Indian Journal of Agricultural Sciences **90** (8): 1631–4, August 2020/Short communication
https://doi.org/10.56093/ijas.v90i8.105981

Effect of tillage practices and time of K application on performance of maize (*Zea mays*) under conservation agriculture

AMARESH PRADHAN[1], S L MEENA[2] and U K BEHERA[3]

ICAR-Indian Agricultural Research Institute, Pusa, New Delhi 110 012, India

Received: 18 November 2019; Accepted: 2 December 2019

Key words: Energy use efficiency, Net returns, Partial factor productivity, Tillage, Yield

Maize (*Zea mays* L.) is the third most important crop in our country in production after rice and wheat. Maize is a nutrient exhaustive crop it requires better nutrient-management practices to express its full potential. In recent past, the productivity of maize has gone down to less than wheat. Potassium has been described as the 'quality element', ensuring optimum quality of agricultural produce. Potassium has two main functions in the plant. First, it has an irreplaceable role in the activation of enzymes that are fundamental to metabolic processes, especially the production of proteins and sugars. Only small amounts of K are required for this biochemical function. Second, K maintains the water content and thus the turgor of cells – a biophysical role.In many cases, lower fertilizer K application in the context of unbalanced fertilization may result in a significant depletion of available soil K reserves, and thus in decreased soil fertility.In conservation agriculture application of fertilizers has emerged as an issue due to the fact that under CA the residue application may hinder the utilization of applied fertilizer. These factors must be considered to carry out new farming practices like CA based potassium management practice that can increase system yields, maintain soil health, reduce environmental pollution. Further it may reduce investment on application of high costly K fertilizer by incorporating crop residue in zero till CA. However, no detailed studies have been conducted to know the time of application of K in maize under conservation agriculture. Keeping in view the above facts the present study was undertaken to see the effect of tillage and K management on yield, nutrient use efficiency, economics and energy in maize under conservation agriculture to maintain crop productivity and soil fertility.

[1]Ph D Scholar (amaresh491@gmail.com), Division of Agronomy, ICAR-IARI, New Delhi 110 012, [2]Principal Scientist (dr_slmeena@yahoo.co.in), Division of Agronomy, ICAR-IARI, New Delhi 110 012, [3]Dean (ukb2008@gmail.com), College of Agriculture, Central Agricultural University (I), Kyrdemkulai, Meghalaya 793 105, India.

The experiment was conducted during the rainy (*kharif*) season (July–October) of 2016 at the research farm of the Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi situated at latitude of 28°38' N and longitude of 77°11' E and 228 m above the mean sea level. The main objective of the study to evaluate the effect of time of K application on the performance of maize (*Zea mays* L.) under conservation agriculture. The soil of the experimental site was sandy clay loam in texture with low in organic carbon, available N, available P and medium in available K with the *p*H 7.9. The experiment was laid out in split-plot design with 3 main plot treatments, 4 subplot treatments and each treatment replicated thrice. The treatments comprised in main plot, i.e. conservation agriculture practices (tillage and residue management- ZT + wheat residue, 3 tonnes/ha); ZT – Bed + wheat residue, 3 tonnes/ha, and CT – No residue); and sub-plot, i.e. K dose and time of application recommended dose as basal (60 kg K_2O/ha, 1/2 at sowing + 1/2 at tasseling, 1/2 at sowing + 1/2 at silking, and 1/3 at sowing + 1/3 at knee height + 1/3 at tasseling). Sun dried chopped residues of the wheat crop of previous season was applied at the rate of 3 tonnes/ha by retaining on the soil surface as mulch in all treatments except conventionally tilled plot after sowing of crops. Maize variety PMH-1 in *kharif* was sown by hand at the seed rate of 20 kg/ha at an inter row spacing of 70 cm. The maize was sown with the help of dibbling. Nitrogen and phosphorus fertilizers were hand placed along with sowing by hand and potassium fertilizer was applied manually as per the treatment. Glyphosate 41% EC (1 kg a.i./ha) was applied 7 days before sowing. Cypermethrin @ 2 ml/l was sprayed on standing crop to control maize leaf webber and leaf roller. Growth parameters, yield attributes and yield were recorded at different growth stages of the crop. The partial factor productivity (kg grain/kg of nutrient applied) of N, P and K was calculated using the formulae as PFP_N = Grain yield (kg/ha)/amount of nitrogen applied (kg/ha); PFP_P = Grain yield (kg/ha)/amount of phosphorous applied (kg/ha); PFP_K = Grain yield (kg/ha)/amount of potassium applied (kg/ha). Economics of different treatments was worked out by taking into account the cost of inputs and income obtained from grain and stalk yield. The energy output from the economic and by-product yield was also estimated. Energy productivity and energy use efficiency were calculated using the following formula as suggested by Mittal and Dhawan (1988), Singh *et al*. (1997) and Burnett (1982), i.e. energy efficiency = energy output (MJ/ha)/energy input (MJ/ha); net energy (MJ/ha) = energy output (MJ/ha) - energy input (MJ/ha).The data collected on different parameters during the experiment were subjected to appropriate statistical analysis following the procedure described by Gomez and Gomez (1984). Significance of difference between means was tested through F test and the least significant difference (LSD) was worked out where variance ratio (F value) was found significant, critical differences (CD) values at 5% level of probability were computed for making comparison between treatments.

The application of variable tillage, residue and potassium management practices showed significant improvement in grain, stover and biological yield in ZT – bed + residue (3 tonnes/ha) over ZT + residue (3 tonnes/ha) and CT-No residue (Table 1). The treatment, ZT– bed + residue (3 tonne/ha) was significantly superior with respect to grain yield and stover yield than ZT + residue (3 tonnes/ha) and CT – No residue. Application of K_2 (1/2 RD at basal and 1/2 at tasseling) recorded significantly higher grain yield and stover yield than other treatments in subplots. The harvest index (HI) of maize showed significant difference due to different tillage and crop residue management practices. Highest HI was obtained in CT – No residue over ZT + residue (3 tonnes/ha) and ZT – bed + residue (3 tonne/ha). Among different K application timings there was no significant difference among treatments. The interaction effect of conservation agricultural practices and timing of potassium application practices for harvest index, grain yield and stover yield was not found. The HI is mainly controlled by partition of photosynthates between harvesting and non-harvesting organs during the crop growth cycle. It is evident that the economic yield is closely related to crop growth process. Hence, the variation in partitioning of photosynthates in grain and vegetative organs of different treatments possibly caused a significant variation in HI. The similar results have also been reported by several researchers (Jat *et al*. 2014).

Partial factor productivity of nitrogen (PFP_N), phosphorous (PFP_P) and potassium (PFP_K) were significantly influenced by different conservation agricultural practices and timing of K application. ZT – bed + residue (3 tonnes/ha) recorded maximum PFP_N, PFP_P and PFP_K over other treatments (Table 1). The lowest values were recorded in CT-No residue. Among timing of K application K_2 (1/2 RD at basal and 1/2 at tasseling) recorded significantly higher values than other treatments. There was no significant interaction effect of conservation agricultural practices and timing of potassium application on partial factor productivity of N, P and K. The higher values in ZT – bed + residue (3 tonnes/ha) is due to the higher yield obtained compared to other treatments as the input of fertilizers are same for all the treatments.

Economics of maize as influenced by different conservation agricultural practices and timing of K application revealed that cost of cultivation were relatively higher in ZT – bed + residue (3 tonnes/ha) and ZT + residue (3 tonnes/ha) than CT – No residue due to addition of residue

Table 1 Yield, partial factor productivity (PEP), economics and energy of maize as influenced by tillage and K management under conservation agriculture

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	PFP_N (kg/ha)	PFP_P (kg/ha)	PFP_K (kg/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio	Output energy (×10^3 MJ/ha)	Energy balance (×10^3 MJ/ha)	Energy use efficiency
Tillage practice											
ZT + Residue (3 t/ha)	4.34	8.50	33.79	356.67	28.91	54.21	44.20	1.25	169.96	116.23	3.16
ZT – Bed + Residue (3 t/ha)	4.66	9.51	32.88	399.62	31.06	58.23	50.91	1.34	187.36	133.63	3.49
CT – No residue	4.19	7.56	35.65	334.25	27.96	52.42	43.38	1.17	156.17	138	8.59
SEm±	0.11	0.34	0.48	5.57	0.37	0.53	0.49	0.02	2.36	2.36	0.07
CD (P=0.05)	0.42	1.35	1.92	21.85	1.44	2.06	1.91	0.07	9.36	9.36	0.27
Timing of K application											
K_1	4.35	8.43	34.09	362.78	29.02	54.42	45.98	1.27	169.36	127.51	5.05
K_2	4.46	8.65	34.08	378.40	29.72	55.72	47.40	1.29	173.71	131.83	5.16
K_3	4.35	8.46	34.03	362.19	28.97	54.32	45.13	1.22	169.66	127.78	5.03
K_4	4.43	8.55	34.22	350.71	29.52	55.35	46.14	1.23	171.94	130.02	5.09
SEm±	0.03	0.05	0.22	3.57	0.20	0.37	0.45	0.01	0.78	0.78	0.03
CD (P=0.05)	0.09	0.16	NS	10.61	0.58	1.09	1.34	0.04	2.31	2.31	0.08
Interaction (Tillage × K)											
SEm±	0.05	0.09	0.37	6.18	0.34	0.64	0.78	0.02	1.35	1.35	0.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

which incurred significant cost (Table 1). The highest cost of cultivation was recorded under ZT – bed + residue (3 tonnes/ha) (37.99 × 10^3 ₹/ha) which was followed by ZT + residue (3 tonnes/ha) (37.84 × 10^3 ₹/ha). Lowest cost of cultivation was recorded with CT- no residue (34.64× 10^3 ₹/ha). Highest gross and net returns were obtained in ZT – bed + residue (3 tonnes/ha). This might be due to higher grain and stover yield under ZT – bed + residue (3 tonnes/ha) compared to other treatments. There are several reports showing savings in irrigation water, labour and production costs, and higher net economic returns in no tillage compared with conventional tillage systems (Jat *et al*. 2009). Similar results were reported by Landers *et al*. (2001) who recorded higher net income under NT compared with CT. B: C ratio was also found to be highest in ZT – bed + residue (3 tonnes/ha). Among timing of K application, K_2 (1/2 RD at basal and 1/2 at tasseling) recorded significantly higher values than other treatments due to higher grain and stover yield. The lowest value was obtained in K_3 (1/2 RD as basal and 1/2 at silking). There was no significant interaction effect of conservation agricultural practices and timing of potassium application on economics of maize**.**

Energy input, energy output, energy balance and energy use efficiency were observed differently due to variable conservation practices and timing of K application (Table 1). CT – No residue recorded minimum input energy and both ZT + residue (3 tonnes/ha) and ZT – bed + residue (3 tonnes/ha) recorded same energy input. This is due to the addition of wheat residues at 3 t/ha. In residue added plots, the high energy value of crop residue (12.5 MJ/Kg) was the reason for maximum energy requirement. These findings are in agreement with Karunakaran and Behera (2016) and Chaudhary *et al*. (2006). Significantly the maximum output energy was obtained with ZT – bed + residue (3 tonnes/ha) followed by ZT+ residue (3 tonnes/ha). The higher energy output was due to production of higher level of seed and stover yield in these two treatments. The least energy output was obtained from CT – No residue. The highest energy balance was obtained in CT – No residue. This was due to less energy requirement and high output energy due to higher yields. Higher energy use efficiency was observed in CT – No residue. Since, crop residues have some energy value; its addition in large quantities makes treatments inefficient with respect to net energy balance and energy use efficiency. Among timing of K application, K_2 (1/2 RD at basal and 1/2 at tasseling) recorded significantly higher energy output, energy balance and energy use efficiency than other treatments. The higher values were due to production of higher level of seed and stover yield. The lowest value of energy output, energy balance was obtained in K_1 (RD as basal). Lowest energy use efficiency was found in K_3 (1/2 RD as basal and 1/2 at silking).

The results of the study revealed that superior grain and stover yield, PFP_N, PFP_P and PFP_K were obtained in zero tillage – bed + residue (3 tonnes/ha) with the application of potassium (1/2 RD as basal and 1/2 at tasseling) over rest of the treatments. The highest cost of cultivation, gross and net returns and benefit: cost ratio were recorded under ZT – bed + residue (37.99 × 10^3 ₹/ha) which was followed by ZT + residue (37.84 × 10^3 ₹/ha). CT – No residue recorded minimum input energy and both ZT + residue and ZT – bed + residue recorded same energy input. Significantly the maximum output energy was obtained with ZT – bed + residue followed by ZT + residue. Higher energy use efficiency was observed in CT – No residue. Among timing of K application, K2 (1/2 RD at basal and 1/2 at tasseling) recorded significantly higher energy output, energy balance and energy use efficiency than other treatments.

SUMMARY

A field experiment was carried out during the rainy (*kharif*) season (July–October) of 2016 at the research farm, New Delhi, to study the effect of time of K application on the performance of maize (*Zea mays* L.) under conservation agriculture. The maximum values of grain yield (4.66 t/ha), stover yield (9.51 t/ha), partial factor productivity of nitrogen (399.62 kg/ha), phosphorous (31.06 kg/ha) and potassium (58.23 kg/ha), net return (50, 910 ₹/ha), B:C ratio (1.34) and output energy (187360 MJ/ha) in maize were recorded with ZT – bed + residue followed by zero tillage (ZT) + residue and conservation tillage (CT)–No residue. The treatment K_2 [half recommended dose (RD) at basal and half at tasseling)] showed significantly higher values of grain yield (4.46 t/ha), stover yield (8.65 t/ha), partial factor productivity of nitrogen (378.40 kg/ha), phosphorous (29.72 kg/ha) and potassium (55.72 kg/ha), net return (47 400 ₹/ha), B:C ratio (1.29), output energy (173710 MJ/ha), energy balance (131830 MJ/ha) and energy use efficiency (5.16) than all other treatments. The yield improvement with ZT – bed + residue was 11.21% over CT-No residue and 7.37% over ZT + residue. ZT – bed + residue registered significantly higher N, P and K content in seed and stover and uptake during the period of study followed by ZT + residue and CT – No residue. It is concluded that the application of 30 kg of K as basal and 30 kg of K at tasseling stage under ZT – bed + residue (3 t/ha) may be recommended for fetching better performance in maize.

AKNOWLEGDEMENTS

Authors are grateful to the ICAR-Indian Agricultural Research Institute, New Delhi for providing research facilities and financial assistance.

REFERENCES

Burnett M. 1982. Energy analysis of three agro-ecosystems. (*In*) Stuard, B Hill (Ed). Paper presented at second International Conference on Basic Technique in ecological farming held during 1-5 October at IFO, Montreal, Brazil: Birkhauser, pp 183–195.

Chaudhary V P, Gangwar B and Pandey D K. 2006. Auditing of energy use and output of different cropping systems in India. *Agricultural Engineering International: The CIGR Journal of Scientific Research and Development* VIII *(June) (Manuscript EE 05 001).*

Gomez K A and Gomez A.A. 1984. *Statistical Procedures for*

Agricultural Research, Second Edition. An International Rice Research Institute Book. A Wiley-Interscience Publication, John Wiley & Sons, New York.

Jat G, Majumdar S P, Jat N K and Mazumdar S. 2014. Effect of potassium and zinc fertilizer on crop yield, nutrient uptake and distribution of potassium and zinc fractions in Typic Ustipsamment. *Indian Journal of Agricultural Sciences* **84**(7): 832–838.

Jat M L, Gathala M K, Ladha J K, Saharawat Y S, Jat A S, Sharma S K, Kumar V and Raj G. 2009. Evaluation of precision land leveling and double zero-till systems in the rice-wheat rotation, water use, productivity, profitability and soil physical properties. *Soil and Tillage Research* **105**: 112–121.

Karunakaran and Behera. 2016. Tillage and residue management for improving productivity and resource-use efficiency in soybean (*Glycine max*)—wheat (*Triticum aestivum*) cropping system. *Experimental Agriculture* **52**(4): 617-634.

Landers J N, Saturino H M and De Freitas P L. 2001. Organizational and policy consideration in zero tillage. (*In*) Saturnino H M and Landers J N (Eds). *Environment and Zero Tillage* Brazil: 13–24.

Mittal J P and Dhawan K C. 1988. *Research Manual on Energy Requirements in Agricultural Sector*. ICAR, New Delhi, pp 20–23.

Singh M K, Pal S K, Thakur R and Verma U N. 1997. Energy input–output relationship of cropping systems. *Indian Journal of Agricultural Sciences* **67**(6): 262–264.