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TILLAGE AND POTASSIUM NUTRITION EFFECTS ON SOIL AND PLANT PROPERTIES IN WHEAT UNDER DIFFERENT IRRIGATION CONDITIONS

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Establishment of a suitable tillage system for improving wheat yield under variable level of irrigation and potassium is important for developing sustainable agriculture. Thus, present investigation was carried out at Experimental Farm, Department of soil science, CSKHPKV, Palampur during Rabi 2016-17 to evaluate the effect of different combination of tillage, irrigation and potassium on nutrient uptake by plants and soil properties. The field experiment was laid out in split-plot design with two tillage methods *i.e.,* C_1: Conventional tillage and C_2: Conservation tillage and two irrigation Levels *i.e.,* I_1: No irrigation and I_2: Two irrigations in main plot and three Potassium level *i.e.,* K1:100%, K_2:125%, and K_3:150% of recommended dose of potassium in sub-plots with three replications. Maximum uptake of N, P and K was observed under conservation tillage system and among the irrigation level, application of two irrigation remained best over no irrigation. Among the potassium level, wheat crop fertilized with 150% of recommended dose of potassium recorded maximum uptake of N, P and K. Soil properties *viz.,* soil pH, soil organic carbon and available N, P and K improved under conservation tillage and two irrigation applications at both depths while soil pH and soil organic carbon were not affected by different level of potassium. However, available potassium was more improved by 150% of recommended dose of potassium at both depths. Bulk density of soil at both the depth was more improved under conventional tillage system, no irrigation supply and 100% recommended dose of potassium.

Wheat (*Triticum aestivum* L.) is an important cereal crop and is extensively cultivated for its seed, a cereal grain. In India, as well as in Himachal Pradesh, the average wheat productivity is quite low, i.e. 31.8 and 15.9 q ha^{-1}, respectively. The moisture deficit is the major reason for such low productivity. For proper crop growth, even mild water stress can be detrimental. Any water deficit greatly disrupts the work of plants, which has a negative effect on plant life processes, both at molecular and whole-plant levels. Consequently, the rate of delivery of mineral elements decreases, limiting plant nutrition and growth (Gonzalez-Dugo *et al.,* 2010). Therefore, we must look for methods for management that can help reduce soil losses as well as mitigate the detrimental effects of moisture stress. Potassium is involved in preserving the permeability of the cell membranes and the proper degree of hydration of the cell protoplasm. The resistance of plants to moisture, heat, frost and diseases is also improved by potassium (Singh, 2000). A sufficient supply of potassium in wheat grown under the rain-fed/limited supply of water will therefore help to mitigate the adverse effects of moisture stress (Grzebisz *et al.,* 2013). The implementation of such a tillage system that conserves the residual moisture and controls the evaporation losses during crop growth can be another way to deal with the limited availability of moisture in wheat. Conventional tillage disturbs the structure of the soil and affects soil temperature, mechanical properties, macro-porous stability and adequate soil water capacity, as well as root growth and distribution (Verhulst *et al.,* 2011). However, the advancement of agricultural research has revealed that tillage operations do not involve crop production practices. Due to reduced soil disturbance during planting activities, seedbed preparation practices tend to a single operation (no-tillage). No-tillage offers an incentive for a new concept of conservation agriculture to revive conventional agriculture (Ehsanullah *et al.,* 2013). Compared to conventional tillage, the no-tillage method has some benefits, such as reduction of machinery moving over the field, fuel consumption, reduction of field preparation time and tillage and soil erosion due to greater aggregate stability, as well as the protective effect of crop residues left over the soil. In addition, no-tillage systems increase the physical properties of the soil, e.g. available water, and some bio pores that can promote root growth (Martinezs *et al.,* 2008). It could be fully stated that the goals of these systems are to monitor water and wind erosion, to minimize energy consumption and to preserve soil and water through the management of plant residues (Wang *et al.,* 2012). Conservation tillage, high crop residue return, and crop rotation will achieve sustainable soil management (Hobbs *et al.,* 2008). Studies conducted under a wide variety of climatic conditions, soil types, and crop rotation systems have shown that soils have substantially higher soil organic carbon (SOC) content compared to conventionally tilled soils under no-tillage and reduced tillage (Alvarez, 2005). No-tillage (NT) has

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been shown to enhance soil properties in many parts of the world, thereby improving water transmission, water retention, and crop yield (He *et al.,* 2009). However, studies on the impact of conservation tillage on the output of wheat cultivated under rain-fed and restricted water conditions, coupled with the use of enhanced potassium application, are very limited, especially under wet temperate conditions. This investigation was therefore carried out to investigate the impact on wheat productivity and soil properties of conservation tillage along with different potassium levels under rain-fed and limited water conditions.

The field experiment was conducted at the experimental farm of Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during rabi season*,* 2016-17. The soil of the experimental site was acidic in reaction and silty clay loam in texture, low in available nitrogen, high in available phosphorus and medium in available potassium. The organic carbon content at the initiation of the experiment was medium. The field experiment was laid out in split-plot design with twelve treatment combinations of two tillage methods, three potassium levels and two irrigation levels each replicated thrice. The main plot consists of two tillage Methods (C_1: Conventional tillage and C_2: Conservation tillage) and two irrigation Levels (I_1: No irrigation and I_2: Two irrigations of 2.5 cm each at tillering and flowering stages only). Subplot consists of three Potassium levels (Percent of the Recommended dose of 40 kg K_2O ha^{-1}) i.e. K1:100%, K_2:125%, and K_3: 150%. The wheat crop (variety HPW 236) was sown on 26th December 2016 and harvested on 7th May 2017. In conservation tillage, only furrows were opened to sow wheat seeds without disturbing the remaining plot area. Crop residues from the previous crop were utilized to cover the plots under conservation tillage. Seeds of wheat were soaked in water for 24 hours before sowing. Soil samples collected from a depth of 0-0.15 and 0.15-0.30 m after the harvest of wheat (2016-17) were air dried and ground in a wooden pestle and mortar to pass through 2 mm sieve and subsequently stored in bags for further analysis. The processed surface soil samples (0-0.15 m and 0.15-0.30 m) were analyzed for soil pH, organic carbon, available nitrogen, phosphorus and potassium and initial samples were also analysed for physical separates. Soil texture was measured International Pipette method by as described by Piper (1966). Bulk density was measured by Core sampler method as described by Singh (1980). Soil pH (1:2.5) was measured Potentiometric method by as described by Jackson (1973). Organic carbon was measured by Wet digestion method as described by Walkley and Black (1934). Available nitrogen was measured by Alkaline Potassium Permanganate method as described by Subbiah and Asija (1956). Available phosphorus was measured by Alkali extraction (0.5 N $NaHCO_3$) as described by Olsen *et al.* (1954). Available potassium was measured by Ammonium acetate method as described by Jackson (1973). The grain and straw samples of wheat were dried in an oven at 60°C. The dried samples were then ground in a wiley mill fitted with stainless steel parts to pass through 1 mm sieve. The samples were then kept in paper bags for subsequent analysis. Nitrogen was measured by Micro Kjeldahl method as described by Jackson (1973). Phosphorus was measured by as Vanado-molybdo-phosphoric acid described by Jackson (1973). Potassium was measured by Flame photometer as described by Black (1965). The nutrient uptake was calculated by multiplying per cent concentration of a particular nutrient with grain and straw yields. The uptake of the nutrients obtained in respect of grain and straw yield was summed up in order to compute the amount of total nutrients removed by the crop.

Nutrient uptake (kg/ha) = Nutrient content (%) x yield (q/ha)/100

Total uptake = uptake in grain + uptake in straw

The data generated from laboratory analyses was subjected to statistical analysis using the technique of analysis of variance for split plot design for the interpretation of results as described by Gomez and Gomez (1984)

The data on the effect of tillage methods, irrigation and potassium levels on grain and straw yield of wheat have been depicted in Fig. 1 and 2. The conservation tillage gave significantly higher yield grain (26.6 q ha^{-1}) and straw (39.5 q ha^{-1}) as compared to conventional tillage. The grain (28.4 q ha^{-1}) and straw (41.1 q ha^{-1}) was significantly higher when there was limited irrigation as compared to no irrigation treatment. The grain and straw yield increased consistently with increase in potassium levels. Application of 150 per cent of recommended dose of potassium resulted in higher grain (28.4 q ha^{-1}) and straw yield (41.8 q ha^{-1}) than that obtained with the application of 100 and 125 per cent of recommended dose of potassium. Application of two irrigations of 2.5 cm each at maximum tillering and flowering stages under conservational tillage was the best interaction and produced the maximum grain (29.5 q ha^{-1}) and straw yield (43.2 q ha^{-1}). Higher grain yield under conservation tillage may be attributed to significantly higher moisture contents in soil for most of the crop duration that might have helped in proper utilization of native and applied nutrients from the soil solution. Potassium nutrition has been reported to be associated with maintaining the permeability of cell membrane and keeping the cell protoplasm in proper degree of hydration under moisture stress conditions. It is known for imparting tolerance in plants against

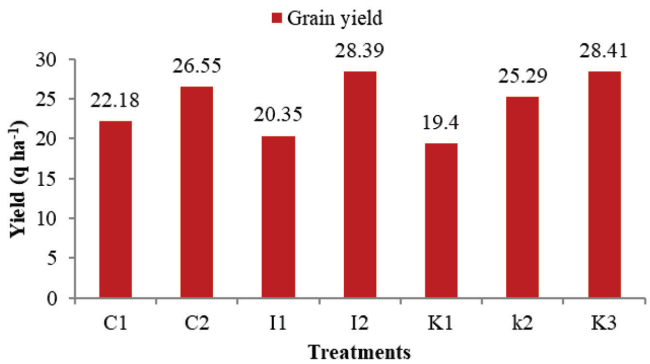

Fig. 1. Effect of tillage, irrigation and potassium levels on grain yield (q ha^{-1})

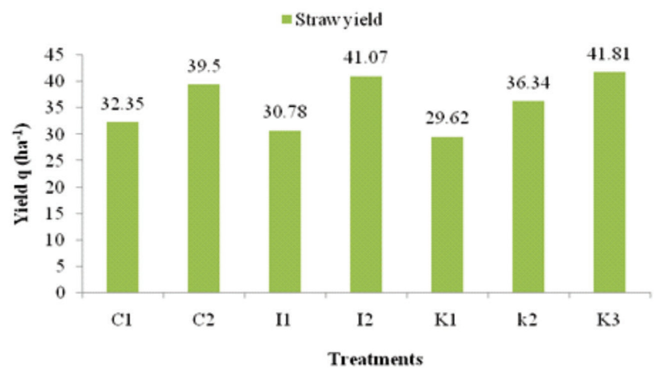

Fig. 2. Effect of tillage, irrigation and potassium levels on straw yield (q ha^{-1})

moisture stress, heat, frost and diseases (Singh, 2000; Alderfasi and Refay, 2010).

A perusal of the data in Table 1 revealed that the tillage methods influenced the N uptake significantly. Nitrogen uptake by wheat grains and straw was about 21 and 27 per cent higher in conservation tillage (C_2) as compared to conventional tillage (C_1), respectively. Similarly, total N uptake by wheat was about 23 per cent more in conservation tillage (C_2) as compared to conventional tillage (C_1). The higher uptake of N under conservation tillage was mainly due to higher grain and straw yields in comparison to conventional tillage as differences in N concentrations in grains and straw between two tillage methods were not very pertinent. Similar results were reported by Singh *et al.* (2017).

The critical examination of data in Table 1 revealed that the irrigation levels influenced the nitrogen uptake significantly. Nitrogen uptake by wheat grains and straw was 39 and 36 per cent more, respectively when limited irrigation was applied (I_2) in comparison to the corresponding values of uptake in no irrigation (I_1). Likewise, the total N uptake by wheat was also higher by about 35 per cent under limited irrigation (I_2) as compared to no irrigation (I_1).

Nitrogen uptake by wheat grains, straw and the total uptake increased consistently with increase in K levels (Table 1). Nitrogen uptake by wheat grains following application of 150 % of recommended dose of potassium (K_3) increased by about 49 and 14 per cent, respectively in comparison to that with the application of 100% (K_1) and 125% of recommended dose of potassium (K_2). Similarly, wheat straw in K_3 registered about 46 and 17 per cent more N uptake than K_1 and K_2, respectively. Whereas, the total N uptake in K_3 was about 48 and 15 per cent higher respectively. The N uptake increased as per the increase in grain and

Table 1. Effect of tillage methods, irrigation and potassium levels on N, P and K uptake (kg ha^{-1})

Treatment	N uptake			P uptake			K uptake		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Tillage methods									
C_1 (Conventional)	38.0	20.1	58.2	5.4	2.4	7.8	6.0	25.2	31.2
C_2 (Conservation)	46.1	25.6	71.7	7.1	3.3	10.4	8.0	31.7	39.7
CD (P=0.05)	3.6	2.6	5.9	0.6	0.3	0.8	1.6	2.7	3.8
Irrigation levels									
I_1 (No irrigation)	35.1	19.4	54.5	5.1	2.4	7.5	5.6	24.2	29.8
I_2 (Limited irrigation)	49.0	26.3	73.4	7.3	3.4	10.7	8.4	32.7	41.1
CD (P=0.05)	3.6	2.6	5.9	0.6	0.3	0.8	1.6	2.7	3.8
Potassium levels (% of recommended K)									
K_1 (100)	33.3	18.5	51.8	4.7	2.2	7.0	4.5	21.5	26.0
K_2 (125)	43.5	23.0	66.5	6.4	2.9	9.3	6.9	28.7	35.6
K_3 (150)	49.4	27.0	76.4	7.5	3.5	10.9	9.6	35.2	44.7
CD (P=0.05)	3.6	2.8	6.0	0.7	0.4	0.9	2.0	3.1	3.8

Note- None of the interaction was found significant straw yields as the differences in concentration were negligible. Similar results were reported by Khaleque *et al.* (2008).

The data on the phosphorus uptake by wheat have been given in Table 1. The critical examination of the data in Table cited above, revealed that the tillage methods influenced phosphorus uptake significantly. Phosphorus uptake by wheat grains, straw and the total P uptake was about 32, 37 and 33 per cent more in conservation tillage (C_2) as compared to conventional tillage (C_1), respectively. Similar results were reported by Singh *et al* (2017).Like, tillage methods, irrigation levels also influenced the phosphorus uptake significantly (Table 1). Phosphorus uptake by wheat grains, straw and the total P uptake in limited irrigation (I_2) was about 42, 43 and 42 per cent more in comparison to that observed in no irrigation (I_1), respectively.

Potassium levels influenced the phosphorus uptake consistently (Table 1). Phosphorus uptake by wheat grains following application of 150 % of recommended dose of potassium (K_3), was about 58 and 17 per cent more than observed in the plots fertilized with 100 (K_1) and 125 per cent of recommended dose of potassium (K_2). Similarly P uptake by wheat straw in K_3 was 56 and 18 per cent more than K_1 and K_2, respectively. Further, the total P uptake by wheat in K_3 was about 57 and 17 per cent more than K_1 and K_2, respectively. Similar results were reported by Saleque *et al.* (2006) and Obaid-ur-Rahman *et al.* (2006). The P uptake increased with the increase in grain and straw yields.

A perusal of the data in Table 1 revealed that like N and P uptake, the tillage methods influenced the potassium uptake significantly. Potassium uptake by wheat grains, straw and the total K uptake was about 32, 26 and 27 per cent more in conservation tillage (C_2) as compared to conventional tillage (C_1), respectively. Similar results were reported by Singh *et al.* (2017). Irrigation levels influenced the potassium uptake significantly (Table 4.10). Potassium uptake by wheat grains, straw and the total K uptake in the plots receiving limited irrigation (I_2) had 51, 35 and 38 per cent more K uptake in comparison to plots receiving no irrigation (I_1), respectively. The critical examination of data in Table 1 revealed that the potassium levels influenced the potassium uptake consistently. Potassium uptake by wheat grains at the application of 150 % of recommended dose of potassium (K_3) was 112 and 38 per cent more than that at 100 per cent of recommended dose of potassium (K_1) and application of 125% of recommended dose of potassium (K_2), respectively. Potassium uptake by wheat straw was about 64 and 23 per cent more potassium than that under K_1 and K_2 levels, respectively. Total K uptake by wheat in K_3 was about 72 and 26 per cent more than that observed in plots receiving 100 (K_1) and application of 125% of recommended dose of potassium (K_2) respectively. The results are in conformity with the findings of Panaullah *et al.* (2006).

The critical examination of Table 2 revealed that the tillage methods did not significantly influence the bulk density in surface (0-0.15 m) and subsurface layer (0.15-0.30 m). The absolute values of bulk density varied between 1.24 to 1.26 Mg m^{-3} in the surface layer whereas, slightly higher values (1.28 to 1.29 Mg m^{-3}) were observed in the subsurface layer The

Table 2. Effect of tillage methods, irrigation and potassium levels on bulk density

Treatment	Bulk density (Mg m^{-3})	
	0-0.15	**0.15-0.30**
Tillage methods		
C_1 (Conventional)	1.24	1.28
C_2 (Conservation)	1.26	1.29
CD (P=0.05)	NS	NS
Irrigation levels		
I_1 (No irrigation)	1.24	1.28
I_2 (Limited irrigation)	1.25	1.28
CD (P=0.05)	NS	NS
Potassium levels (% of recommended K)		
K_1 (100)	1.24	1.27
K_2 (125)	1.26	1.29
K_3 (150)	1.25	1.29
CD (P=0.05)	NS	NS

*None of the interaction was found significant

data pertaining to the effect of irrigation levels on bulk density after the harvest of wheat 2016-17 have been presented in Table 2. The critical examination of Table revealed that the irrigation levels did not significantly influence the bulk density in surface (0-0.15 m) as well as subsurface layer (0.15-0.30 m). The absolute values of bulk density varied between 1.24 to 1.25 Mg m^{-3} in surface and 1.28 Mg m^{-3} in the subsurface layer.

Like, the effect of tillage and irrigation levels, application of higher levels of K also did not bring out any significant change in bulk density of the soil at both the depths (Table 2) after the first season of experimentation. However, the values of bulk density varied between 1.24 to 1.26 Mg m^{-3} and 1.27 to 1.29 Mg m^{-3} in surface and subsurface layers, respectively.

The data in Table 3 revealed that there was no effect of different type of tillage methods on soil pH after the harvest of wheat in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) and the pH values varied between 5.64 to 5.67 Mg m^{-3} and 5.57 to 5.61 Mg m^{-3} in surface and subsurface layers, respectively. The data pertaining to the effect of irrigation levels on soil pH after the harvest of wheat 2016-17 have been presented in Table 3. The critical examination of Table revealed that the irrigation levels did not influence the soil pH in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) significantly and it varied between 5.65 to 5.66, in the surface layer. Whereas, its value in subsurface layer was 5.59 under both the irrigation levels.

The data on soil pH in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) after the harvest of wheat have been presented in Table 3. The data revealed that there was no effect of potassium levels on soil pH. Soil pH hovered around 5.6 in surface and subsurface layer under varying levels of K. The significant effects of tillage, irrigation and K levels might be expected in the long run as it was too early for various treatments to exert influence on soil pH.

The critical examination of Table 3 revealed that conservation tillage significantly increased the soil organic carbon content by 4.97 % in the surface layer (0-0.15 m) as compared to conventional tillage and in subsurface layer (0.15-0.30 m), the effect of tillage methods was not found significant. Similar results were reported by Neugschwandtner *et al.* (2014). Kern and Johnson (1993) found increased SOC particularly at 0–20 cm depth. The increase in organic carbon due to conservation tillage may be attributed to decomposition of part of the applied residues under enhanced activity of microbes due to better hydrothermal regimes during the crop duration. The data in Table 3 revealed that there was no significant effect of irrigation levels on soil organic carbon after the harvest of wheat in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) though little higher OC contents were observed under limited irrigation. The data on soil organic carbon in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) after the harvest of wheat have been presented in Table 3. The data revealed though application of 150 per cent of recommended K resulted in higher OC contents at 0-0.15 m soil depth among K levels (8.70 g kg^{-1}) in comparison to 100 per cent of recommended K (8.62 g kg^{-1}) and 125 per cent of recommended K (8.66 g kg^{-1}) but these differences were not significant. Similarly, in the subsurface layer also no significant differences were

Table 3. Effect of tillage methods, irrigation and potassium levels on soil pH and soil organic carbon (SOC) (g kg^{-1})

Treatment	pH		SOC	
	0-0.15	0.15-0.30	0-0.15	0.15-0.30
Tillage methods				
C_1 (Conventional)	5.6	5.6	8.5	7.6
C_2 (Conservation)	5.7	5.6	8.9	7.9
CD (P=0.05)	NS	NS	0.1	NS
Irrigation levels				
I_1 (No irrigation)	5.7	5.6	8.6	7.7
I_2 (Limited irrigation)	5.7	5.6	8.7	7.8
CD (P=0.05)	NS	NS	NS	NS
Potassium levels (% of recommended K)				
K_1 (100)	5.7	5.6	8.6	7.6
K_2 (125)	5.7	5.6	8.7	7.7
K_3 (150)	5.7	5.6	8.7	7.8
CD (P=0.05)	NS	NS	NS	NS

*None of the interaction was found significant

observed in organic carbon due to varying K levels, though numerically higher contents were observed in the highest level of K.

The critical examination of Table 4 revealed that the tillage methods did not significantly influence the available nitrogen in surface (0-0.15 m) and subsurface layer (0.15-0.30 m). The contents of available N varied from 267 to 274 kg ha^{-1} in the surface layer and 247 to 252 kg ha^{-1} in the subsurface layer. The data pertaining to the effect of irrigation levels on available nitrogen after the harvest of wheat have been presented in Table 4. The critical examination of Table revealed that the irrigation levels did not significantly influence the available nitrogen in surface (0-0.15 m) and subsurface layer (0.15-0.30 m). The available N contents under two irrigation levels though varied between 267 and 270 kg ha^{-1} in surface and between 248 and 250 kg ha^{-1} in the subsurface layer. The data on available nitrogen in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) after the harvest of wheat have been presented in Table 4. The data revealed that there was no significant effect of potassium levels on available nitrogen. The contents of available N varied between 268 to 269 kg ha^{-1} in the surface layer and hovered around 249 kg ha^{-1} in the subsurface layer.

The data in Table 4 revealed that there was no significant effect of tillage methods on available phosphorus after the harvest of wheat in surface (0-0.15 m) and subsurface layer (0.15-0.30 m). The contents of available P varied from 21 to 23 kg ha^{-1} in the surface layer and 16 to 18 kg ha^{-1} in the subsurface layer. The data pertaining to the effect of irrigation levels on available phosphorus after the harvest of wheat have been presented in Table 4. The critical examination of Table revealed that the irrigation levels did not influence the available phosphorus in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) significantly. The available P contents under two irrigation levels though varied between 21 and 23 kg ha^{-1} in surface and between 16 and 18 kg ha^{-1} in the subsurface layer.

The data on available phosphorus in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) after the harvest of wheat have been presented in Table 4. The data revealed that there was no significant effect of potassium levels on available phosphorus. The contents of available phosphorus varied between 22 to 24 kg ha^{-1} and 16 to 18 kg ha^{-1} in the surface and subsurface layer, respectively.

A perusal of the data on available potassium in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) after the harvest of wheat crop (Table 4) indicated that there was no significant effect of tillage methods on available potassium. The contents of available K varied from 149 to 152 kg ha^{-1} in the surface layer and 134 to 137 kg ha^{-1} in the subsurface layer. The data pertaining to the effect of irrigation levels on available potassium after the harvest of wheat have been presented in Table 4. Results revealed that the irrigation levels did not influence the available potassium in surface (0-0.15 m) and subsurface layer (0.15-0.30 m) significantly. The available K contents under two irrigation levels though varied between 149 and 152 kg ha^{-1} in surface and between 134 and 137 kg ha^{-1} in the subsurface layer. The data on available potassium in surface (0-0.15 m)

Table 4. Effect of tillage methods, irrigation and potassium levels on available N (kg ha^{-1}), P (kg ha^{-1}) and K (kg ha^{-1})

Treatment	Available N		Available P		Available K	
	(0-0.15)	(0.15-0.30)	(0-0.15)	(0.15-0.30)	(0-0.15)	(0.15-0.30)
Tillage methods						
C_1 (Conventional)	267.0	246.8	21.3	17.0	149.3	134.2
C_2 (Conservation)	274.1	251.8	23.5	18.5	152.5	137.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels						
I_1 (No irrigation)	267.1	248.1	21.4	16.6	149.2	134.6
I_2 (Limited irrigation)	270.0	250.4	23.4	18.8	152.6	137.6
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Potassium levels (% of recommended K)						
K_1 (100)	269.1	248.6	22.1	17.0	145.4	130.5
K_2 (125)	268.9	249.3	22.3	18.0	149.7	135.2
K_3 (150)	267.7	249.8	24.8	18.2	157.7	142.5
CD (P=0.05)	NS	NS	NS	NS	**4.7**	**3.1**

*None of the interaction was found significant

and subsurface layer (0.15-0.30 m) after the harvest of wheat have been presented in Table 4. The data revealed that the available potassium in the surface layer at the application of 150 per cent of recommended dose of potassium (K_3) was 8.44 and 5.35 per cent more than application of 100 per cent of recommended dose of potassium (K_1) and application of 125 per cent of recommended dose of potassium (K_2) respectively. Also, the available K at the application of 150 per cent of recommended dose of potassium (K_3) was 9.23 and 5.39 per cent more than application of 100 per cent of recommended dose of potassium (K_1) and application of 125 per cent of recommended dose of potassium (K_2), respectively in the sub surface layer. Similar results were reported by Tariq *et al.* (2011) and Hossain *et al.* 2013. The increase in soil K with increasing K addition may be due to conversion of non-exchangeable-K to exchangeable-K in soils.

Therefore, from the present investigation it is conclusively inferred that conservation tillage, two irrigation applications and 150% recommended dose of potassium were remained superior in terms of uptake of nitrogen, phosphorus and potassium and improvement of soil properties *viz.,* soil pH, Soil organic carbon and available nitrogen, phosphorus and potassium while bulk density was improved under conventional tillage system, no irrigation supply and application of 100% recommended dose of potassium over conservation tillage system, two irrigation applications and 125% recommended dose of potassium, 150% recommended dose of potassium, respectively.

Authors' contribution

Conceptualization of research work and designing of experiments(SKS); Execution of field/lab experiments and data collection (HS); Analysis of data and interpretation (HS, SKS); Preparation of manuscript (HS, SKS).

LITERATURE CITED

Alderfasi A A and Refay Y A 2010. Integrated use of potassium fertilizer and water schedules on growth and yield of two wheat genotypes under arid environment in Saudi Arabia 1- effect on growth characters. *Am-Eurasian J Agric Environ Sci* **9**(3): 239-47.

Alvarez R 2005. A review of nitrogen fertilizer and conservation tillage effects on soil organic carbon storage. *Soil Use Manag* **21**: 38-52.

Black C A 1965. *Methods of Soil Analysis part-I*. American Society of Agronomy, Madison, Wisconsin, USA.

Choudhary M A and Baker C J 1993. Conservation tillage and seeding systems in the South Pacific. *Soil Tillage Res* **27**: 283-302.

Ehsanullah A R, Khan S, Qamar R, Ghaffar A and Mustafa G 2013. Impact of tillage and mulch on water conservation in wheat (*Triticum aestivum L.*) under rice-wheat cropping system. *J Agric Res* **51** (3): 255-65.

Gomez K A and Gomez A A 1984. Statistical Procedure for Agricultural Research. 2nd edition. *Wiley Inter Science, New York, USA*. 680p.

Gonzalez-Dugo V, Durand J L and Gastal F 2010. Water deficit and nitrogen nutrition of crops. *Agron Sustain Dev* **30**: 529-44.

Grzebisz W, Gransee A, Szczepaniak W and Diatta J 2013. The effects of potassium fertilization on water-use efficiency in crop plants. *J Plant Nutr Soil Sci* **176**: 355-74.

He J, Wang Q, Li H, Tullberg J N, McHugh A D, Bai Y, Zhang X, McLaughlin N and Gao H 2009. Soil physical properties and infiltration after long-term no tillage and ploughing on the Chinese Loess Plateau. *N Z J Crop Hortic Sci* **37**: 157-66.

Hobbs P R, Sayre K and Gupta R 2008. The role of conservation agriculture in sustainable agriculture. *Philos Trans Royal Soc* **363**: 543-55.

Hossain A, Silva J A T D and Bodruzzaman M 2013. Rate and application methods of potassium in light soil for irrigated spring wheat. *Songklanakarin J Sci Technol* **37**(6): 1-25.

Jackson M L 1973. *Soil Chemical Analysis*. Prentice Wall. Inc. Englewood Chiffs. New Jersey, USA.

Kern J S and Johnson M G 1993. Conservation tillage impacts on national soil and atmospheric carbon levels. *Soil Sci Soc Am J* **57**: 200-10.

Khaleque M A, Paul N K and Meisner C A 2008. Yield and N use efficiency of wheat as influenced by bed planting and N application. *Bangladesh J Agric Res* **33**(3): 439-48.

Martinez E, Fuentes J P, Silva P, Valle S and Acevedo E 2008. Soil physical properties and wheat root growth as affected by no-tillage and conventional tillage systems in a Mediterranean environment of Chile. *Soil Tillage Res* **99**: 232-44.

Neugschwandtner R W, Liebhard P, Kau H P and Wagentrist H 2014. Soil chemical properties as affected by tillage and crop rotation in a long-term field experiment. *Plant Soil Environ* **60**(2): 57-62.

Obaid-ur-Rahman M A, Rafa H U and Hassan N M 2006. Effect of balanced fertilization on yield and phosphorus uptake in wheat-rice rotation. *J Agric Res* **44**(2): 105-14.

Olsen S R, Cole C V, Watanable F S and Dean L A 1954. Estimation of available phosphorus in soil by extraction by sodium bicarbonate. *USDA Circular* **930**: 19-23.

Panaullah G M, Timsina J, Saleque M A, Ishaque M, Pathan A B M B U, Connor D J, Saha P K, Quayyum M A, Humphreys E and Meisner C A 2006. Nutrient uptake and apparent balances for rice-wheat sequences. *J Plant Nutr* **29**: 173-87.

Piper C S 1966. *Soil and Plant Analysis* (Asia Edition), Hans Publishers, Bombay, India.

Saleque M A, Timsina J, Panaullah G M, Ishaque M, Pathan A B M B U, Connor D J, Saha P K, Quayyum M A, Humphreys E and Meisner C A 2006. Nutrient uptake and apparent balances for rice-wheat sequences. *J Plant Nutr* **28**: 157-72.

Singh P K, Kumar A, Singh B K, Singh A C and Kumar S 2017. Long term impact of tillage systems, irrigation and nitrogen on soil properties, growth, yield, nutrient uptake and quality of wheat (*Triticum aestivum L.*). *Int J Agric Sci* **7**(4): 555-66.

Singh R A 1980. *Soil Physical Analysis*. Kalyani Publishers, Ludhiana, India.

Singh S S 2000. Soil fertility and nutrient management. Kalyani Publishers, Ludhiana, pp. 32-36.

Subbiah B W and Asija G L 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr Sci* **25**: 259-60.

Tariq M, Saeed A, Nisar M, Mian I A and Afzal M 2011. Effect of potassium rates and sources on the growth performance and on chloride accumulation of maize in two different textured soils of Haripur, Hazara Division. *Sarhad J Agric* **27**(3): 415-22.

Verhulst N F, Kienle K D, Sayre J, Deckers D, Raes A, Limon-Ortega L, Tijerina-Chavez and Govaerts B 2011. Soil quality as affected by tillage-residue management in a wheat-maize irrigated bed planting system. *Plant Soil* **340**: 453-66.

Walkley A and Black C A 1934. An examination of wet acid method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci* **37**: 29-38.

Wang X, Wu H, Dai K, Zhang D, Feng Z, Zhao Q, Wu X, Jin K, Cai D, Oenema O and Hoogmoed W B 2012. Tillage and crop residue effects on rainfed wheat and maize production in Northern China. *Field Crops Res* **132**: 106-16.