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Influence of Green Manure and Potassium Nutrition on Soil Potassium Fractions and Yield of Rice Crop

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A B S T R A C T

A field experiment was conducted with rice during *kharif* 2015 at Agricultural college farm, Mahanandi to study the influence of different levels of potassium either alone or in combination with green manure on yield and soil K fractions (water soluble, exchangeable, fixed and non-exchangeable forms) at different stages of rice crop. All the forms of K increased with increasing levels of potassium up to 120 kg K_2O ha^{-1} at all the stages of crop growth.Green manure either alone or in combination with K fertilizer recorded higher values of exchangeable K and yield as compared with fertilizer treatments alone. The results clearly indicated that increase in fixed K with increasing fertilizer doses from 0 to 120 kg K_2O ha^{-1} at all the stages of crop growth. The highest fixed K and non-exchangeable K was observed at 120 kg K_2O ha^{-1} (T_4). Whereas the highest yield, water soluble and exchangeable form were obtained with the treatment (T_8) GM+120 kg K_2O ha^{-1} which was on par with (T_7) GM+80 kg K_2O ha^{-1} and (T_6) GM+40 kg K_2O ha^{-1}. Hence, the incorporation of green manure (*dhaincha*) at flowering stage before transplantation along with 40 kg K_2O ha^{-1} may be recommended for rice crop. However, the results will have to be confirmed by conducting extensive field trails in farmer's fields on long term basis.

Introduction

Potassium plays a very instrumental role in plant nutrition and physiology and it has been found to activate more than sixty enzymes. In soils, potassium exists in various forms such as water soluble, exchangeable, non-exchangeable, fixed K, lattice K and total K. The above forms of K are in equilibrium and related to each other (Das *et al.*, 2000). Dynamic equilibrium reactions occurring between different forms of K have a profound effect on the K nutrition and the direction of rate of these reactions determines the fate of applied K and release of non-exchangeable K (Singh *et al.*, 2004). Rice is an important food crop in the world. It is the staple food in South-East Asia and at present more than half of the world population depends on this crop. It is also one of the most important cereals in India and occupies second position in cultivation after wheat. Rice is one of the major field crops in Kurnool district, the crop is cultivated in an area of 91,568 ha (Department of Agriculture, 2014). The higher grain yield of rice was observed with application of 50% of RDP either alone or in combination with green manure in Vertisol of high available phosphorus in KC canal ayacut of Nandyl (Jyothi, 2013).The soils of Agricultural college farm, Mahanandi were high in available K and K supplying power of rice growing soils of canal ayacut in Kurnool district is low as indicated by PBC^K. Hence judicious application of potassic fertilizer is required for better crop production were reported by Prasad (2014) and Swamanna (2015). Incorporation of *dhaincha* at flowering stage before transplanting of rice was followed by most of the farmers in major rice growing areas of Kurnool district. Though much work has been reported on green manure in combination with N and P in rice crop but no investigation have been carried out in green manure along with K fertilizer in rice crop. Hence, present investigation will be carried out to know the yield and different forms of K as influenced by green manure and potassium at different stages of crop growth in rice.

Materials and Methods

A field experiment was conducted at Agricultural College Farm, Mahanandi in Kurnool district of Andhra Pradesh during *Kharif* 2015. The soils of experimental field was sandy loam with soil pH 7.97, EC 0.33 dSm^{-1}, organic carbon 0.55%, low in available N (239 kg ha^{-1}), high in P_2O_5 (82 kg ha^{-1}) and K_2O (1075 kg ha^{-1}) respectively. Eight treatments viz., 0, 40, 80 and 120 kg K_2O ha^{-1} alone and in combinations with green manure were employed. The treatment details are given in table 1, which were laid out in randomized block design and replicated thrice. A common recommended dose of nitrogen (240 kg N ha^{-1}) and phosphorus (80 kg P_2O_5 ha^{-1}) were applied to all the treatments. Nitrogen in the form of urea was applied in three equal splits as basal, at tillering and at panicle initiation stages. Phosphorus in the form of single super phosphate was applied basally. Potassium in the form of muriate of potash was applied in two equal splits as basal and at panicle initiation stage as per the treatments. Green manure (*dhaincha*) was grown in the treatments T_5, T_6, T_7 and T_8 ploughed *in situ* at flowering before transplantation. The content of N, P and K in green manure was 3.5, 0.3 and 1 percent respectively. The grains from each plot were cleaned sundried and constant weight was recorded and expressed in kg ha^{-1}. The straw from each net plot was allowed to dry in the field until a constant weight was obtained and the final weight was recorded and expressed in kg ha^{-1}. After transplantation representative soil samples were collected from each treatment plot at tillering, panicle initiation and harvest stages, was dried and processed for analysis. Water soluble potassium was determined in 1:5 soil: water extract by equilibrating for 5 minutes (Kanwar and Grewal, 1966). The available potassium was determined by Neutral normal ammonium acetate method with 1:5 soil: water extract, shaking for 5 minutes as described by Jackson (1973). The exchangeable potassium was obtained as a difference of the available and water soluble potassium. The fixed form of potassium was estimated using 1*N* HNO_3 (1:10 soil: acid ratio) boiling for 10 minutes (Wood and De Turk, 1941).The non-exchangeable potassium was obtained by deducting the available potassium from fixed potassium.

Results and Discussion

Water soluble K

The data pertaining to water soluble K at tillering, panicle initiation and harvest stages indicated that water soluble K significantly varied due to the different treatments at all the stages of crop growth (Table 1; Fig. 1).

At tillering stage green manure either alone or in combination with K fertilizer recorded higher values of water soluble K as compared with fertilizer treatments alone. But at panicle initiation and harvest stages, K fertilizer treatments and green manure treatments also equally effective in increasing water soluble K. The water soluble K increased in K fertilizer treatments from tillering to harvesting stage while decreased in green manure treatments.

This might be due to the green manure hold the K in exchangeable sites there by decreased the water soluble form. Among all treatments T_8, T_7 and T_4 almost equally effective in increasing water soluble K when compared to other treatments. The lowest water soluble K was observed in control (T_1) but it was on par with T_2 (40 kg K_2O ha^{-1}) at all the stages of crop growth.

Exchangeable K

The exchangeable K significantly increased with increasing levels of K fertilizer application and also with green manure incorporation (Table 1; Fig. 2).

The increase in exchangeable K at 120 kg ha^{-1} over no potassium application was 2.8, 7.8 and 8.4 percent at panicle initiation and harvesting stage, respectively. Green manuring *in situ* alone also significantly increased the exchangeable K when compared to T_1 (Control) and T_2 (40 kg K_2O ha^{-1}).

Compared to green manuring and K fertilizer alone, their combinations recorded higher values of exchangeable K at all the stages of crop growth. Among all treatments higher exchangeable K obtained with T_8 (G.M+ 120 kg K_2O ha^{-1}) but it was at par with T7 (G.M + 80 kg K_2O ha^{-1}) and T_6 (G.M + 40 kg K_2O ha^{-1}) at all the stages of crop growth.

The higher exchangeable K obtained with green manuring along with higher dose of K fertilizer was due to the extensive root system of green manure crops may improved the physical condition of soil and liberated CO_2 and organic acids which helped in dissolving native potassium in soil and thus increasing the availability of K (Swarup, 1991; Dhudhan *et al.*, 2004; Singh *et al.*, 2009).

Fixed K

Unlike exchangeable K, the fixed K increased from tillering to harvest stage (Table 1; Fig 3). At tillering stage, the highest fixed K was observed in control except T_8 (G.M+120 kg K_2O ha^{-1}) due to lower uptake of K in control.

However later stages *i.e.*, panicle initiation and harvest stage, the lowest fixed K observed in control due to the absence of K fertilization and significant depletion of fixed K when compared to other treatments.

Syers *et al.*, (2011) also reported that, in the absence of adequate K fertilization significant depletion of K reserves in soil take place leading to yield loss and higher economic risk to farmers.

The highest fixed K observed with T_8 (G.M + 120 kg K_2O ha^{-1}) at tillering stage was due to the excess K fertilizer application and conversion of water soluble and exchangeable form to fixed form.

Later stages *i.e*., panicle initiation and harvest stage the highest fixed K was observed at 120 kg K_2O ha^{-1} (T_4). The results clearly indicated that increase in fixed K with increasing fertilizer doses from 0 to 120 kg K_2O ha^{-1} at all the stages of crop growth.

These findings indicate that addition of higher doses of fertilizers increases the fixation capacity of soil. Rao *et al.,* (2000) also reported that fixation of added K with the rate of added K irrespective of soil mineralogy.

Fig.1 Water soluble K as influenced by different levels of potassium and green manure at different stages of crop growth

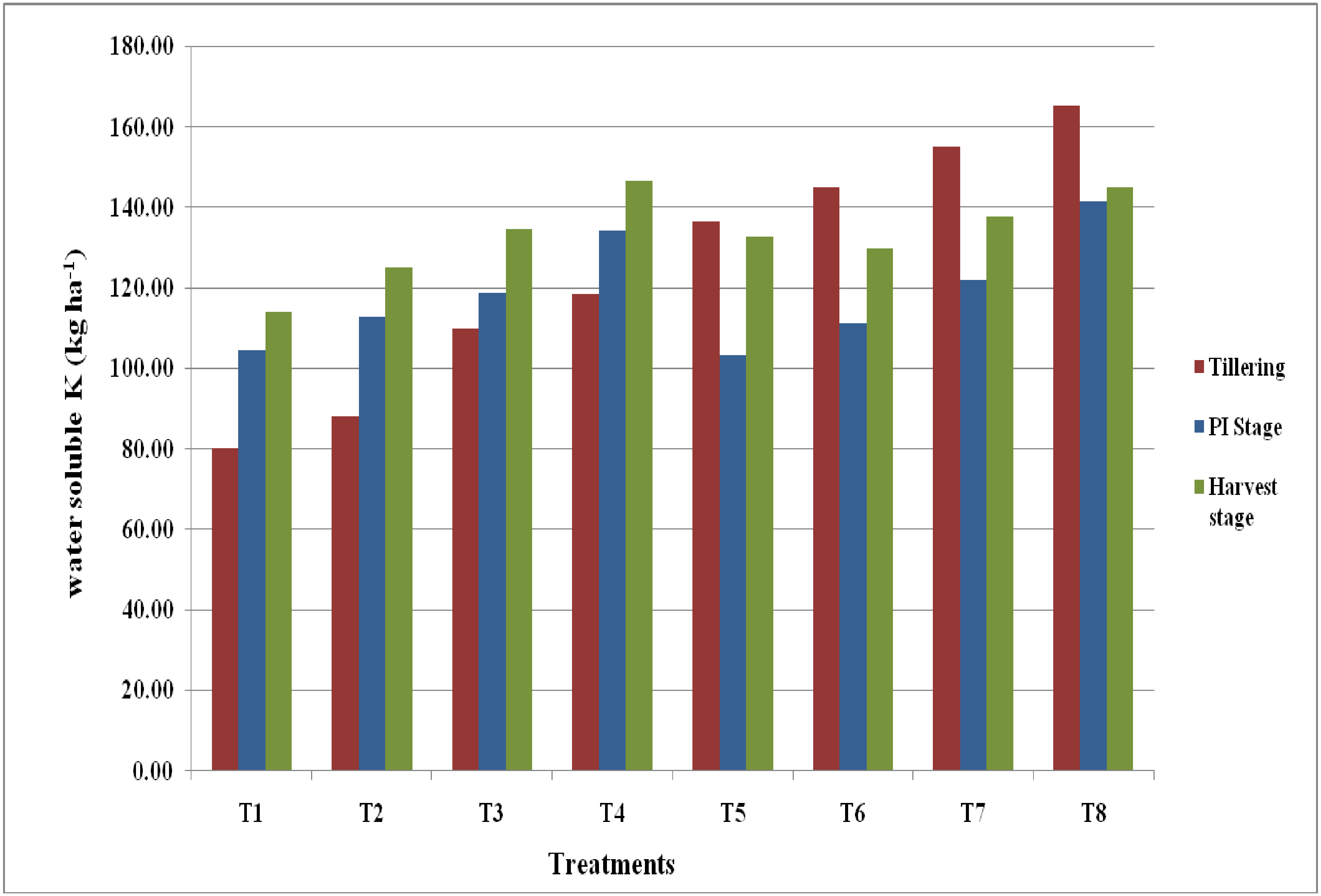

Fig.2 Exchangeable K as influenced by different levels of potassium and green manure at different stages of crop growth

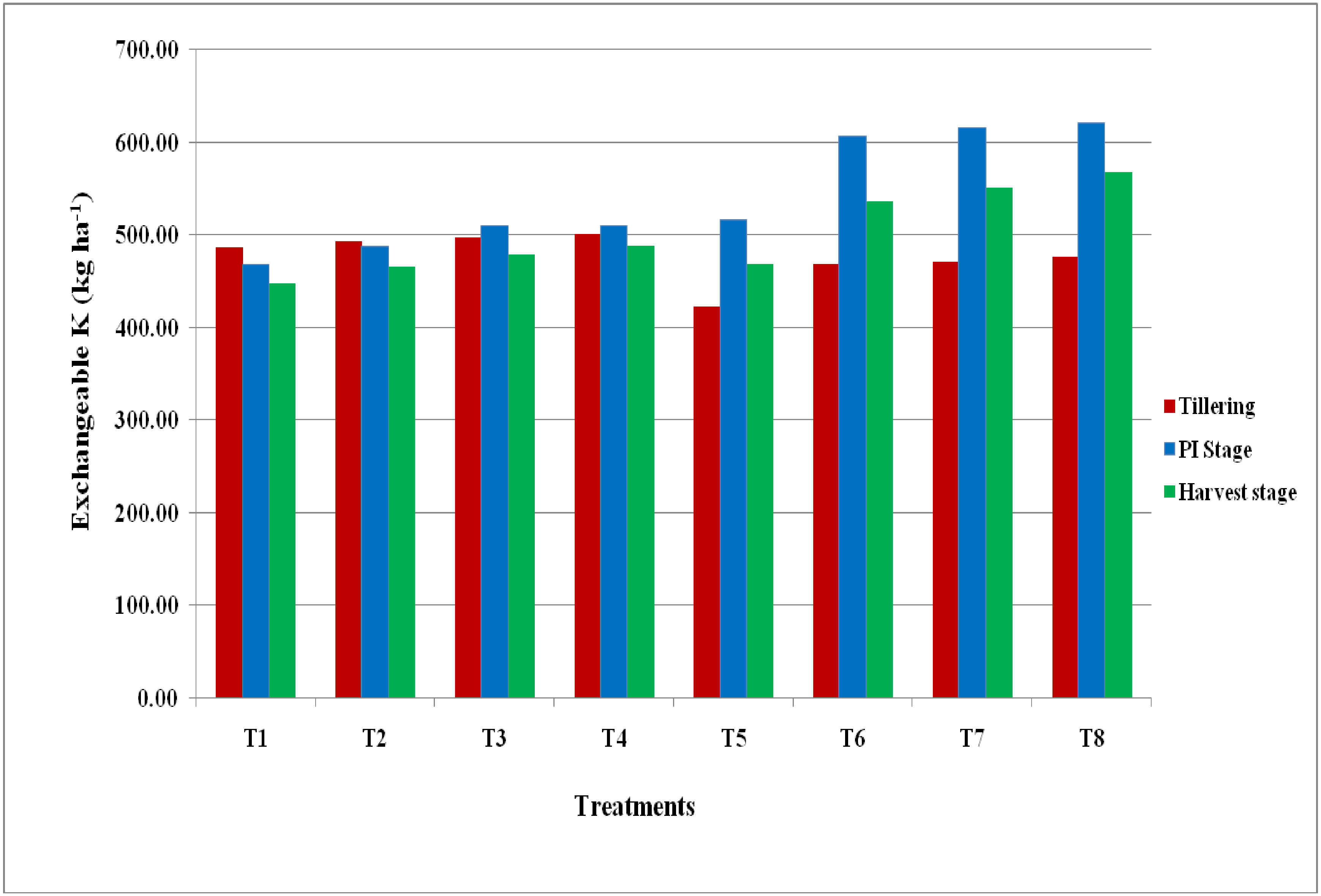

Fig.3 Fixed K as influenced by different levels of potassium and green manure at different stages of crop growth

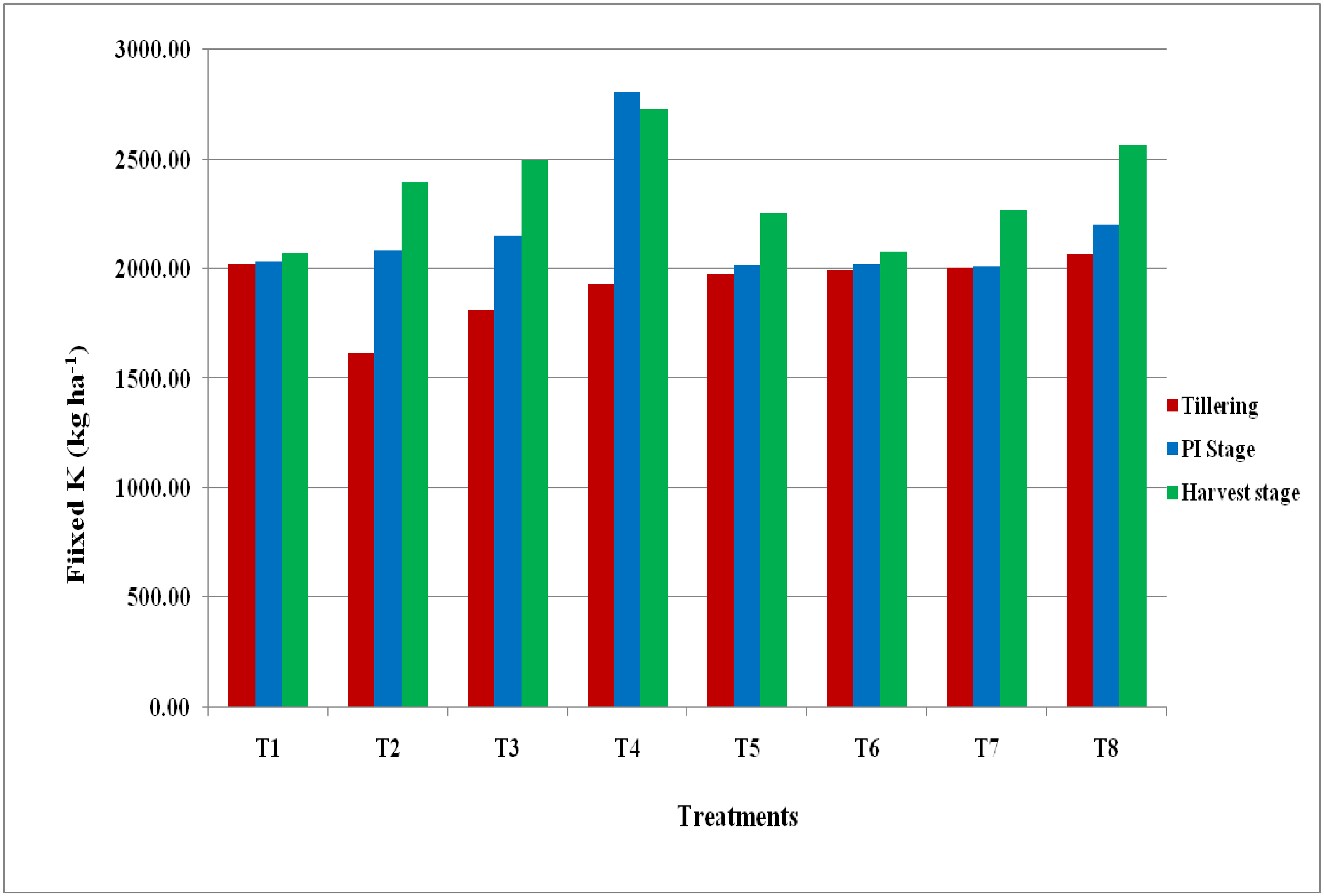

Fig.4 Non exchangeable K as influenced by different levels of potassium and green manure at different stages of crop growth

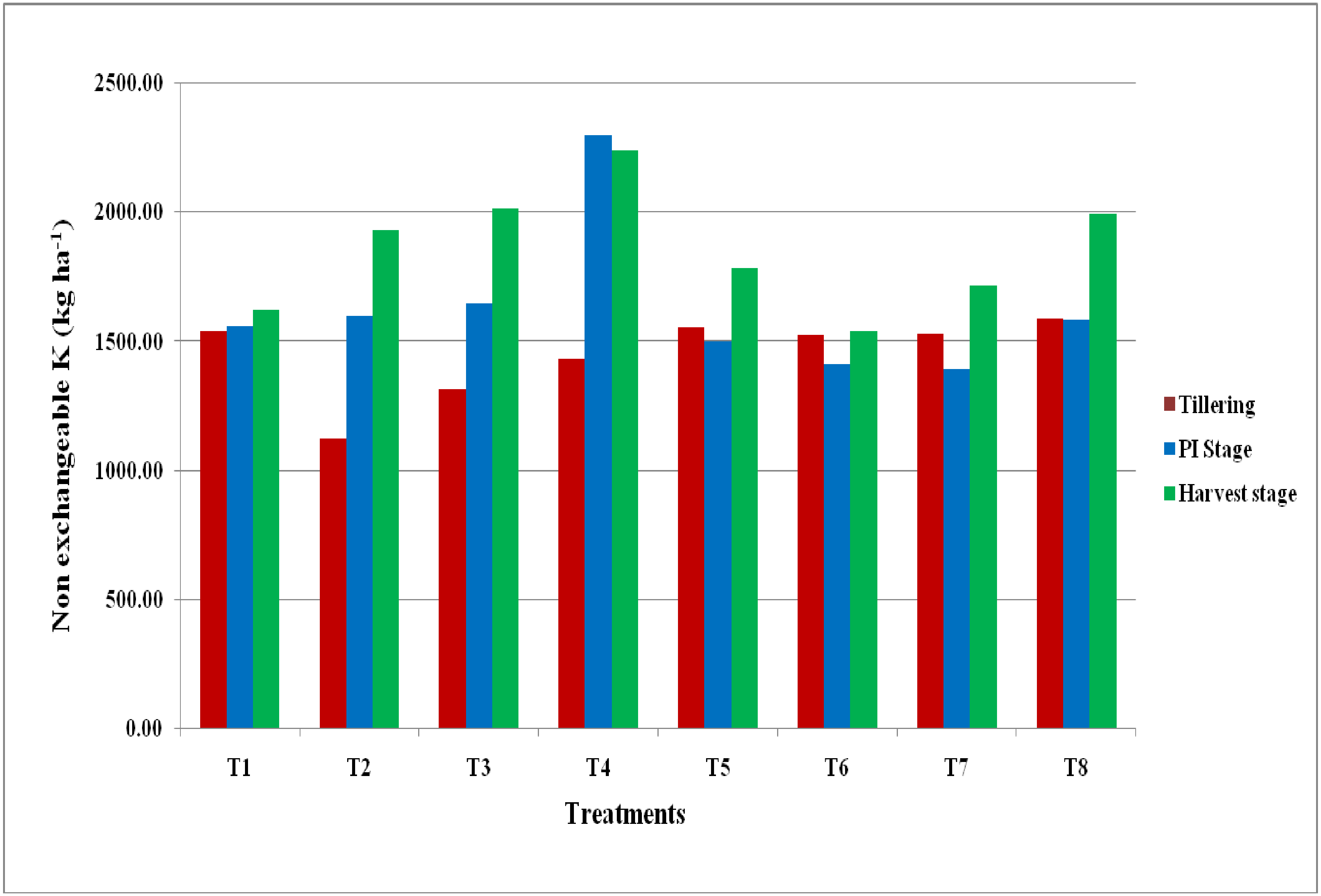

Table.1 Different forms of K as influenced by green manure and K at different stages of crop growth in Rice

	Water soluble K			**Exchangeable K**			**Fixed K**			**Non exchangeable K**		
Treatments	Tillering	PI	Harvest	Tillering	PI	Harvest	Tillering	PI	Harvest	Tillering	PI	Harvest
T_1 : 0% RDK (Control)	80	102	114	487	469	448	2025	2031	2073	1458	1454	1512
T_2 : 50% RDK (40 kg K_2O ha^{-1})	88	113	125	494	487	466	1615	2085	2396	1033	1492	1805
T_3 : 100% RDK (80 kg K_2O ha^{-1})	98	119	134	498	508	480	1813	2155	2494	1217	1528	1880
T_4 : 150% RDK (120 kg K_2O ha^{-1})	118	134	146	501	509	489	1933	2806	2730	1314	2167	2095
T_5 : GM (*dhaincha)in situ* only	136	103	133	423	515	469	1977	2015	2253	1418	1393	1651
T_6 : GM+ 40 kg K_2O ha^{-1}	145	111	130	468	606	537	1993	2020	2077	1380	1299	1410
T_7 : GM+ 80 kg K_2O ha^{-1}	155	122	138	471	615	551	2003	2011	2270	1377	1273	1582
T_8 : GM+ 120 kg K_2O ha^{-1}	165	141	145	477	621	568	2065	2205	2567	1423	1462	1853
SE(m)±	4.8	6.4	4.2	11	7	13	41	14.2	7.09	46.3	66	13
CD (P=0.05)	15	20	13	34	20	40	124	43.6	21.7	141	204	39
CV	6	9	5	4	2	5	3	2	1	6	8	1

Table.3 Yield attributes as influenced by different levels of potassium and green manure

Treatments	**Number of tillers/m²**	**No. of productive Tillers/m²**	**Number of grains/panicle**	**Filled grains/ panicle**	**Test weight (g)**
T_1: 0% RDK (Control)	455	411	133	124	14.03
T_2: 50% RDK (40 kg K_2O ha^{-1})	477	444	153	142	14.53
T_3:100% RDK (80 kg K_2O ha^{-1})	500	455	154	141	14.73
T_4:150% RDK (120 kg K_2O ha^{-1})	522	500	155	145	15.04
T_5:GM (*dhaincha)in situ* only	555	489	152	144	14.89
T_6:GM+ 40 kg K_2O ha^{-1}	577	533	153	146	15.67
T_7:GM+ 80 kg K_2O ha^{-1}	622	544	156	147	15.74
T_8:GM+ 120 kg K_2O ha^{-1}	733	677	158	149	15.86
SE(m) ±	9.85	13.03	1.4	1.8	0.17
CD(p=0.05)	31	40	4.13	5.51	0.53
CV %	3.07	4.45	1.54	2.20	1.99

Table 2. Grain and straw yield a influenced by different levels of potassium and green manure

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1. 0% RDK (Control)	5008	6173
T_2. 50% RDK (40 kg K_2O ha^{-1})	5281	6716
T_3. 100% RDK (80 kg K_2O ha^{-1})	5433	7664
T_4. 150% RDK (120 kg K_2O ha^{-1})	5517	7830
T_5. GM (*dhaincha)in situ* only	5493	8979
T_6. GM+ 40 kg K_2O ha^{-1}	5552	9617
T_7. GM+ 80 kg K_2O ha^{-1}	5671	10403
T_8. GM+ 120 kg K_2O ha^{-1}	5748	10931
SE(m)±	95	465
CD (P=0.05)	292	1424
CV	5	7

Non-exchangeable K

Similar to fixed K, the non-exchangeable K increased from tillering to harvest stage (Table 1 and Fig. 4). At tillering stage the highest non-exchangeable K was observed in control, except T_8 (G.M +120 kg K_2O ha^{-1}). In later stages *i.e.*, panicle initiation and harvest stages, the highest non- exchangeable K was observed at T_4 (120 kg K_2O ha^{-1}). The results further showed that increasing the level of fertilizer from 0 to 120 kg ha^{-1} increased the non- exchangeable form of K at all stages of crop growth. This indicates that fixation of K increased with addition of K (Sarada, 1988; Talely *et al.*, 1993).

Application of green manure showed higher values of non-exchangeable form of K when compared with all K fertilizer treatments at tillering stage. This might be due to prevent the leaching of water soluble form and conversion water soluble K to non-exchangeable K.

Yield

All the treatments recorded significantly higher grain and straw yield than control except T_2 (40 kg K_2O ha^{-1}) (Table 2). Grain and straw yield increased with increasing levels of K up to120 kg K_2O ha^{-1}. However, there was no statistical difference between the three levels of K (40, 80 and 120 kg K_2O ha^{-1}) in increasing grain and straw yield. The increased grain and straw yield by the application of K fertilizer was due to the continuous supply of K to the during crop growth period which was more beneficial and increased total no of tillers, No of productive tillers, number of grains per panicle and test weight (Table 3) resulted higher yields of rice (Meena *et al.,* 2003; Surekha *et al.*, 2003).

Application of green manure in combination with K recorded higher grain and straw yield than when applied alone. The highest grain and straw yield were obtained with T_8 (GM + 120 kg K_2O ha^{-1}), but which were on par with T_7 (GM + 80 kg K_2O ha^{-1}) and T_6 (GM + 40 kg K_2O ha^{-1}). Green manure in combinations with K fertilizers increased the grain yield due to increased total no of tillers, No of productive tillers, number of grains per panicle and test weight (Table 3) and decomposition of succulent green manure crop, which favoured for release of nutrients and their continuous availability in soil for sustaining higher grain and straw yield of rice. Highest grain yield with green manure along with NPK fertilizers in rice was also reported by Sharma *et al.,* (2001) and Singh *et al.,* (2002).

The results showed that increasing the level of K fertilizer from 0 to 120 kg K_2O ha^{-1} increased the yield and all forms of K at all stages of crop growth. Green manure in combination with potassium fertilizer recorded the higher yield as well as water soluble and exchangeable form of K. But increasing the level of fertilizer from 0 to 120 kg ha^{-1} increased the non- exchangeable and fixed form of K at all stages of crop growth. The highest fixed K and non-exchangeable K was observed at 120 kg K_2O ha^{-1} (T_4) whereas the highest yield, water soluble and exchangeable form were obtained with form (T_8) GM+120 kg K_2O ha^{-1} which was on par with (T_7) GM+80 kg K_2O ha^{-1} and (T_6) GM+40 kg K_20 ha^{-1}. Hence, the incorporation of green manure (*dhaincha*) at flowering stage before transplanting along with 40 kg K_2O ha^{-1} may be recommended for rice crop. However extensive field trails in farmer's fields is also recommended for further validation of the results.

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