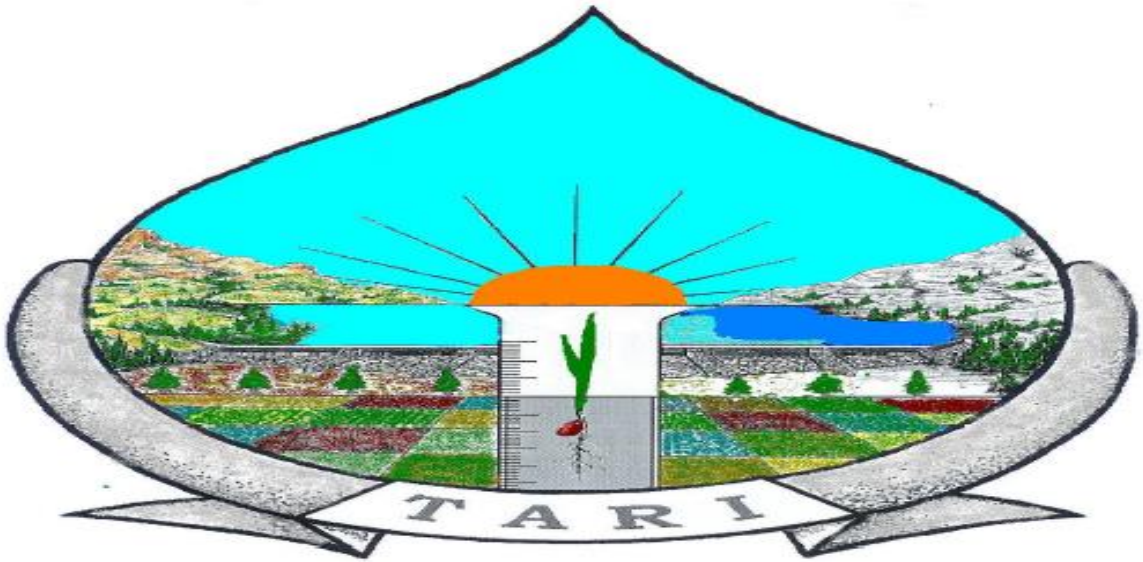

Tigray Agricultural Research Institute

Mekelle Soil Research Center

IPI – Ministry of Agriculture – Hawassa University – Ethiopian Agricultural Transformation Agency (ATA) joint symposium - The Role of Potassium in Balanced Fertilization.
24-26 November 2015 , Hawassa University, Hawassa, Ethiopia

EFFECTS OF POTASSIUM FERTILIZER RATES AND SOURCES ON YIELD AND YIELD COMPONENTS OF BARLEY (*Hordeum Vulgare* L.) IN VERTISOLS OF SOUTHEREN TIGRAY, ETHIOPIA

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NOVEMBER 2015

HAWASSA, ETHIOPIA

IPI – Ministry of Agriculture – Hawassa University – Ethiopian Agricultural Transformation Agency (ATA) joint symposium - The Role of Potassium in Balanced Fertilization.
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Presentation outline

- *Introduction*
- *Materials and methods*
- *Results and discussion*
- *conclusion*
- *Recommendations*

INTRODUCTION

- Agriculture is the driving force of the Ethiopian economy
- Poor soil fertility is considered as a major constraint of crop production
  - ✓ Continuous cultivation and nutrient mining
  - ✓ Free grazing
  - ✓ Deforestation
- Application of fertilizers containing N and P (urea and DAP) began in the late 1960s
- Continuous application of N and P fertilizers have led to the depletion of other important nutrient elements such as K (Abiye *et al*., 2004; Bereket *et al*., 2011)

Introduction cont……

- Globally, 75, 14 and 60 million tons of N, P and K is removed from the soil per year

- Usually the N and P nutrients removed are replenished however only 35% of the K removed is replenished (Smil, 1999)

- In the case of Ethiopia, not only K but also N and P are in negative nutrient balance (-122 kg N ha^{-1}, -13 kg P ha^{-1} and - 82 Kg K ha^{-1}) (Kiros *et al*., 2014)

Introduction cont……

- Particularly, K is ignored for the past decades in Ethiopian farming system such as for barley crop production

This is due to

- ✓ Ethiopian soils were believed to contain sufficient quantity of K nutrient.
- ✓ Lack of attention

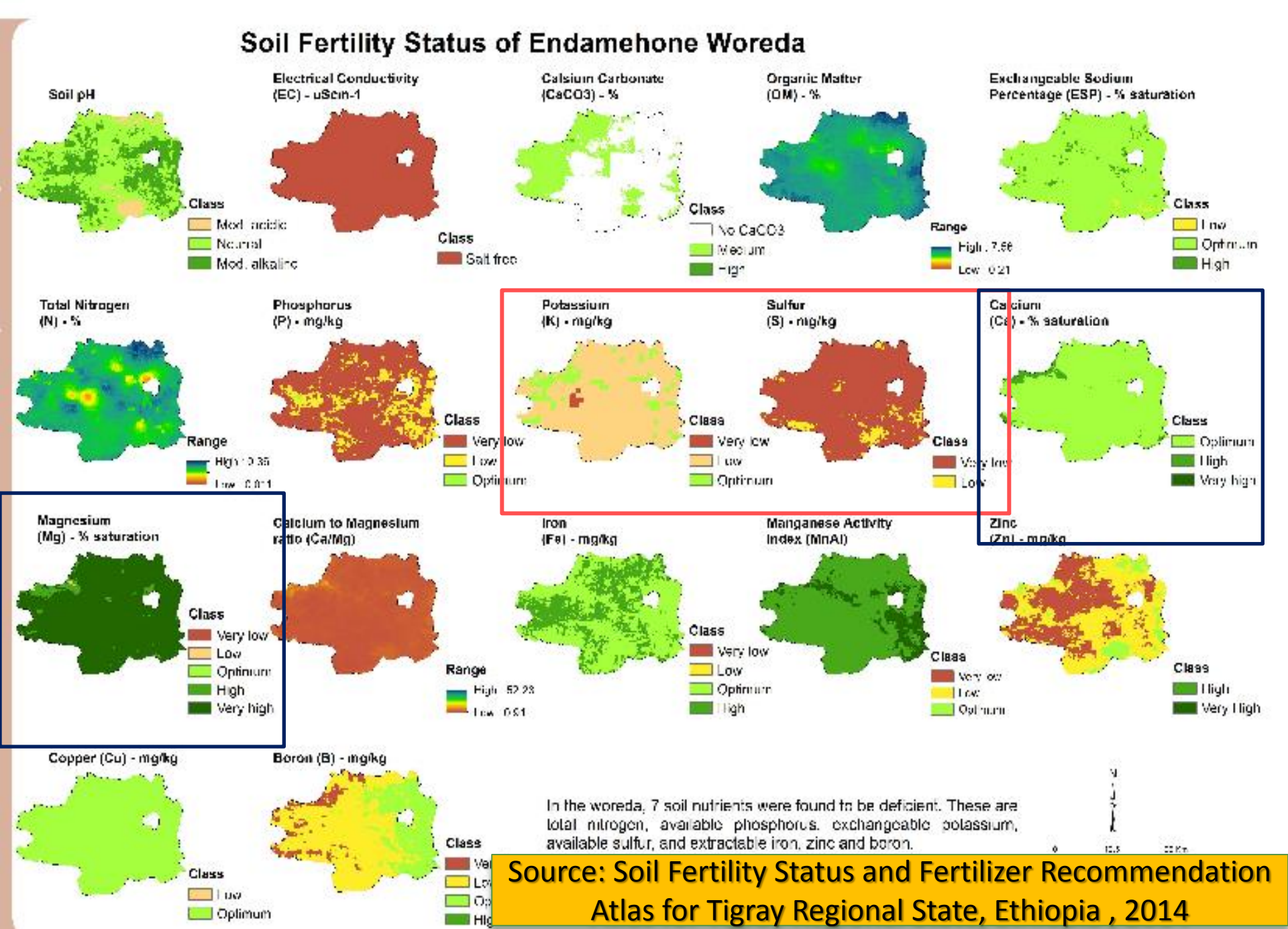
Previous research indicates that K is becoming depleted and deficiency symptoms are being observed

Introduction cont……

- Different researches were conducted at Tigray regional state and results were found
  - ✓ K was deficient in Vertisols at the study area (Fassil and Charles, 2009)
  - ✓ K was deficient in Luvisols under barley production at Atsbi-Wemberta district (Abegaz, 2008)

- Therefore, potash fertilizer trials is mandatory in the major field crops of Ethiopia

Soil Fertility Status of Endamehone Woreda



Source: Soil Fertility Status and Fertilizer Recommendation Atlas for Tigray Regional State, Ethiopia , 2014

Objective

This study was initiated to

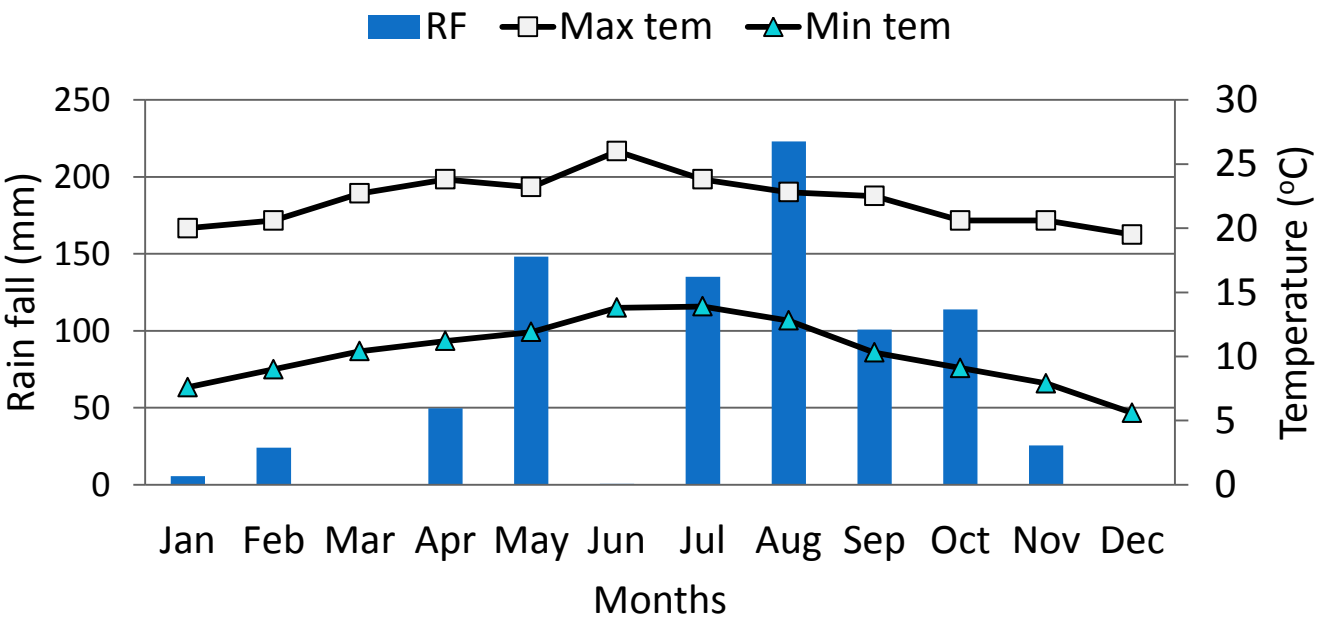
- Identify the effective source and rates of potassium fertilizer application for optimum yield and yield component of barley grown on Vertisols

MATERIALS AND METHODS

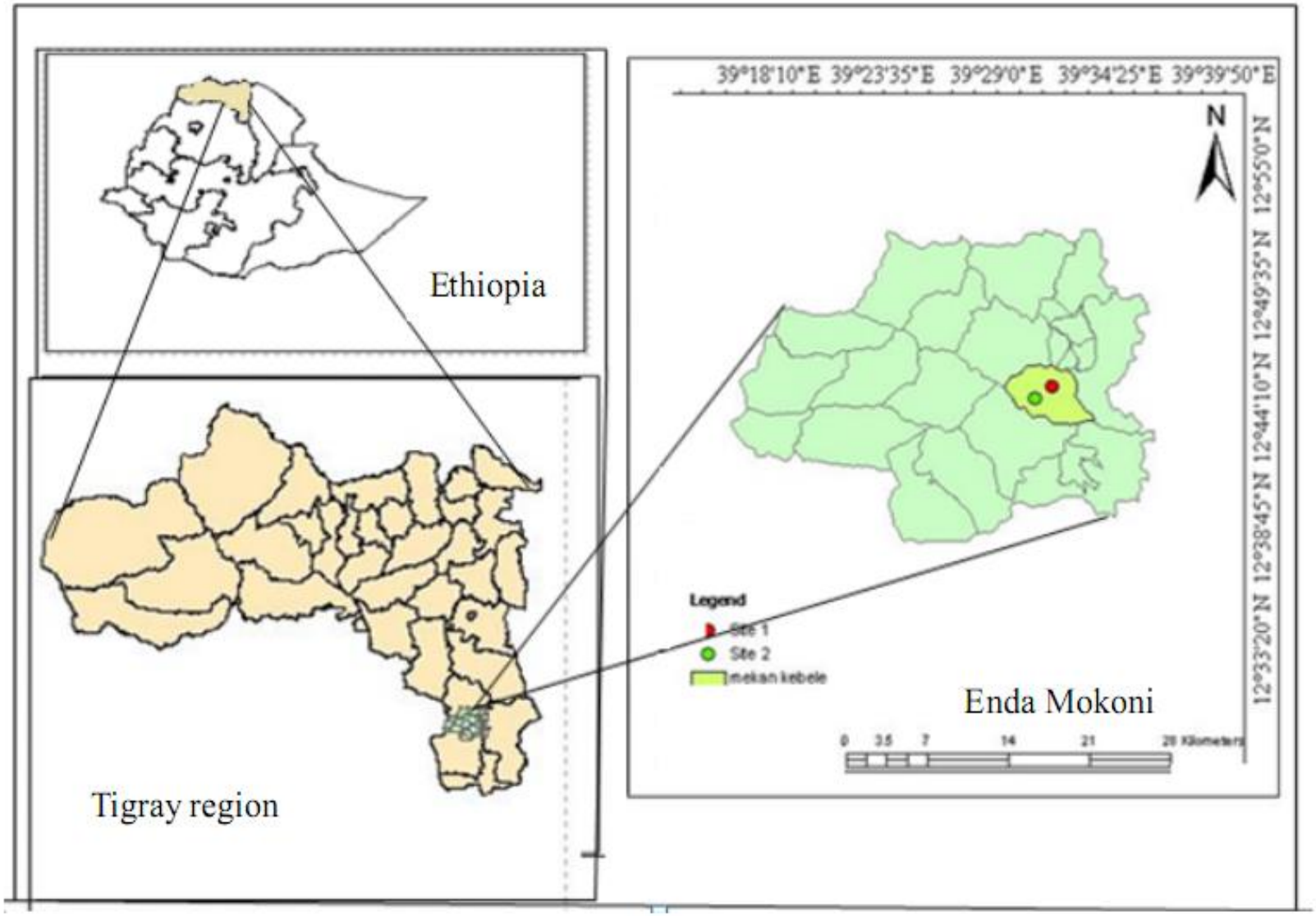
Experimental Site

The Experiment was conducted in Tigray Regional state at Enda-Mokoni district (Kebele: Mekan) in Vertisols

- ✓ 662 km N of Addis Ababa and 123 km S of Mekele
- ✓ Longitude = extends from 39°18'E to 39°39'
- ✓ Latitude = extends from 12°33'N to 12°55'
- ✓ Elevation = 2430 masl



Location map of the study area



Treatment setup

- There was 12 treatments
  - Control (no fertilizer)
  - Rec. N and P (46 kg N and 69 kg P_2O_5 ha^{-1})
  - Five K rates (15, 30, 45, 60 and 75 kg K ha^{-1}) in the form of KCl plus recommended N and P
  - Five K rates (15, 30, 45, 60 and 75 kg K ha^{-1}) in the form of K_2SO_4 plus recommended N and P

Experimental Design

- RCBD with 3 reps
- Plot size: 3 m * 3 m (9 m^2)
- Spacing between
  - Replications =1.5 m
  - Plots = 1m
  - Rows = 0.2 m

Soil Sampling and analysis

- Before planting, one surface composite soil samples
- After harvesting, 36 soil samples from each plot

Parameter	Standard procedures	References
Particle size	Hydrometer method	Bouyoucos, 1962
pH (1:2.5)	pH meter	Rhoades, 1982
EC (1:5)	EC meter	Jakson, 1967
OC	Walkely and Black method	Walkely and Black, 1934
TN	Kejeldah method	Bremner and Mulvaney, 1982
Avail. P	Olsen method	Olsen *et al*., 1954
Exch. Bases and CEC	Ammonium acetate method	FAO, 2008

Data Collection

On plot basis

- Grain yield
- Biomass yield
- Straw yield
- Harvest index (HI%)

On plant basis (5 plants)

- Grain per spike
- Spike length (cm)

Data Analysis

- ANOVA was carried out using SAS version 9.1

- Significant difference between and among treatment means were assessed using LSD at 0.05 level of significance

- $$MRR(\%) = \frac{\Delta NR}{\Delta TVC}$$

RESULTS AND DISCUSSION

Table1: Selected physical properties of soil profile and composite surface soil sample of the study area

Depth (cm)	Layer	Particle size (%)			Textural class	BD*	TP (%)	Water content		
		Sand	Silt	Clay				FC (%)	PWP (%)	AWH C**
0 – 30	Surface	37	21	42	Clay	1.20	54.7	35.50	20.51	117.8
31- 110	Sub	27	25	48	Clay	1.34	49.4	36.96	24.05	129.1
111 -180+	surface	18	27	55	Clay	1.40	47.2	37.58	22.52	149.4
Composite surface soil sample before planting										
0 -20	-	25	33	42	Clay	-	-	-	-	-

According to Hazelton and Murphy (2007) The study area lies under low to moderate BD except at the subsurface which was at the critical value

In agreement with Brady and well (2002) Bulk density consistently increases with soil depth

Table 2: Selected soil chemical properties of soil profile and composite surface soil sample of the study area

Depth (cm)	Layer	pH (H_2O)	OC (%)	TN (%)	Av P (mg kg^{-1})	K:Mg ratio	CEC (cmolc kg^{-1})	Exchangeable base (Cmolc (+) kg^{-1})				PBS
								Ca	Mg	K	Na	
0 – 30	Surface	6.6	1.42	0.085	11.42	1.38:1	40.6	7.4	0.8	1.11	0.06	23.07
31- 110	Sub	7.1	0.89	0.079	8.58	0.54:1	41.2	10.6	1.8	0.97	0.07	32.66
111 -180+	surface	7.4	0.35	0.041	6.12	0.62:1	45.1	11.5	1.3	0.81	0.17	30.55
Composite surface soil sample before planting												
0 – 20	-	6.7	2.03	0.103	14.52	0.24:1	38.4	10.8	5.0	1.19	0.04	44.34

- due to low amount of organic matter and complete removal of biomass from the field (Tekalign *et al*., 2014)
- Soil fertility and fertilizer recommendation atlas for Tigray region was in the order of Ca > Mg > Na > K

Table 3: Soil potassium as affected by different levels of K fertilizer on Vertisols

K From KCl (kg ha^{-1})	K nutrient content (%)
0	0.007d
15	0.014bc
30	0.017ab
45	0.018a
60	0.019a
75	0.019a
K From K_2SO_4 (kg ha^{-1})	
15	0.013c
30	0.017ab
LSD (	
CV (%	

According to Singh *et al.* (1999), the available K content of the soil analysis result categorized under medium

Response of barley to applied KCl and K_2SO_4 fertilizer

- On Yield & Yield Component of Barley
  - Spike length
  - Grain spike^{-1}
  - Grain yield
  - Straw yield
  - Harvest index

Table 4: Mean of Spick length, Gain per spike, Straw yield, Gain Yield and Harvest Index as affected by KCl and K_2SO_4 fertilizers

Treatments	SL (cm)	GS	GY (Kg ha^{-1})	SY (Kg ha^{-1})	HI
Control	1.62e	39.46bc	1072.90f	2579.90cd	0.29c
Rec. NP	2.84de	40.93c	2487.20bcd	3258.50bc	0.42ab
15 KCl	3.47bcd	41.20bc	2001.50de	3489.20abc	0.38abc
30 KCl	4.18abcd	40.20c	2104.10cd	3521.20ab	0.38abc
45 KCl	3.53abcd	43.00bc	2546.80bcd	3597.70ab	0.42ab
60 KCl	4.27abcd	43.67abc	2778.50ab	4161.80ab	0.40ab
75 KCl	4.92a	49.53a	3316.70a	4096.60ab	0.45a
15 K_2SO_4	3.47bcd	42.60bc	1425.70ef	2095.50d	0.39ab
30 K_2SO_4	3.12cd	39.26c	2038.40cde	3952.70ab	0.34bc
45 K_2SO_4	4.73ab	40.53bc	2257.30bcd	3952.40ab	0.36abc
60 K_2SO_4	4.47abc	38.13c	2581.30bcd	3911.50ab	0.40ab
75 K_2SO_4	4.93a	46.93ab	2664.40bc	4413.10a	0.38abc
Mean	3.77	42.17	2272.90	3585.82	0.38
LSD (0.05)	1.37	6.19	649.40	933.03	0.09
CV (%)	22.11	8.83	16.87	15.37	13.45

Table 5: Partial budget analysis of K fertilizer for Vertisols soil type

Fertilizer rate (kg K/ha	Fertilizer cost (Birr)	Transport and labor cost [Birr]	Total variable cost (TVC) [Birr]	Grain yield (kg/ha)	Total revenue (TR) [Grain yield*7.5]	Net revenue [TR-TVC]	Marginal rate of return (ratio)	Marginal rate of return (%)
K from KCl								
0	0.00	0.00	0.00	1072.90	8046.75	8046.75	-	-
15	176.90	24.00	200.90	2001.50	15011.30	14810.35	33.67	3367
30	353.81	43.00	396.81	2104.10	15780.80	15383.94	2.93	293
45	530.72	62.00	592.72	2613.40	19600.50	19007.78	18.50	1850
60	707.62	81.00	788.62	2778.50	20838.80	20050.13	5.32	532
75	884.52	100.00	984.52	3316.70	24875.30	23890.73	19.60	1960
K from K2SO4								
0	0.00	0.00	0.00	1072.90	8046.75	8046.75	-	-
15	383.40	24.00	407.40	1953.90	14654.30	14246.90	15.22	1522
30	766.80	43.00	809.80	2038.40	15288.00	14478.20	0.57	57
45	1150.20	62.00	1212.20	2257.30	16929.80	15717.60	3.08	308
60	1533.60	81.00	1614.60	2581.30	19359.80	17745.20	5.04	504

CONCLUSION

- Application of different sources and rates of K fertilizer significantly ($P < 0.01$) influenced crop parameters such as
  - Spike length, Grain per spike, Grain Yield and Straw Yield

- Mean grain yield of 3316.70 kg ha^{-1} was obtained at the highest KCl rate (75 kg K ha^{-1}) with an increment of 209% over the control (no fertilizer)

Conclusion …. cont

- The use of K fertilizer in the form of KCl is more advantageous than K_2SO_4 because of the higher cost of K_2SO_4 and market inaccessibility

- The highest marginal rate of return obtained at 75 kg K ha^{-1} However, 75 kg K ha^{-1} and 60 kg K ha^{-1} statistically equal from the source of KCl

RECOMMENDATIONS

- Application of K fertilizer at a rate of 60 kg K ha^{-1} in the form of KCl along with the recommended N and P fertilizer is crucial to improve the productivity of barley at Vertisols of the study area.

- Because of its availability in the market and lower cost benefit, KCl is preferable than K_2SO_4.

Recommendations ….cont

- The foundation of the perception that Ethiopian soils are rich in potassium content needs further investigation.

- Soil test based application of potash fertilizer should be done on site specific conditions because the availability of the element may vary depending on the nature of the soils.

At heading stage

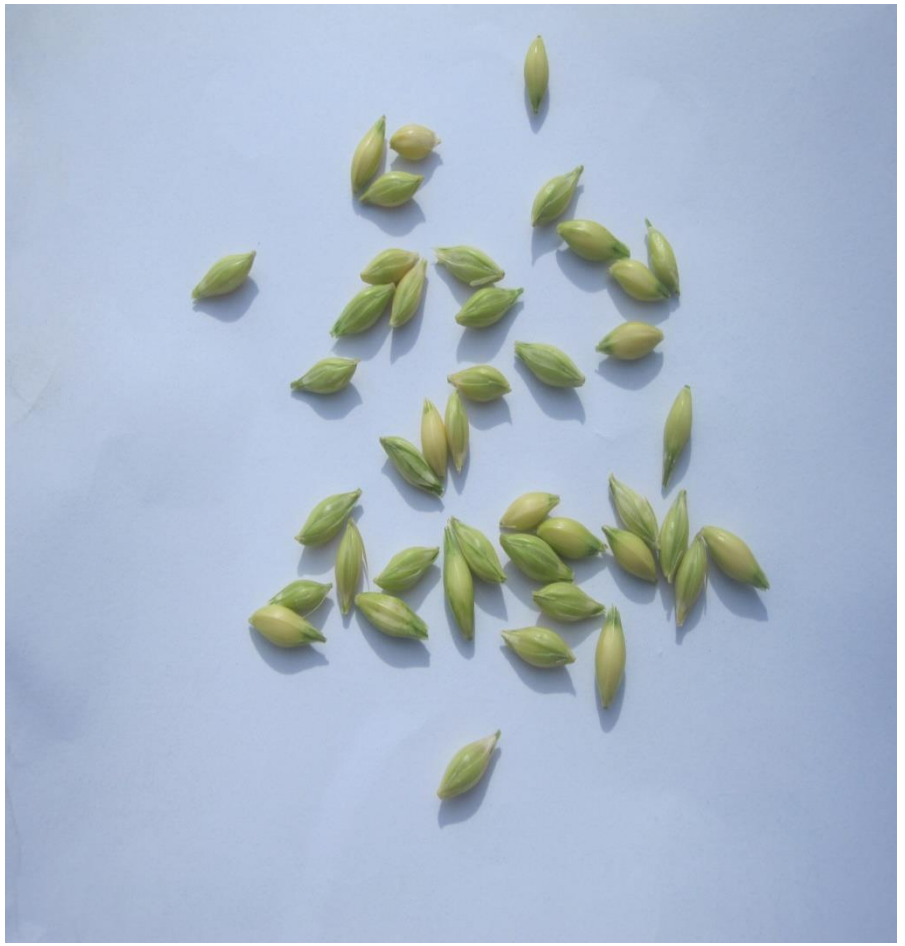
At maturity stage

Rec. N and P

Control (no fertilizer)

75 kg K ha^{-1} from source of KCl

75 kg K ha^{-1} from source of K_2SO_4



Future area of research could be

- Time of application and method of placement
- Verifying the ATA soil fertility map
- Conducting experiments in different AEZ, Soil type and crop type

Thank you!