Indian Journal of Agronomy **64** (4): 528–532 (December 2019)

Research Communication

Effect of potassium management on crop growth, yield and economics of spring maize (*Zea mays*) in western Uttar Pradesh

PREM SINGH[1], U.P. SHAHI[2], V.K. SINGH[3], NEERAJ K. AWASTHI[4] AND P.K. RAI[5]

Sardar Vallabh Bhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh 250 110

Received: July 2019; Revised accepted: December 2019

ABSTRACT

A field experiment was conducted during the *spring* season of 2015–2016 on Typic Ustochrept soil of western Indo-Gangetic Plains to evaluate the effect of potassium management on crop growth, yield and economics of spring maize in western Uttar Pradesh. Twelve treatments comprising 100% NP, 100% NPK, 100% NP + 125% K, 100% NP + 150% K, 125% NPK, 150% NPK, 100% NP + Crop residue, 100% NP + FYM, 100% NP + SPM, SSNM, SSNM–K and SSNM+K were evaluated in a randomized block design with these replications. The data on growth, yield and its contributing traits recorded and expressed on plot area basis (15 m^2), were maximum with the application of 150% NPK. The experimental results revealed that growth attributes (plant height, number of functional leaves, dry matter accumulation and leaf area index), yield attributing traits viz., number of cobs, cob length, number of grains, cob weight, grain weight, test weight, shelling (%), grain, stover and biological yield and uptake of nitrogen (N), phosphorus (P) and potassium (K) in maize differ significantly among different treatments and were maximum with the application of 150% NPK. The response of SSNM was statistically similar with 150% NPK in most of the growth and yield parameters.

Key words: Potassium management, Spring maize productivity, SSNM

Maize (*Zea mays*) is one of the important cereal crops next to wheat and rice in the world and India. Being, a C_4 plant it has very high yield potential, is why it is called miracle crop and 'queen of cereals'. Maize has many types like normal yellow, white grain, sweet corn, baby corn, pop-corn, waxy corn, high amylase corn, high oil corn, quality protein maize, etc. Maize provides food, feed and fodder and serves as source of basic raw material for the number of industrial products, viz. starch, oil, protein, alcoholic beverages, food, sweeteners, cosmetics, bio-fuel, etc. Thus, maize has attained an important position as industrial crop because 83% of its produce is used in starch and feed industries (Anonymous, 2015). Maize is important crop of western Uttar Pradesh since it is much suited for a most remunerative crop in the sequence as rice-potato-maize.

Potassium is one of the major plant nutrients for crop production and quality determination by its impact on many physiological processes such as water regulations, photosynthesis, assimilate transport and enzyme activation. Crop having deficiency of K manifested reduction in number and size of leaves, resulting decline in rate of the photosynthesis and photosynthetic assimilate, required for the growth and development of plant (Guo *et al.,* 2019). The production of less photosynthetic assimilates and their poor translocation exhibited negative effect on yield and quality of maize (Pettigrew, 2008). The loss of protein quality in maize is due to inherent low soil fertility and poor nutrient management practices like less uses of inorganic fertilizers, no use of organic manures, poor recycling of crop residue and no use of secondary and micro-nutrients (Vanlauwe *et al.,* 2011).

Integrated nutrient management (INM) aims to achieve the efficient use of chemical fertilizers in conjugation with organic manures. Long-term fertilizer experiments involving intensive cereal-based cropping systems reveal a declining trend in productivity even with the application of recommended levels of N, P and K fertilizer (Mahajan and Sharma, 2005). The INM entails the maintenance of soil fertility to an optimum level for crop productivity to obtain maximum benefit from all possible sources of plant nutrients, *i.e.* organic as well as inorganic in an integrated manner. The conjunctive use of organic manure and chemical

[2]**Corresponding author's e-mail:** vkumarsingh_01@yahoo.com
[1]M.Sc. Student, [2]Associate Professor, Sardar Vallabh Bhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh 250 110; [3]Principal Scientist and Head, [5]SRF, ICAR–Indian Agricultural Research Institute, New Delhi 110 012, [4]Head of India, Sirius Minerals, PLC, U.K.

fertilizers can augment the nutrient use efficiency and also enhance the productivity of quality protein maize (Kumar *et al*., 2005). Site-Specific Nutrient Management (SSNM), approach aims to increase farmers profit through increased yield of maize per unit of applied fertilizer and reduced disease and insect damage. The SSNM whether based on nutrient status of soil or plant in a given field, ensures that nutrients applied through fertilizers are managed according to the needs of the soil-plant system. Thus, as compared to blanket fertilizer recommendations for different crops, which are still prevalent in several developing countries, SSNM is a sound scientific approach that ensures soil health on a long-term basis (Shah and Wu, 2019). The features of SSNM are optimal use of existing indigenous nutrient sources such as crop residues and application of N, P and K fertilizer to crop is adjusted in accordance to location and season. In maize cultivation, the farmers showed much attention only to N fertilization and often P and K applications are carried out at minimal level, mostly missing K fertilization. The SSNM approach not only aims to reduce or increase fertilizer use, but it is also an effective tool for supplying crop nutrients to achieve higher yield and more net returns per unit of fertilizer invested. The practice of imbalance and inadequate fertilizer application affects the soil productivity in general and particularly depletes the essential nutrients (Cassman *et al.*, 1996). Thus, poor nutrient management due to lack of proper and balanced use of chemical fertilizers including micronutrients is one of the factor responsible for low yields and poor quality of maize.

The present study was conducted at Crop Research Centre of Sardar Vallabh Bhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh during the spring season of 2015–16, which is located at latitude of 29˚40' N and longitude of 77˚42' E and at an altitude of 237 meter above mean sea level. Meerut lies in the heart of western Uttar Pradesh and has semi-arid to sub-tropical climate. The soil of the study site was sandy loam with *p*H 8.06, EC 0.30 dS/m and organic carbon 4.48 g/kg soil. Soil of experimental site was low in nitrogen (198.9 kg/ha) and potassium (201.63 kg /ha), medium in Phosphorus and Sulphur (13.58 and 13.10 kg/ha, respectively). The experiment was laid in randomized block design (RBD) with 12 treatments comprising T_1, 100% NP; T_2, 100% NPK; T_3, 100% NP + 125% K; T_4, 100% NP + 150% K; T_5, 125% NPK; T_6, 150% NPK; T_7, 100% NP + Crop residue; T_8, 100% NP + FYM; T_9, 100% NP + SPM; T_{10}, SSNM; T_{11}, SSNM–K; and T_{12}, SSNM+K and 3 replications. The size of each plot was 5 × 3 m^2. All recommended package of practices were followed during the experiment. Observations related to growth parameters, viz., plant height, number of functional leaves, leaf area index, and dry-matter accumulation/plant were made at 30 and 60 days after sowing (DAS) and at harvest stage of the crop. Five plants were randomly selected from the sampling area to record such observations. The data obtained were analyzed statistically for the significance. The treatment differences were tested by least significant difference at 5% of probability. All the statistical analysis was carried out using statistical software package given by Sheron *et al.* (1998).

The data regarding the effect of different treatments on different growth attributes are presented in Table 1. Results revealed that maximum plant height was recorded with the application of 150% NPK (T_6), which was statistically at par to T_{12} and significantly higher than the rest of the treatments. Deletion of K from RDF' and addition of super optimal level of K over recommended NPK resulted in a significant variation in plant height. Plant height also differs significantly with the additional NPK application recorded over recommended NPK. Imbalances in plant nutrition directly affect the number and functions of leaves while balanced nutritional support resulted in *vice-versa.* Maximum number of functional leaves per plant was recorded under 150% RDF. Dry matter accumulation per plant differs from 166 to 243 g being highest with the application of 150% NPK. With exception of the dry matter accumulation per plant, this treatment was significantly higher than the rest of the other treatments. Deletion of K from SSNM resulted in a significant reduction in dry matter while additional of K over SSNM increases the dry matter. These results were supported by the findings of Pettigrew (2008) and Damon and Rengel (2008).

The important yield attributes are presented in Table 1. Number of cobs per plant varied from 1.00 to 1.84 under different treatments. The maximum number of cobs per plant (1.84) were recorded in T_6 followed by T_{10} and T_{12} treatments showed significantly higher number than the rest of the other treatments. Deletion of K from 100% NPK and addition of super optimal level of K over recommended NPK resulted into significant variation by recording more cobs. The cob length (cm) was significantly affected by different treatments. Cob length differ from 16.4 to 20.6 cm, maximum cob length (20.6 cm) observed with the application of 150% NPK (T_6) was statistically at par to T_{12} and significantly higher than rest of the treatments. Deletion of K from RDF did not result in any significant variation however, addition of super optimal level of K over recommended NPK resulted in a significant variation. Addition of crop residues, FYM and SPM over 100% NP did not exhibit any significant effect on cob length (cm). Numbers of grains/cob were significantly affected by different treatments. Number of grain/cob differ from 325 to 430, maximum number counted with the application of

Table 1. Effect of different treatments on growth, and yield attributing character at harvest stage

Treatment	Plant height (cm)	No. of functional leaves	Dry-matter accumulation (g)	Cobs/ plant	Cob Length (cm)	No. of grains/ cob	Grain weight/ cob (g)	Test Weight (g)
T_1, 100% NP	156.1	7.5	165.6	1.00	16.4	324.7	115.0	220.0
T_2, 100% NPK	163.3	8.2	175.4	1.20	17.4	338.3	128.0	231.0
T_3, 100% NP + 125% K	168.7	8.6	207.9	1.26	18.3	357.0	153.0	234.0
T_4, 100% NP + 150% K	187.3	9.3	223.2	1.44	18.5	378.9	161.0	236.0
T_5, 125% NPK	191.9	9.6	232.1	1.62	19.2	395.2	170.0	241.0
T_6, 150% NPK	208.6	10.7	243.0	1.84	20.6	430.3	177.0	254.3
T_7, 100% NP + CR	179.9	7.4	197.5	1.26	17.2	362.9	150.0	225.0
T_8, 100% NP + FYM	189.0	8.1	219.6	1.62	17.5	365.5	154.0	227.6
T_9, 100% NP+SPM	181.0	7.9	192.8	1.44	17.1	361.2	148.0	222.0
T_{10}, SSNM	195.5	8.9	220.5	1.78	17.8	371.4	165.0	236.0
T_{11}, SSNM–K	188.1	8.4	206.5	1.60	17.0	374.2	156.0	232.0
T_{12}, SSNM+K	197.2	9.9	240.8	1.80	19.1	404.9	175.0	251.0
SEm±	1.2	0.5	1.0	0.05	0.6	13.2	5.7	06.5
CD (P = 0.05)	3.6	1.6	2.9	0.16	1.6	37.9	16.0	19.9

150% NPK (T_6) were statistically at par with T_5 and T_{12} and significantly higher than rest of the treatments. Ijaz *et al.* (2014) reported that effect of different K rates (0, 125, 150 and 175 kg/ha) on growth and yield of hybrid maize (Hycron 11 Plus). Application of K significantly increased both the yield and quality parameters of the hybrid maize. Maximum grain weight (177 g)/cob observed with the application of 150% NPK (T_6), was significantly higher than all the treatments with exception of T_4, T_5, T_{10} and T_{12}. Test weight was significantly affected by different treatments. Test weight differs from 220 to 254 g. Maximum test weight (254 g) recorded with the application of 150% NPK (T_6) was significantly higher than rest of the treatments except T_4, T_5, T_{10} and T_{12}. This may be due to better vegetative growth with 150% NPK, more photosynthesis and translocation of photosynthets to sink with additional K application. Application of 62.5 kg K/ha provided the higher test weight of Deccan-103 Hybrid maize (Shivashankar and Sudhakar, 1994).

The yield of grain and stover of maize is presented in Table 2. The grain yield varied from 3.62 to 7.21 t/ha, maximum grain yield was 7.21 t/ha under 150% NPK which was statistically at par with T_{12} and T_{10} and significantly higher over rest of the treatments was found in T_6. Deletion of K and addition of super optimal level of K over 100% NPK also resulted in a significant variation in grain yield. Grain yield increased by 25% due to application of K over 100% NP. Similarly a gain of 12.1 and 30.0% in grain yield was noticed due to additional application of 25 and 50% K over 100% NPK (Fig. 1).

Application of organic sources improved the grain yield of maize significantly. Even crop residue and FYM application outyielded 100% NPK while, SPM application could not exhibit any significant effect (Table 2). There might be possibility of occurring statistically comparable results of the treatments consisting of SPM and FYM as both the plant nutrients sources are of organic origin. Further, these organic sources release different nutrients in the soil solution gradually with time. Application of SSNM also significantly higher grains yielded than RDF. The stover yield differs from 5.09 to 7.92 t/ha with maximum (7.92 t/ha) recorded with the application of 150% NPK (T_6) was statistically at par with T_5, T_{10} and T_{12}. Deletion of K from recommended NPK and addition of super optimal level of K (25%) over 100% NPK did not result in any significant variation in stover yield however a significant effect of additional 50% K application was found. The additional application of 25 and 50% NPK showed significantly higher stover yield than RDF (T_2). Application of different organic sources over 100% NP and over 100% NPK resulted in a significant improvement in stover yield. Stover yield increased by 10% due to K application while, 25 and 50% additional application of K over RDF resulted an increase of 7.8 and 21.9%, respectively. Maize being an exhaustive crop will respond well to higher level of nutrient application. Application of K increased the corn yield

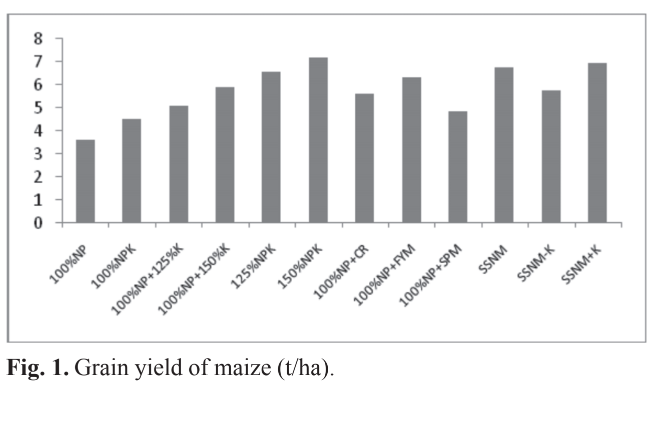

Fig. 1. Grain yield of maize (t/ha).

Table 2. Effect of different treatments on yield and economics of maize crop

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Cost of cultivation (₹/ha)	Gross returns	Net returns	Benefit: cost ratio
T_1, 100% NP	3.62	5.09	26,157	54,503	28,346	1.08
T_2, 100% NPK	4.53	5.62	29,007	67,454	38,447	1.32
T_3, 100% NP + 125%K	5.08	6.06	29,807	75,402	45,595	1.52
T_4, 100% NP + 150%K	5.89	6.85	30,517	87,248	56,731	1.85
T_5, 125% NPK	6.58	7.34	30,923	97,157	66,234	2.14
T_6, 150% NPK	7.21	7.92	32,747	106,336	73,589	2.24
T_7, 100% NP + CR	5.62	6.66	26,427	72,492	46,065	1.74
T_8, 100% NP + FYM	6.32	7.02	28,657	83,373	54,716	1.90
T_9, 100% NP + SPM	4.88	5.88	31,157	93,288	62,131	1.99
T_{10}, SSNM	6.78	7.54	32,195	100,087	67,892	2.10
T_{11}, SSNM–K	5.74	6.72	29,345	85,071	55,726	1.89
T_{12}, SSNM + K	6.94	7.72	35,315	102,451	67,136	1.90
SEm±	0.21	0.24	-	-	-	-
CD (P= 0.05)	0.61	0.70	-	-	-	-

significantly by 17 to 20%. Potassium is reported to increase the translocation efficiency of photosynthates from source to sink therefore; higher grain yield is well expected. Lei *et al.* (2000) also reported that average increase in grain yield occurred between 17.3 and 23.2% with 112.5 kg K/ha and 20.1 to 26.2% with 225 kg K/ha respectively, when compared with the NP treatment.

Economics: Due to variation of inputs applied in different treatments, cost of cultivation varied from ₹26,157 to 35,315. Maximum cost of cultivation ₹35,315 with the application of SSNM+K (T_{12}) was followed by T_6 (Table 2). Gross return under different treatments was varied from ₹54,503 to ₹1,06,336. Maximum gross return was found in T_6 (150% NPK) followed by T_{12} (SSNM). Net return which is a difference of gross return and cost of cultivation was maximum under treatments in T_6 (150% NPK) followed by T_{10} (SSNM). Variation in cost of cultivation of maize under different nutrient management practices have been reported by Bangarwa *et al.* (1988), Sekar *et al.* (2010), Jeet *et al.* (2012), Sawarkar *et al.* (1999), Lingaraju *et al.* (2010) and Haque *et al.* (2012). Benefit : cost ratio was maximum (2.24), similar result was also supported by Sur *et al.* (1997) and Negi *et al.* (1992). The highest B:C ratio might have been attributed to dual advantage i.e. saving in inputs and additional returns due to higher yields.

On the basis of one year experiment it can be concluded that in the extensively cultivated soils, 150% recommended NPK application practice for spring maize could be the best option in terms of crop productivity, and economic feasibility.

REFERENCES

Anonymous 2015. Agriculture statistics at a glance, ministry of agriculture. GOI and FAS/New Delhi.

Bangarwa, A.S., Katron, M.S. and Singh, K.P. 1988. Effect of plant density and level and proportion of nitrogen fertilization on growth, yield and yield components of winter maize. *Indian Journal of Agricultural Sciences* **58**(11): 854–858.

Cassman, K.G., Dobermann, A., Sta, Cruz, P.C., Gines, G.C., Samson, M.I., Descalsota, J.P., Alcantara, J.M., Dizon, M.A. and Olk, D.C. 1996. Soil organic matter and the indigenous nitrogen supply of intensive irrigated rice systems in the tropics. *Plant and Soil* **182**: 267–278.

Damon, P.M. and Rengel, Z. 2008. Crops and genotypes differ in efficiency of potassium uptake and use. *Physiology Plant Diagnosis Journal* 1,399–5,412.

Guo, J., Jia, Y., Chen, H. Zhang, L., Yang, J., Zhang, J., Hu, X., Ye, X., Li, Y., and Zhou, Y. 2019. Growth, photosynthesis, and nutrient uptake in wheat are affected by differences in nitrogen levels and forms and potassium supply. *Scientific Report* **9**: 1,248.

Haque, A. M., Moniruzzaman., Rahman, S. M. and Alam, M. Q. 2012. Profitability of hybrid maize (*Zea Mays* L.) seed production under contract farming in Bangladesh a farm level study. *Bangladesh Journal of Agricultural Research* **37**(2): 327–334.

Ijaz, M., Mahmood, A. and Ullah, H. 2014. Response of maize hybrid (*Zea mays* L.) to different levels of potassium. *Agriculture Research Communication* **1**(1): 30–38.

Jeet, S., Singh, P.J., Kumar, R., Kumar, P., Kumar, R., Kumari, R., Anupma, and Pravin, S. 2012. Effect of nitrogen and sulphur levels on yield, economics and quality protein maize (QPM) hybrids under dryland condition of eastern Uttar Pradesh. *Indian Journal of Agricultural Sciences* **51**(1): 10–13.

Kumar, A., Gautam, R.C., Singh, R. and Rana, K.S. 2005. Growth, yield and economics of maize (*Zea mays* L.) wheat (*Triticum aestivum*) cropping sequence as influenced by integrated nutrient management. *Indian Journal of Agricultural Sciences* **75**(11): 706–711.

Lei, Y., Yhang, B., Zhang, M., Zhao, K., Qio, W. and Wang X. 2000. Corn response to potassium in liaoning province. *Better Crops International* **14**(1): 6–9.

Lingaraju, B.S., Parameshwarappa, K.G., Hulihalli, U.K. and

Basavaraja, B. 2010. Effect of organics on productivity and economic feasibility in Maize-Bengal gram cropping system. *Indian Journal of Agricultural Research* **44**(3): 211–215.

Mahajan, A. and Sharma, R. 2005. Integrated nutrient management (INM) system- Concept, need and future strategy. *Agrobios Newsletter* **4**(3): 29–32.

Negi, S.C., Singh, K.K. and Thakur, R.C. 1992. Effect of phosphorus with and without FYM on yield and uptake of NP and protein content in wheat-maize sequence. *Himachal Journal of Agricultural Research* **18**: 5–8.

Pettigrew, W.T. 2008. Potassium influences on yield and quality production for maize, wheat, soybean, and cotton. *Physiological Plantarum* **133**(4): 670–681.

Sawarkar, S.D., Gupta, G.P., Rathore, G.S. and Shrivastava, S.K. 1999. Response of maize to soil application of zinc in sandy loam soil of Madhya Pradesh, India **28**: 109–110.

Sekar, S., Amanullah, M.M., Manoharan, S., Muthukrishnan, P., Subramanian K. S. and Vincant, S. 2010. Influence of fertilizer levels and growth substances on yield and economics of hybrid maize. *Madras Agricultural Journal* **3**: 58–61.

Shah, F. and Wu, W. 2019. Soil and crop management strategies to ensure higher crop productivity within sustainable environments. *Sustainability* **11**(5): 1,485.

Sheron, O.P., Tonk, D.S., Kaushik, L.S., Hasija, R.C. and Pannu, R.S. 1998. Statistical softwere package for agriculture research workers, recent advances in information theory, statistic and computer, Department of mathematics and statistics CCSHAU Hissar.

Shivashankar, K. and Sudhakara B.S.N. 1994. Influence of organic matter, spacing and fertilizer levels on growth and yield of maize. *Process Seminar on Technology for Sustainable Crop Production* pp. 22–25.

Sur, V.K., Saritha, J. and Verma, T.S. 1997. Efficient and economic fertilization of rainfed maize (*Zea mays* L.) to graded levels of nitrogen, phosphorus and potash in the summer season. *Gujarat Agriculture University Research Journal* **14**: 55–57.

Vanlauwe, B., Kihara, J., Chivenge, P., Pypers, P., Coe, R. and Six, J. 2011. Agronomic use efficiency of N fertilizer in maize-based systems in sub-Saharan Africa within the context of integrated soil fertility management. *Plant and Soil* **339**: 35–50.