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Potassium response in maize crop in coarse textured soils of Haryana

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Abstract
Field experiments were carried out on sandy soils of Karnal, Bawal and Balsamand of Haryana for (2018 to 2019) to study the effect of potassium application (0, 30, 60 and 90 kg K_2O ha^{-1}) on maize fodder *(*African Tall). The results revealed that maize crop responded to potassium application significantly up to 60 kg K_2O ha^{-1}. The potassium application significantly increased maize straw yield and fresh yield. The K content and K uptake by maize crop increased with potassium fertilizer application to the soil.

Keywords: Potassium, response, uptake, maize fodder, dry yield, fresh yield, loamy sand

Introduction
Increasing population demands more food with every day in the future. About 1000 million people in world are unable to get daily dietary intakes, and more than 400 million are facing malnutrition problems. Hunger and hunger induced diseases kill about 11 million children of less than 5 years of age annually. United States of America and China produce approximately 60% of the world maize crop, while 68% of land devoted to maize crop is located in the developing world, which contribute only 46% of total maize production, indicating the need for improving yield of maize crop in developing countries. Maize is 3rd largest food crop after wheat and rice. Maize is primary source of energy in the dairy industry as it is a good source of proteins, carbohydrates, Fe, vitamin B, and minerals. Maize green fodder is quite rich in proteins. It provides raw materials for flakes, starch, corn oil and custard. Potassium activates many enzymes and plays an important role in the maintenance of electrical potential gradients across cell membranes and the generation of turgor in plants. It regulated for photosynthesis, protein synthesis and starch synthesis (Mengel and Kirkby, 1996) [11].
Potassium (K) is a major and essential plant macronutrient and the most abundantly absorbed cation in higher plants (Sparks and Huang 1985) [19]. It plays a major role in activating »60 enzymes, regulating stomatal function, controlling water relations, especially under rainfed condition, influencing the water balance of the plant system, and underpinning agronomic productivity and sustainability (Mengel 1985; Sparks and Huang 1985) [11, 19]. Dissimilar nitrogen (N) and phosphorus (P), K does not form bond with carbon (C) or oxygen, so it never becomes a part of protein and other organic compounds. Although K is not a constituent of any plant structures or compounds, it is involved in nearly all processes needed to sustain the plant life. However, to increase crop production, more attention has been paid to N and P fertilizers, but not to K, by either inorganic fertilizer or organic manure. During green revolution and with the progressive intensification of agriculture, the soils are getting depleted in K reserve at a faster rate and available soil K levels have also dropped due to leaching, runoff, and erosion. As a consequence, K deficiency is becoming one of the major constraints in crop production. The K requirement of crops is met from the reserve K fraction (Srinivasarao *et al*. 2006) [20]. A negative K balance in soil under intensive cropping occurs because of low external input and large crop removal, leading to depletion of the Non-exch or reserve K (Srinivasarao *et al*. 2006) [20].
It has been estimated that in 1980, the available K status of 82% soils of Haryana was high and the remaining 18% were medium. But due to intensive cropping, continuous mining and limited/ no use of K-fertilizer, the available K status of Haryana soils has depleted.

About 21, 52 and 27% of Haryana soils have become low, medium and high in available K status, respectively (Anonymous 2011) [1].

Materials and Methods

To study the response of K in maize fodder crop, pot experiments were conducted from kharib season of 2018-19 at CCS HAU, (Haryana). The soil sample collected from Karnal, Bawal and Balsamand. The experiments were laid out in randomized block design with three replications. There were four treatment combinations *viz*., $N_{80}P_{30}K_0$, $N_{80}P_{30}K_{30}$, $N_{80}P_{30}K_{60}$ and $N_{80}P_{30}K_{90}$. The soils of the experimental fields were loamy sand in texture, alkaline in reaction. The soil pH, EC and soil texture were determined by standard methods Jackson (1973) [8]. Available N was estimated by alkaline permanganate oxidation method as outlined by Subbaiah and Asija (1956) [22]. Available P was determined by Olsen's method (Olsen *et al*. 1954) [12] using spectrophotometer (660 nm wave length). Available K was extracted with neutral normal ammonium acetate and the content of K in the sample was estimated by flame photometer (Jackson 1973) [8]. The potassium treatments were applied before sowing as per treatments through muriate of potash (MOP). As per recommendations, a uniform basal dose of 40 kg N and 30 kg P_2O_5 through DAP and urea and 25 kg $ZnSO_4$ were applied at sowing while remaining 25 kg N through urea was top dressed at first irrigation. The maize fodder crop was harvested at maturity. Soil and straw samples were analyzed for available K in soil and K concentration and straw, respectively (Jackson 1973) [8]. Available K was extracted by neutral normal ammonium acetate and estimated by flame photometer and K concentration in straw was estimated after samples were digested in HNO_3-$HClO_4$ mixture (4:1). Results were statistically analyzed by methods of Panse and Sukhatme (1978) [13].

Results and Discussion

Table 1: Effect of potassium fertilization on dry matter and fresh yield and nutrient uptake by maize

Physiographic unit	K level (mg kg^{-1})	Yield (g pot^{-1})		Nutrient uptake (mg kg^{-1})			
		Dry matter	Fresh yield	N	P	K	Zn
P1	K_0	36.39	210.11	499.36	101.60	484.34	3.77
	K_{30}	36.25	211.51	503.26	102.83	487.51	3.81
	K_{60}	36.92	215.01	512.18	103.73	489.21	3.83
	K_{90}	37.20	215.14	513.74	105.03	491.72	3.84
	CD (0.05)	NS	NS	NS	NS	NS	NS
P2	K_0	29.14	168.22	331.40	35.67	283.042	2.13
	K_{30}	31.56	181.92	352.91	38.77	323.171	2.18
	K_{60}	33.59	196.32	365.34	44.90	364.846	2.28
	K_{90}	34.27	199.52	377.85	44.03	380.945	2.30
	CD (0.05)	1.61	8.41	16.69	4.55	31.86	0.10
P3	K_0	28.12	162.21	306.43	31.13	271.25	2.08
	K_{30}	30.45	177.21	309.69	35.20	294.80	2.10
	K_{60}	33.15	192.71	324.55	40.03	341.65	2.20
	K_{90}	33.78	196.71	331.70	40.13	349.06	2.21
	CD (0.05)	1.10	8.56	12.72	4.22	29.33	0.09

P1-Typic Natrustalfs, P2-Typic Ustorthents, P3-Typic Ustipsamments

Response of potassium to maize crop

The potassium releasing power of different soils was assessed in a screen house experiment by growing maize. Soils collected from different physiographic units were used for this purpose. The experiment was conducted in 5 kg capacity plastic pots. Different levels of potassium (0, 30, 60 and 90 mg kg^{-1}) were applied before sowing the maize crop.

Effect of potassium application dry matter and fresh yield

The data (Table 1) indicated that the maize fodder crop in control plots varied from 28.12 to 36.39 yield (g pot^{-1}) and 162.21 to 210.11 yield (g pot^{-1}) respectively, at three different locations of soil sample during one season crop study due to variation in general fertility of the soil. The dry matter yield of maize increased with increase in application of potassium (Table 1). Dry matter and fresh yield from 33.78 to 37.20 yield (g pot^{-1}) respectively, and 196.71 to 210.11 yield (g pot^{-1}) respectively, with application of different rate of potassium application. The highest dry matter yield was recorded in Typic Natrustalfs (37.2 g pot^{-1}) and lowest in Typic Ustipsamments (33.7 g pot^{-1}). The K_{90} mg kg^{-1} level recorded significantly higher dry matter yield over control (K_0 mg kg^{-1}) and K_{30} mg kg^{-1} levels in all physiographic units but was at par with K_{60} mg kg^{-1} level except in Typic Natrustalfs.

The increased yield with K fertilization might be due to increased availability, absorption and translocation of K nutrient by and into the maize fodder crop, increased enzyme activity, photosynthesis, transport of sugars, protein and starch synthesis and ultimately increased crop yield. Rekhi *et al*. (2000) [16], Singh *et al*. (2002) [16-18, 25, 26], Yadav and Yadav (2004) [24-26], Yadav *et al*. (2012) [24-26] and Yadav *et al*. (2013) [24-26] also observed the significant effect of K application in sesame, mustard, groundnut, pearl millet and wheat.

The effect of K application on NKP and Zn uptake by maize

The significant increase in maize fodder crop K uptake was observed with the increase in the levels of applied K (Table 1). The NPK and Zn uptake increased significantly in all the physiographic units with the exception of Typic Natrustalfs. The highest nitrogen uptake was recorded in Typic Natrustalfs (513.7 mg kg^{-1}) and lowest in Typic Ustipsamments (331.7 mg kg^{-1}). Similarly, the highest potassium uptake was recorded in Typic Natrustalfs (491.7 mg kg^{-1}) and lowest in Typic Ustipsamments (349.0 mg kg^{-1}). Likewise, the highest phosphorous uptake was recorded in Typic Natrustalfs (105.0 mg kg^{-1}) and lowest in Typic Ustipsamments (40.1 mg kg^{-1}). In the same way, the highest zinc uptake was recorded in Typic Natrustalfs (3.8 mg kg^{-1}) and lowest in Typic

Ustipsamments (2.2 mg kg^{-1}). The K_{90} mg kg^{-1} level recorded significantly higher nutrient uptake over control (K_0 mg kg^{-1}) and K_{30} mg kg^{-1} levels in all physiographic units but was at par with K_{60} mg kg^{-1} level except in Typic Natrustalfs. The increased K uptake by crop might be due to increased dry matter yield and increased K uptake in maize fodder crop due to K fertilization. Similar results were also observed in groundnut and pearl millet by Hadvani and Gundalia (2003) [7] and Yadav *et al*. (2012) [24-26]. Secondly, because NO_3^- is taken up by plant roots through an active process (Streeter and Barta, 1984; Fageria, 2001) [6, 21], therefore, NO_3^- uptake may be affected through the influence of K on the translocation of photosynthetic assimilates, needed to support this active uptake process (Ashley and Goodson, 1972; Fageria, 2001) [2, 6]. Zhang *et al*. (2010) [10, 27] also reported increase in nitrogen uptake with increase in levels of potassium. The increased uptake of P with increased levels of K may be due to synergistic effect of P and K mediated by nitrogen. Li *et al*. (2007) [10, 27] concluded that K application increased P percentage in maize stalk most likely due to more uptake of N that enhanced the increased uptake of P.

Bukhsh *et al*. (2009) [3] also reported that K application promoted P uptake by plants and consequently improved P concentration in stalk. Similar results were ascertained by Jat *et al*. (2014) and Ravindra *et al*. (2014) [9, 15] who reported increased uptake of N, P and K by wheat and maize crop due to K application, respectively. Cherney and Cherney (2005) [5] also reported higher uptake of K by sorghum and different grasses with increasing application of potassium. The data reported above clearly bring out the synergistic effect of K application on the N, P and Zn content and N uptake by maize. Watson (1963) [23] attributed such a higher nutritional uptake mainly by greater expansion of root system caused by increased supply of photosynthetic productions. The higher uptake of K by maize may be ascribed to the contact between K ions and roots which increases with increase of K availability in the soil. Moreover, in pots the plants have to take up nutrients from confined mass of soil. Singh *et al.* (2014) [16-18, 25, 26] also reported significant effect of K fertilizer on potassium uptake by crop.

Patil *et al*. (2017) [14] reported that significantly higher total N, P, K uptake by maize crop was recorded when 125% of K_2O was applied. The increase in uptake of zinc with increasing levels of K may be due to the favourable effect of K on photosynthesis and metabolic processes thereby augmenting the production of photosynthates and their translocation to different plant parts which eventually increased the Zn concentration in the stalks. Chaudhary *et al*. (2017) [4] evinced that the application of potassium increased the uptake of zinc which was possibly due to enhanced growth and development of plants because of higher photosynthetic activity

Conclusion

The dry matter yield of maize increased with increase in application of potassium. The dry matter yield increased significantly in all the physiographic units having medium amounts of ammonium acetate extractable K with the exception of Typic Natrustalfs where the levels of K were adequate. The K^{90} mg kg^{-1} level recorded significantly higher dry matter yield over control (K_0 mg kg^{-1}) and K_{30} mg kg^{-1} levels in all physiographic units. There was variation in dry matter and green fodder yield with respect to physiographic units which may be due to the wide variation of soil K pools and K-supply potential of these soils. The highest nutrient uptake was recorded in Typic Natrustalfs and lowest in Typic Ustipsamments. The K_{90} mg kg^{-1} level recorded significantly higher nutrient uptake over control (K_0 mg kg^{-1}) and K_{30} mg kg^{-1} levels in all physiographic units.

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