LONG-TERM EFFECT OF POTASSIUM FERTILIZATION ON WATER CONTENT IN SORGHUM (FODDER) AND WHEAT GROWING ON INCEPTISOL

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Farmers' practice of cultivating high yielding varieties of crops without applying potassium fertilizer has been depleting potassium reserve of the alluvial soils since the advent of green revolution in India (Singh et al., 2002; 2008; Singh and Bansal, 2013; Singh and Bansal, 2016). Due to leaching loses of applied potassium and native soil potassium (Singh et al.,2001) the rate of depletion is more in loamy sand alluvial soils than sandy loam soils. Consequently, from the soil, potassium deficiency has been inheriting in growing crops resulting decrease in crop yield. Potassium concentrations in growing crop plant affects growth of plants, nitrogen uptake and therefore also affect the water content in plants.

Due to more percolation rate and low water holding capacity of loamy sand alluvial soils, significant amount of irrigation water is leached to lower soil depth and cant not absorbed by growing crop plants. Therefore, growing crops on these soils require more irrigations than crops on sandy loam soils. Potassium fertilization in sorghum and wheat growing on such type of soil could be helpful for absorbing more water from the loamy sand soil as potassium content in plant also affects stomata opening and closing in leaf.

Keeping these in view, this study on long term effect of potassium fertilization on water content in sorghum and wheat was conducted as such types of study on potassium reserve depleted alluvial soil of Northern India is meager.

MATERIAL AND METHODS

This study was conducted in 2019-2020 in long-term fertilizer experiment which was started in 1985 at Potash Research Institute of India, Gurgaon(Haryana) with sorghum and wheat cropping system. Information on initial soil properties (1985) and nutrient elements status are given in table.1. There were seven treatment combination: $N_0P_0K_0$, $N_{120}P_{60}K_0$, $N_{120}P_{60}K$ 6_0, $N_{120}P_{60}K_{120}$, $N_{240}P_{120}K_0$, $N_{240}P_{120}K_{120}$, **and $N_{120}P_{60}K_{60+10t\ FYM}$** . Doses of nitrogen, phosphorus and potassium written in subscript in kg/ ha were applied in sorghum and wheat through urea, Diammonium phosphate, and Murate of potash respectively. Zinc suphate @ of 25kg/ha was also applied in wheat only. These treatments were repeated three times in randomized block experiment design. Each treatment was applied plot having $15m^2$ area. Every year, sorghum was sown in last week of June and harvested in first week of September. Wheat was sown between 15-20 November and harvested in second week of April.

In 2019-2020, two irrigations of equal amount of water were given in sorghum and four irrigations of equal water were given in wheat. Values of Quality parameter of applied irrigation water are given in table 2. Soil samples were collected before and after the irrigation for the determining the moisture in soil samples. Sorghum plant samples were collected at 50 days and wheat plant were collected at heading stage for determining the water content in plant. Grain samples of wheat were collected at 130 days for determine the moisture in grain.

For determining the potassium status of soil and plant and other nutrient elements, soil and plant samples were also collected. The samples of plant, soil and water were analysed following standard methods given in (Jackson,1973, 1979) and (Tandon, 1993).

RESULTS AND DISCUSSION

Long-term effect on potassium status of soils

Long-term cultivation of sorghum and wheat without potassium fertilizer for the 34 years resulted decrease in both 1N NH_4Oac-K and boiling 1N HNO_3-K status of soils (table 3). Potassium status of soils of plots which had not been receiving potassium fertilizer since 1985 decreased to low level in 2019-2020 from its medium level in 1985. This was attributed to native soil K uptake by growing sorghum and wheat for 34 crop cycles.

Long-term effect on soil moisture content

At soil Surface (0-15cm), long-term potassium application through murate of potash for the 34 crops cycles did not significantly affect the soil moisture content when measured just after applying irrigation (Table 4) This showed that long-term potassium fertilizer application did not affect the water holding capacity of loamy-sand inceptisol(Table 4). However, soil moisture was significantly decreased with potassium fertilization when measured before applying the irrigation in sorghum and wheat. It was attributed to more absorption of water by enhanced growth of both crops with potassium fertilization.

Long-term Effect on water content in sorghum and wheat:

Long-term potassium application through murate of potash significantly increased the water content in sorghum fodder, wheat plant and wheat grain (Table 4 and 5).This was attributed to more uptake of nitrogen by sorghum and wheat with potassium fertilization (Table 6). Data in table 4 showed that moisture content in soil before application of the irrigation decreased at 0-15 cm surface layer with potassium fertilizer due to more absorption of water by enhanced growth of sorghum and wheat. This decreased percolation loses of irrigation water in loamy sand soil.

Long-term effect on nitrogen uptake, potassium content and yield of sorghum and wheat

Long- term potassium fertilization for the 34 crop cycles significantly resulted increase in nitrogen uptake by growing sorghum and wheat (Table 6). Concentration of potassium also significantly increased. Significant increase in nitrogen uptake was attributed to significant increase in yield of sorghum and wheat with long-term potassium fertilizer application (Table 6).

Table 1: Properties and nutrient status of soil in 1985

Properties (0-15cm)		Properties (0-15cm)	
pH(1:2)	8.2	Clay mineralogy	35% Illite
EC(1:2) dSm^{-1}	0.19	Classification	Udic Haplustept

OC ($mg\ kg^{-1}$)	2.37	Bulk Density ($Mg\ m^{-3}$)	1.42
CEC [($cmol(p^{+})kg^{-1}$)]	4.20	Hydraulic- Conductivity ($cm\ h^{-1}$)	4.5
% Sand	79.6	Available- N ($mg\ kg^{-1}$)	63.5
% Silt	9.4	Olsen P($mg\ kg^{-1}$)	2.5
%Clay	11.0	1N NH_4OAc-K ($mg\ kg^{-1}$)	75.0
Texture	Loamy-sand	Boiling 1N HNO3- K ($mg\ kg^{-1}$)	785

Table 2: Average chemical composition of ground water being used in irrigations

Properties	value	Properties	value
pH	7.65	HCO_3^{-1} ($meq\ L^{-1}$)	6.40
EC(dSm^{-1})	1.06	CO_3^{-2} ($meq\ L^{-1}$)	nil
Ca+Mg ($meq\ L^{-1}$)	5.50	Cl^{-1} ($meq\ L^{-1}$)	4.9
Na^{+} ($meq\ L^{-1}$)	5.58	NO_3^{-1} ($mg\ L^{-1}$)	trace
		SAR ($meq\ L^{-1}$)$^{1/2}$	3.37
K^{+} ($mg\ L^{-1}$)	3.90	RSC ($meq\ L^{-1}$)	0.9

Table 3: Long-term effect of potassium fertilization on potassium status of soil

Treatments Kg/ha/crop	1N NH_4OAc-K 1985 0-15cm(mg/kg)	1N NH_4OAc-K 2020 0-15cm(mg/kg)	Boiling 1N HNO_3-K 1985 0-15cm(mg/kg)	Boiling 1HNO_3-K 2020 0-15cm(mg/kg)
$N_0P_0K_0$	75	65.0	785	652
$N_{120}P_{60}K_0$	75	48.7	785	518
$N_{120}P_{60}K_{60}$	75	63.3	785	628
$N_{120}P_{60}K_{120}$	75	81.7	785	724
$N_{240}P_{120}K_0$	75	43.8	785	538

$N_{240}P_{120}K_{120}$	75	68.8	785	682
$N_{120}P_{60}K_{60+10t\ FYM}$	75	57.7	785	610
C.D ($P\leq0.05$)	-	9.06	-	7.44

Table 4. Long-term effect of potassium fertilization on water content in sorghum and wheat in (2019-2020)

Treatments Kg/ha/crop	Amount of irrigation water applied (kiloliters) in one irrigation	%Soil moisture after irrigation (mean values of sorghum and wheat seasons)	%Soil moisture before irrigation (mean values of sorghum and wheat seasons)	%Water content in sorghum at 50 days on fresh weight basis)	%Water content in wheat at heading on fresh weight basis)
$N_0P_0K_0$	816	17.32	9.75	84.02	81.11
$N_{120}P_{60}K_0$	816	17.37	8.67	87.11	83.7
$N_{120}P_{60}K_{60}$	816	17.78	7.34	89.64	85.73
$N_{120}P_{60}K_{120}$	816	17.84	6.90	90.20	87.36
$N_{240}P_{120}K_0$	816	17.39	7.42	88.26	85.23
$N_{240}P_{120}K_{120}$	816	17.54	6.52	90.80	87.73
$N_{120}P_{60}K_{60+10t\ FYM}$	816	20.48	8.70	90.70	87.48
C.D ($P\leq0.05$)	NA	0.76	1.88	1.26	1.23

Table 5: Long-term effect of potassium fertilization on K content in sorghum and wheat and water content (2019-20)

Treatments Kg/ha/crop	%Water content in wheat at heading	%moisture content in wheat grain at 130days	% K content in wheat plant At Harvest	%Water content in sorghum at 50days	% K content in sorghum at Harvest
$N_0P_0K_0$	81.11	5.00	1.52	84.02	1.86
$N_{120}P_{60}K_0$	83.70	20.90	1.09	87.11	0.52
$N_{120}P_{60}K_{60}$	85.73	23.55	1.45	89.64	0.95
$N_{120}P_{60}K_{120}$	87.36	24.55	1.84	90.20	1.59
$N_{240}P_{120}K_0$	85.23	14.17	0.80	88.26	0.49
$N_{240}P_{120}K_{120}$	87.73	28.78	1.81	90.80	1.05
$N_{120}P_{60}K_{60+10t\ FYM}$	87.48	29.03	1.91	90.70	1.16
C.D ($P\leq0.05$)	1.23	0.79	0.22	1.26	0.22

Table 6. Long term effect of potassium fertilizer on nitrogen uptake and yield of sorghum and wheat

Treatments Kg/ha/crop	Total N uptake by wheat (kg/ha)	N Uptake by sorghum fodder (kg/ha)	Yield 2019-20 Wheat grain q/ha	Yield 2019 sorghum dry matter (fodder) q/ha
$N_0P_0K_0$	21.39	12.08	5.55	14.15
$N_{120}P_{60}K_0$	81.63	34.16	35.10	62.23
$N_{120}P_{60}K_{60}$	97.01	51.37	38.52	84.35
$N_{120}P_{60}K_{120}$	112.22	68.10	45.50	87.65
$N_{240}P_{120}K_0$	122.2	50.09	39.28	60.72
$N_{240}P_{120}K_{120}$	167.91	78.30	53.42	100.00
$N_{120}P_{60}K_{60+10t}$ FYM	119.96	71.59	48.35	94.70
C.D ($P \leq 0.05$)	4.80	3.57	0.84	2.92

SUMMARY

To assess the long-term effect of potassium fertilization on soil and crops, a long-term fertilizer experiment was started at Potash Research Institute of India in 1985 with sorghum(fodder)-wheat cropping system.

In 1985, soil of this experiment was loamy-sand in texture. The soil had slightly alkaline pH, normal electrical conductivity, low organic carbon status, moderate water holding capacity and saturated hydraulic conductivity. This soil had medium 1N NH_4OAc –K and boiling 1N HNO_3 –K status in 1985. Soil is classified as Haplustept. Due to loamy sand texture, growing sorghum and wheat require frequent irrigations.

After, 34 cycles of sorghum and wheat, long term potassium fertilizer application significantly increased water content in growing sorghum and wheat. Therefore, growing sorghum and wheat with potassium fertilizer efficiently utilized irrigation water and reduced percolation loses of irrigation water in loamy sand soil. This was attributed to increased nitrogen uptake by sorghum and wheat with potassium fertilization. Yield of sorghum and wheat also increased.

CONCLUSION

It is concluded from this long-term study that potassium fertilization in sorghum and wheat grown on potassium reserve depleted loamy-sand inceptisol significantly increased water content in sorghum and wheat and better utilized irrigation water reducing its percolation loses in soil. Therefore, In potassium reserve depleted loamy-sand inseptisol, potassium fertilization is needed for increasing the yield and better utilization of irrigation water to cultivate sorghum(fodder) and wheat.

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