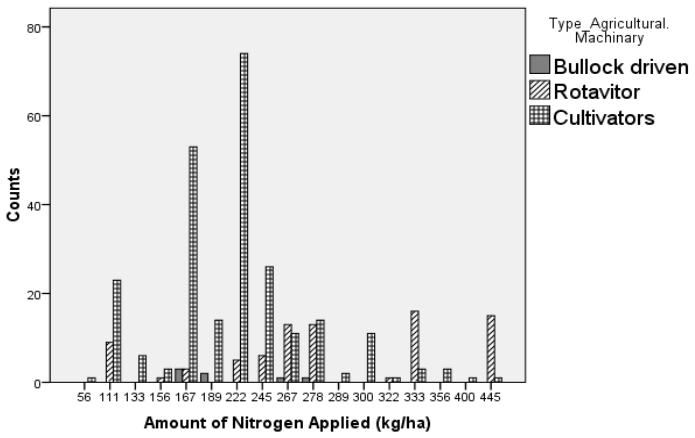

Figure 2 Amount of nitrogen applied (kg/ha) with various types of agricultural machinery

Sources of information

Source of Information about agricultural machinery appears to have an important role in determining yield of sugarcane.

Table 11 Association between average yield of sugarcane for years 2012 and 2013 (t/ha) and source of information about agricultural machinery

Source of information	Average yield 2012 and 2013	Number of respondents	Std. deviation
Fellow Farmers	58.67	297	23.081
Extension Department	114.01	19	21.156
Own resources	85.37	20	19.907
Total	63.39	336	26.668

Table 11 shows that higher yield (average 114.01 t/ha) was achieved by 19 farmers who obtained information about agricultural machinery from the Provincial Government of agricultural extension department, followed by 20 farmers who used their own resources to find information about sugarcane machinery (85.37 t/ha). Those 297 farmers who used fellow farmers as the source of information about agricultural machinery had the lowest average yields (58.67 t/ha).

Table 12 shows that four farmers out of seven who ploughed with bullocks used their own resources to find information about sugarcane cultivation which may explain why they were not yet using modern cultivation methods. However, 93% of the farmers who used the tractor-drawn cultivator for land preparation also got agricultural information from fellow farmers and only one respondent got information from the Provincial agricultural extension department. The 78% farmers who used rotovators as their land preparation equipment used Fellow farmers as their source of information and 22% the Provincial agricultural extension department.

Table 12 Association between type of machinery and source of agricultural information

Types of Machinery	Source of Agricultural Information			Total
	Fellow Farmers	Agric. Extension Department	Own resources	
Bullock pulled ploughs	3 (43)	--	4 (57)	7 (100)
Rotovators	64 (78)	18 (22)	--	82 (100)
Cultivators	230 (93)	1 (0.4)	16 (7)	247 (100)
Total	297 (88)	19 (6)	20 (6)	336 (100)

Note: The numbers presented in brackets are percentages.

Conclusions and Recommendations

On the basis of the findings and results of this research study, we have formulated the following conclusions and recommendations.

Conclusions

Interestingly, the farmers who used bullocks for land preparation were the group that achieved the highest average yield of sugarcane in 2012-13 but they also spent more time on land preparation, grew sugarcane on the most fertile land “Silt Loam’, used recommended rates of nitrogen fertilizer, as well as their own resources to obtain information. However, they were the smallest group among the farmers surveyed (only seven farmers out of 336) so it seems that the conversion to mechanization among sugarcane farmers in these two districts in Pakistan is well advanced.

Most sugarcane growers in Mardan and Chassada used small hired rotary cultivators as their chosen machinery for land preparation and the cost of using that equipment is closely grouped around $US50-80 per hectare while the cost to farmers of

using a tractor and cultivator were spread across a much wider range, from less than $US50 to $150 per hectare but with a strong tendency to fall into the lower cost categories. Average cost per hectare for land preparation by rotary cultivators and tractor drawn cultivators were $US 20.4 and 24.6 respectively. It seems that sugarcane growers use hired tractor drawn cultivators which tend to be more expensive than rotary cultivators because they save time and contribute to achieving a high yield of sugarcane.

The use of Nitrogen fertilizer affects the yield of sugarcane. Maximum yields of 130 to 150 t/ha yield of sugarcane were achieved by some farmers in the study area who reported using between 244 and 268 kg/ha of nitrogen fertilizer. The farmers using bullock-drawn ploughs who achieved the highest yields mostly applied about 280 kg /ha nitrogen.

Recommendations

The Government, through the Department of Agriculture and Extension and relevant NGOs should create awareness among the farm population about the importance of proper land preparation for high yields of sugarcane and encourage sugarcane growers to apply recommended rates of Nitrogen per hectare to their sugarcane crops. The Government and relevant NGOs should train the sugarcane growers in Pakistan to use modern technology in the cultivation of sugarcane. Further research into appropriate strategies to provide farmers in Pakistan with access to agricultural machinery services, whether by ownership of their own equipment, wider availability of contractors, group ownership of machinery, or other means is suggested to identify the best options.

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