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# Effect of different levels of potassium on nutrient content and uptake by kharif maize (*Zea mays* L.)

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## Abstract
A field experiment entitled was conducted during *kharif* season of 2017 at Crop Research Farm of Tirhut College of Agriculture, Dholito see the effect of different levels of potassium on soil properties, nutrient content and uptake by*kharif* maize crop. Experiment was laid out in Randomized block design with four replications and nine treatments at different level of potassium (0, 30, 60, 90, 120 and 150 kg ha$^{-1}$) in which three treatments $T_7$, $T_8$ and $T_9$ along with 5 tons of FYM.The soil of the experimental field was sandy loam in texture, calcareous in nature with pH 8.2 and low in organic carbon (0.44%). The soil contained 210, 16.32 and 122 kg ha$^{-1}$ available N, $P_2O_5$ and $K_2O$, respectively. N and P content of grain and stover were non-significant due to different treatments. However, significantly higher K content of grain and stover was recorded with treatment $T_9$ ($T_4$ + 5 t FYM ha$^{-1}$). Significantly higher N, P & K uptake of grain and stover were recorded under $T_9$ ($T_4$ + 5 t FYM ha$^{-1}$) as compared to other treatments.

**Keywords:** Potassium levels, FYM, content, uptake

## Introduction
Potassium is an essential nutrient element for all living organisms including plants and animals and its importance in Indian agriculture has increased. It is a univalent cation found in largest concentration in the cell sap and hence it is called a “master cation”. Potassium activates many enzymes and plays an important role in the maintenance of potential gradients across cell membranes and the generation of turgor pressure in plants. Itregulate photosynthesis, protein synthesis and starch synthesis (Mengel and Kirkby, 1996) [12].
Potassium has also been referred to as the ‘quality nutrient’. The quality effects are more closely linked to its interactions with nutrients such as nitrogen, than to absolute levels of K. Increasing the dose of K increases the K uptake by plants due to increase in interaction of K ions and roots of plants with increasing K availability in soil. Potassium levels increases the shoot contents of N, P, K, Ca, S and Zn in the plants due to its stimulation of root and shoot growth (Filho *et al*., 2017) [6]. Well-developed root systems have the ability to exploit a greater soil volume, which is fundamental principle for increasing the contact between roots and nutrients, resulting in an improvement in nutrient uptake (Medeiros *et al*., 2005) [11]. Potassium is required by plants in large quantities, equal to or more than N, and plays a key role in many metabolic processes in the plant.
FYM is the principle source of organic matter in our country and it is a source of primary, secondary and micronutrients to the plant growth. FYM is the principle source of organic matter in our country and it is a source of primary, secondary and micronutrients to the plant growth. It is a constant source of energy for hetrotropic microorganisms, help in increasing the availability of nutrient and crop produce quality. The entire amount of nutrients present in farmyard manure is not available immediately but about 30 per cent of nitrogen, 60 to 70 per cent of phosphorus and 70 per cent of potassium are available to the first crop, while remaining amount of nutrients will be available to succeeding crop (Kaihura, 1999) [8]. The application of FYM also enhanced the availability of plant nutrient present in soil. While, FYM applied with Zn and K increased the uptake of deficient nutrients as well as improving the soil chemical, biological and physical properties of soil. FYM is a store house of nutrient, which contain all essential plant nutrients. It is beneficial as apply fertilizer like K in combination with FYM (Nawab *et al*., 2011) [13].
Maize has a high production potential as an exhaustive crop for potassium fertilizer when compared to any other cereal crop. Moreover, productivity of maize largely depends on its

nutrient requirement. Large quantity of potassium will be taken up by maize crop, which accounts to more than 400 kg $K_2O$ ha$^{-1}$ under intensive cropping system (Kusro *et al*., 2014) [10]. So, with this background present study to know the effect of different levels of K on nutrient content and up take by maize crop was carried out.

## Materials and Methods

A field experiment was conducted at the Crop Research Centre of Tirhut College of Agriculture, Dholi, Muzaffarpur, Bihar during *Kharif* 2017. The soil of the experimental plot was calacareous alluvium in nature developed on the sediments of the river Burhi Gandak mainly by the deposition of sediments through the ages. The chief characteristics of this soil is the high content of free calcium carbonate ranging from 10 to 45 per cent which is distributed throughout the depth of the profile. The experiment was laid out in a randomized block design with four replications. The treatment comprised of nine treatments *viz*., RD of N and P + 0 kg K ha$^{-1}$ ($T_1$), RD of N and P + 30 kg K ha$^{-1}$ ($T_2$), RD of N and P + 60 kg K ha$^{-1}$ ($T_3$), RD of N and P + 90 kg K ha$^{-1}$ ($T_4$), RD of N and P + 120 kg K ha$^{-1}$ ($T_5$), RD of N and P + 150 kg K ha$^{-1}$ ($T_6$), $T_2$ + 5 t FYM ha$^{-1}$ ($T_7$), $T_3$ + 5 t FYM ha$^{-1}$ ($T_8$), $T_4$ + 5 t FYM ha$^{-1}$ ($T_9$). Pioneer-3377 variety of maize was sown according to the dates decided in the treatment, maintaining 60 cm row-to-row and 20 cm plant to plant distance with the seed rate of 20 kg ha$^{-1}$ at 3-4 cm depth with a fixed dose of nitrogen (120 kg ha$^{-1}$) and phosphorus (60 kg ha$^{-1}$) and quantity of FYM required for plot was calculated as per treatment details. Source of nutrients were urea for nitrogen, Di ammonium Phosphate for phosphorus, muriate of potash for potassium. One third dose of Nitrogen, full dose of Phosphorus and Potash was applied as basal dose. The remaining two third of the Nitrogen was applied in equally two half split at knee high stage and before emergence of tassel. Prior to layout of the experiment, samples of surface soil upto 15 cm depth were taken randomly from different places and mixed to make a composite sample. All technical precautions prescribed for standard soil sampling were taken. The soil samples were brought to the laboratory, air-dried and ground, thereafter sieved through 2 mm sieve. The soil samples thus obtained were analysed for various physical and chemical properties by following procedure.

**Table 1:** Physical properties of the soil of experimental plot

| Particulars | Value obtained | Method employed |
|---|---|---|
| Soil separates (%) | | |
| Sand | 47 | International pipette method (Piper, 1966) [15] |
| Silt | 42.20 | |
| Clay | 10.40 | |
| Texture | Sandy loam | |

Chemical properties of the soil of experimental plot

| Particulars | Initial value obtained (0-15 cm depth) | Method used |
|---|---|---|
| Soil pH (1:2, soil: water) | 8.2 | Glass electrodes pH meter (Jackson, 1973) [7] |
| EC (dSm$^{-1}$) | 0.35 | Conductivity bridge (Jackson, 1973) [7] |
| Organic carbon (%) | 0.44 | Walkley and Black (1934) [23] |
| Available N (kg ha$^{-1}$) | 210 | Alkaline permanganate method (Subbiah and Asija, 1956) [20] |
| Available $P_2O_5$ (kg ha$^{-1}$) | 16.32 | Olsen's method (Olsen *et al*., 1954) [14] |
| Available $K_2O$ (kg ha$^{-1}$) | 122 | Flame photometer method (Jackson, 1973) [7] |

After harvest the grain and straw sample was separated and oven dried at 65 °C ± 2 ºC for 48 hours or till constant weight. Sample was grinded in an electric stainless-steel grinder. The powdered plant sample of 0.5 g was digested with concentrated $H_2SO_4$ in presence of digestion mixture ($CuSO_4$ + $K_2SO_4$ + selenium powder) in digestion unit for 3 hours and temperature maintained at 420 °C. The digested sample was further diluted carefully with distilled water to a known volume. Then aliquot was transfer to distillation unit and was steam distilled with 20 ml of 40 percent sodium hydroxide in a semi-micro Kjeldhal apparatus. The liberated ammonia was trapped in boric acid mixed indication solution. Then, it was titrated against standard acid (0.01N $H_2SO_4$) and the amount of nitrogen liberated was estimated and expressed the concentration in percentage. Nitrogen percentage in plant sample was calculated from the following formula:

$$\text{Percent N} = \frac{0.014 \times N\,(S-B)}{W} \times 100$$

Where,
S = ml. of standard acid required for the titration of the plant sample.
B = ml. of standard acid required for blank titration
N = normality of acid.
W = Weight of plant sample in gram.

Powdered plant samples (0.5 g) were digested in 10-15 ml tri-acid mixture of $HNO_3$, $HClO_4$ and $H_2SO_4$ in a ratio of 10:3:1 on a hot plate until a clear colourless solution was obtained and the volume was reduced to 1-2 ml. The digested material was cooled and transferred to 50 ml volumetric flask and volume was made up to the mark by adding distilled water. The dissolved material was filtered through Whatman No. 1 filter paper. A blank was carried out in the same way having no plant material. From these digested plant samples, P was estimated by vanado-molybdate yellow colour method and determined with the help of spectrophotometer. Potassium in the digested plant samples was determined by using flame photometer. The nutrient uptake by plants was calculated by using the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in sample (\%)} \times \text{Yield (kg ha}^{-1}\text{)}}{100}$$

## Result and Discussions

### Effect of different treatments on chemical analysis of soil pH, EC and organic carbon

The data pertaining to the effect of different treatments on soil pH, EC and organic carbon after harvest was found non-significant has been presented in Table-2. The maximum pH, EC and organic carbon were obtained in treatment $T_5$ (8.24), $T_6$ (0.40 dSm$^{-1}$) and $T_9$ & $T_7$ (0.49%), respectively. However minimum pH, EC and organic carbon reported in $T_8$ (8.15), $T_1$& $T_2$ (0.35 $dSm^{-1}$) and $T_1$ & $T_4$ (0.44%), respectively. Similar results were obtained by Babu and Reddy (2000) [1], Shujrah *et al*. (2011) [19] reported that decrease in soil pH may be due to increase in partial pressure of $CO_2$ and production of organic acids.

**Available nitrogen and phosphorous**

The data presented in table-2 showed that available nitrogen and phosphorous of soil have non-significant due to different treatments. Maximum available nitrogen and phosphorous (213.83 kg $ha^{-1}$& 22.24 kg $ha^{-1}$, respectively) was recorded with treatment $T_9$ (RD of N and P+ 90 kg K along with 5 t FYM $ha^{-1}$) however, the minimum available nitrogen and phosphorous (208.63 kg $ha^{-1}$ & 18.35 kg $ha^{-1}$, respectively) recorded in $T_1$ (RD of N and P + 0 kg K). Wakeel *et al*. (2002) [26] reported that higher available nitrogen content in soil under FYM addition could be due to favorable microbial activity and improved physical condition of soil. Prasad *et al*. (1996) [16] and Yurtseven *et al*. (2002) [25] reported the influence of FYM in increasing the phosphorus availability in soil.

**Available potassium**

Available potassium of soil significantly influenced by different treatments have been presented in Table-2. Significantly higher available potassium (134.56 kg $ha^{-1}$) was noticed in $T_6$ (RD of N and P + 150 kg K $ha^{-1}$) which was on par with treatment $T_5$ (130.61 kg $ha^{-1}$), $T_8$ (128.55 kg $ha^{-1}$) and $T_9$ (132.32 kg $ha^{-1}$), respectively and lower available potassium was recorded in the $T_1$ (105.74 kg $ha^{-1}$). This might be due to high dose of K fertilizer, organic manure 5 tons FYM $ha^{-1}$ and levels of K increased markedly the available potassium status in soil. The results are in accordance with the findings of Khatic and Dikshit (2001) [9], Richard *et al*. (2004) [17] and Wortmann *et al*. (2009) [24].

**Effect of different treatments on chemical analysis of plant Nitrogen (N) and Phosphorous(P) content in grain and stover**

Data pertaining in Table-3 to influence of potassium levels revealed that K content in grain and stover was found to increased significantly while maximum N and P content in grain and stover could not reach up to level of significance. However, among all the treatments, maximum N and P content was recorded both in grain (1.415 and 0.303%, respectively) and stover (0.764 and 0.119%, respectively) with the application of recommended dose of N and P+ 90 kg K along with 5 t FYM $ha^{-1}$ ($T_9$).

**Potassium (K) content in grain and stover**

K content in grain and stover of maize significantly influenced by different levels of potassium have been presented in Table- 3. Significantly, higher K content in grain and stover (0.545 and 1.234%, respectively) were recorded in $T_9$(recommended dose of N and P+ 90 kg K along with 5 t FYM $ha^{-1}$) while lowest K content in grain and stover (0.456 and 1.145%, respectively) were under control plot ($T_1$). This might be due to application of higher dose of potassium that resulted increase in the nutrient uptake and their accumulation in grain and stover of maize, Dan and Thind (2005) [5] and also, it might be due to luxury consumption of K Brady and Well (2007) [4] and synergetic interaction between N and K Ujwala Ranade (2011) [22]. FYM improves the soil environment which encourages proliferation of roots, draw more water, nutrients from larger area and also from greater depth, and increased K availability in the soil for longer span. Similar findings have been reported by Roy *et al*. (2001) [18].

**Nitrogen (N), Phosphorous (P) and Potassium(K) uptake by grain and stover**

Uptake of nutrients is a function of nutrient content and grain and stover yield. The mean results indicated that potassium levels influenced significantly higher uptake of N, P and K both in grain (89.41, 19.15 and 34.44 kg $ha^{-1}$, respectively) and stover (77.63, 12.09 and 125.39 kg $ha^{-1}$, respectively) with the application of recommended dose of N and P+ 90 kg K along with 5 t FYM $ha^{-1}$ ($T_9$) have been presented in Table-4. This indicated a favourable soil micro climate régime induced by the incorporation of FYM. Application of FYM reduces P fixation by releasing considerable amount of a variety of organic acids during decomposition and as well as inducing chelating effects on micronutrients which probably enhanced the availability of phosphorus (Behera and Singh, 2010) [3]. Applications of FYM not only solubilize the unavailable nutrients but also contains significant amount of N, P, K and micronutrients. Thus, application of FYM has resulted in an overall significant increase in uptake of nutrients at lesser cost for longer duration. These findings were supported by Bagavatiammal and Muthiah (1995) [2] and Sudhir *et al*. (1998) [21].

**Table 2:** Postharvest soil properties as affected by different treatments

| Treatments | N (kg/ha | $P_2O_5$ (kg/ha) | $K_2O$ (kg/ha) | pH | EC ($dSm^{-1}$) | OC (%) |
|---|---|---|---|---|---|---|
| $T_1$: RDF of nitrogen and phoshphorus + 0 kg potassium fertilizer | 208.63 | 18.35 | 105.74 | 8.22 | 0.35 | 0.44 |
| $T_2$-: RDF of nitrogen and phoshphorus + 30 kg potassium per ha | 210.52 | 18.74 | 117.27 | 8.23 | 0.35 | 0.45 |
| $T_3$: RDF of nitrogen and phoshphorus + 60 kg potassium per ha | 210.68 | 19.12 | 123.45 | 8.23 | 0.36 | 0.45 |
| $T_4$: RDF of nitrogen and phoshphorus + 90 kg potassium per ha | 209.31 | 19.34 | 127.22 | 8.22 | 0.37 | 0.44 |
| $T_5$: RDF of nitrogen and phoshphorus + 120 kg potassium per ha | 211.54 | 20.05 | 130.61 | 8.24 | 0.38 | 0.46 |
| $T_6$: RDF of nitrogen and phoshphorus + 150 kg potassium per ha | 211.24 | 19.63 | 134.56 | 8.23 | 0.40 | 0.47 |
| $T_7$: $T_2$ + 5.0 t/ha FYM | 212.57 | 21.45 | 122.72 | 8.16 | 0.36 | 0.49 |
| $T_8$: $T_3$+ 5.0 t/ha FYM | 213.24 | 21.65 | 128.55 | 8.15 | 0.36 | 0.48 |
| $T_9$: $T_4$+ 5.0 t/ha FYM | 213.83 | 22.24 | 132.32 | 8.18 | 0.37 | 0.49 |
| SEm± | 7.67 | 1.14 | 2.27 | 0.29 | 0.01 | 0.02 |
| CD (P=0.05) | NS | NS | 6.68 | NS | NS | NS |

Where, CD: Critical difference, FYM: Farm yard manure, RDF: Recommended dose of fertilizer, SEm: Standard error of mean, NS: Not significant

**Table 3:** N, P and K content in maize as affected due to different treatments

| Treatments | N content in grain | N content in stover | P content in grain | P content in stover | K content in grain | K content in stover |
|---|---|---|---|---|---|---|
| $T_1$: RDF of nitrogen and phosphorus + 0 kg potassium fertilizer | 1.362 | 0.691 | 0.284 | 0.106 | 0.456 | 1.145 |
| $T_2$: RDF of nitrogen and phosphorus + 30 kg potassium per ha | 1.374 | 0.714 | 0.286 | 0.109 | 0.473 | 1.156 |
| $T_3$: RDF of nitrogen and phosphorus + 60 kg potassium per ha | 1.378 | 0.734 | 0.286 | 0.111 | 0.487 | 1.172 |
| $T_4$: RDF of nitrogen and phosphorus + 90 kg potassium per ha | 1.386 | 0.741 | 0.289 | 0.113 | 0.506 | 1.187 |
| $T_5$: RDF of nitrogen and phosphorus + 120 kg potassium per ha | 1.398 | 0.748 | 0.294 | 0.114 | 0.516 | 1.211 |
| $T_6$: RDF of nitrogen and phosphorus + 150 kg potassium per ha | 1.397 | 0.744 | 0.292 | 0.114 | 0.525 | 1.217 |
| $T_7$: $T_2$ + 5.0 t/ha FYM | 1.384 | 0.751 | 0.296 | 0.115 | 0.498 | 1.178 |
| $T_8$: $T_3$+ 5.0 t/ha FYM | 1.414 | 0.763 | 0.301 | 0.117 | 0.514 | 1.207 |
| $T_9$: $T_4$+ 5.0 t/ha FYM | 1.415 | 0.764 | 0.303 | 0.119 | 0.545 | 1.234 |
| SEm± | 0.025 | 0.017 | 0.005 | 0.004 | 0.009 | 0.011 |
| CD (P=0.05) | NS | NS | NS | NS | 0.027 | 0.033 |

Where, CD: Critical difference, FYM: Farm yard manure, RDF: Recommended dose of fertilizer, SEm: Standard error of mean, NS: Not significant.

**Table 4:** N, P and K uptake (kg/ha) in maize as affected due to different treatments

| Treatments | N uptake by grain | N uptake by stover | P uptake by grain | P uptake by stover | K uptake by grain | K uptake by stover |
|---|---|---|---|---|---|---|
| $T_1$: RDF of N and P + 0 kg K fertilizer | 58.06 | 56.53 | 12.11 | 8.67 | 19.44 | 93.67 |
| $T_2$: RDF of N and P + 30 kg K per ha | 65.13 | 62.56 | 13.56 | 9.55 | 22.42 | 101.29 |
| $T_3$: RDF of N and P + 60 kg K per ha | 73.14 | 68.71 | 15.18 | 10.39 | 25.85 | 109.71 |
| $T_4$: RDF of N and P + 90 kg K per ha | 77.98 | 71.65 | 16.26 | 10.93 | 28.47 | 114.77 |
| $T_5$: RDF of N and P + 120 kg K per ha | 81.50 | 73.74 | 17.14 | 11.24 | 30.08 | 119.38 |
| $T_6$: RDF of N and P + 150 kg K per ha | 80.26 | 72.70 | 16.78 | 11.14 | 30.16 | 118.93 |
| $T_7$: $T_2$ + 5.0 t/ha FYM | 78.76 | 72.82 | 16.85 | 11.25 | 28.34 | 114.23 |
| $T_8$: $T_3$+ 5.0 t/ha FYM | 83.75 | 75.86 | 17.83 | 11.63 | 30.44 | 120.00 |
| $T_9$: $T_4$+ 5.0 t/ha FYM | 89.41 | 77.63 | 19.15 | 12.09 | 34.44 | 125.39 |
| SEm± | 2.414 | 2.20 | 0.510 | 0.338 | 1.02 | 3.517 |
| CD (P=0.05) | 7.087 | 6.456 | 1.499 | 0.991 | 2.996 | 10.328 |

Where, CD: Critical difference, FYM: Farm yard manure, RDF: Recommended dose of fertilizer, SEm: Standard error of mean, NS: Not significant

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