ISSN:0976-4933
Journal of Progressive Science
Vol.06, No.02, pp 143-152 (2015)

Influence of legumes residues decomposition on change in physico-chemical properties of alluvial soil

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Abstract

A laboratory experiment was conducted on the decomposition of legumes residues on change in soil properties. The Incubation experiment was carried out for 0-42 days in alluvial soil with different doses of different legumes residues decomposition. For the analysis of soil samples were drawn for pH, EC, Bd, Organic carbon, available N.P.K.S to assess their content in agriculture farm alluvial soil (Inceptisols). The bulk density and pH was found decrease in treatment combination of pigeon pea, lentil and pea with their increased amount viz. 30 t/ha & 60 t/ha of soil incorporation. The EC of soil was not effective to decrease by legume residues materials treated under study. Organic carbon enrichment was showed not significantly beneficial effect on their enhancement while legume residues and materials were indicated greater available N in T_6 at 42 days. The treatment combination of legume residues materials showed small variation with gradual increase in available phosphorus in all stage. Similarly, greater in available K and S content were noticed maximum at 42 days with incorporation of pea (T_7) @60t/ha but the gradual pattern was observed in sequence as legume residues (pigeon pea, lentil and pea) over the control. So, legume residues as pigeon pea, Lentil and pea were showed as elastic change in the chemical properties of soil due to addition of their chemical reaction with @60 t/ha.

Keywords- legumes residues, incubation study and soil properties

Introduction

About 355 million tons (mt) of crop residues are annually produce in India of which 180 mt can be utilized to supply about 3.54 mt plant nutrients (Chandra, 2011). Crop residues application have been found that improving physical, chemical and biological properties of soil. In fact, legume crop residues and crops are generally benefit the succeeding cropping system due to decomposition than release of different organic acids to decrease soil salinity and alkalinity, improving soil structure and availability of plant nutrients with its become organic carbon strengthen in soils. The accumulation of organic matter in soil has been suggested to be one of the causes of soil acidification observe under arhar pasture, lentil and pigeon pea and cereal rotations (Yan *et al.* 1996). Soil acidification remains one of the key issues facing agricultural productivity and sustainability in world crop residues and other plant materials can a liming effect when add to soil in the absence of plant and leaching materials (Sakala *et al.* 2004, Tang *et al.* 1999). However, the chemical mechanism for pH change by crop residues is not fully understood. While the amount and timing of residues application is largely indicated by the farming system and grow in season of legume residues may be important for the development of acidification within soil system. Increases in pH towords acidity, after the addition of legume residues are purported to occur to the decarboxylation of organic acids (Tang and Yu, 1991, Yan *et al.* 1996). Keeping in view on the above facts present study was planned and executed with objectives.

Materials and methods

A incubation study was conducted in laboratory of department with legume residues *viz.* pea, lentil and pigeon pea. All residues were collected from local farmer's field and chapped before incorporation in pots. Residues were dried and weight as per need of treatment combination. The surface soil (0–15 cm) samples were collected from college Agriculture farm, Nedharia Ballia (U.P.) when no crop was standing in field and no rainfall occurred during the prior 48 hrs. Collected soil was air dried in shade, powdered and made free from the plant, gravels and stones etc before the pot feeling. Collected soil sample were initially analyses for the Bulk density (Mg m^{-3}) -1.33, pH- 7.00, EC (dS/m)- 0.99, organic carbon (%)-0.23, available N (kg/ha)- 313.6, available P (kg/ha)-4.221, available K (kg/ha)-202.8, available S (mg/kg)- 2.35 adopted standard method described by Tandon (2005); Jackson (1973) and Singh *et al.* (2005) and Piper (1966). Each pot had 1.0 kg of well processed soil and after incorporation of treatment moisture were maintained 60 per cent. Observation were recorded as- soil pH, EC, bulk density, organic carbon, available N, P, K, S at 7, 14, 21, 28, 35, and 42 days after treatments. The treatment details as-T_1-Control, T_2-pigeon pea @30t/ha, T_3-pigeon pea @60t/ha, T_4-lentil @30t/ha, T_5-lentil@60t/ha, T_6-pea @30t/ha, T_7-pea@60t/ha**.** The soil sample collected from the incubation study in laboratory drawn at 7, 14, 21, 28, 35 and 42 DAT. Soil sample were of each pot and processed for estimation of physic, chemical properties adopted following method. Soil p^H was determined with glass electrode Beckman's p^H meter in 1:2.5 ratio of soil: water suspension method described by Kanwar and Chopra (1998), soil electrical conductivity (dSm^{-1}) of the supernatant liquid of the 1:2.5 ratio of soil - water suspension was determined with conductivity meter method described by Kanwar and Chopra (1998). Organic carbon was determined by Walkley's and Black's (1934) rapid titration method as described by Kanwar and Chopra (1998), available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus by using Olsen's *et al.* (1954) and coloure was developed by ascorbic acid method, available potassium by ammonium acetate method described by Muhr *et al*. (1965), available sulpher was determined by soil extraction by 0.15% $CaCl_2$ H_2O solution and turbidity method of Williams and Steinberg (1969) described by Chhonkar *et al.* (2005). The statistical analysis on the data was done by method described by Gomez and Gomez (1984) using randomized block design and significance of the treatment mean were made with the help of critical difference calculated. The experiment in earthen pots was conducted adopting rangomized block design with three replication of 07 treatment combination in alluvial soil (Inceptisols).

Results and discussion-

Bulk density (Mg m^{-3})

The bulk density of soil was estimated by the stage wise soil for all six (7, 14, 21, 28, 35 & 42 days) incubation stage (table-1). It was found to decreased (1.18 Mgm^{-3}) in all stage of with treatment combination of legume residues significantly. Although, application of legume residues at higher doses viz. @ 30 and 60 ha^{-1} were increased than the treatment combination with pigeon pea, Lentil and pea, (1.22 mg^3), (1.26 mg^3), 1.28 mg^3) also at stage 1^{st} (7 days). At 14, 21, 28, 35 and 42 days, bulk density in the treatment combination with different legume residues were observed similar to the control value. While doses of legume residues showed significantly increased bulk density of soil. In fact decrease in bulk density of soil in the treatment combination of pigeon pea, Lentil, and pea due to increase organic carbon in surface soil (Chuman and Sur, 2006) lower doses of legume residues application were increased the bulk density might be due to addition of minerals in the surface soil. Benbi *et al.* (1998) reported a significant decrease in the surface layer bulk density on the manured field and high rate resulted the decreased in bulk density of the soil.

Table-1.Effect of different legumes residues on change in Bulk density (Mg m^{-3}) of soil

Treatment Combination		Days of incubation					
		7 days	14 days	21 days	28 days	35 days	42 days
T_1	Control	1.32	1.33	1.32	1.34	1.33	1.32
T_2	Pigeon pea@30t/ha	1.22	1.32	1.26	1.25	1.26	1.25
T_3	Pigeon pea@60t/ha	1.30	1.25	1.30	1.24	1.22	1.25
T_4	Lentil@30t/ha	1.26	1.36	1.31	1.33	1.28	1.33
T_5	lentil@60t/ha	1.31	1.33	1.28	1.30	1.27	1.33
T_6	pea@30t/ha	1.28	1.30	1.33	1.27	1.33	131
T_7	pea@60t/ha	1.26	1.32	1.19	1.30	132	130
	CD(P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Soil pH -The effect of different legumes straw on soil p^H (table-2) was ranged from 7.00 pH value with Lentil application to 7.52 by the application of @ 60t ha^{-1}, lentil residues at 7, 14, 21, 28, 35 and 42 pH value of all treatment combination were significantly gradual decreased except application of pigeon pea, lentil and pea @ 30 and @ 60 t ha^{-1} over the control and legume residues. After treatments with legume residues soil pH decreased from its initial value particularly pigeon pea, lentil and pea were added, significant decreased in pH value. Though, pH tended to decrease in the legume residues T_1, T_2, T_3, T_4, T_5, T_6 and T_7 were attributed to increase in partial pressure of CO_2 and production of organic acids due to legume residues decomposition (Chuman and Sur, 2006). The application (T_5 and T_6) or conjunctive use of crop residue with Lentil and pea helped in pH activity. The applications of higher dose of lentil alone were found to increase the pH value might be due to initial pH value of lentil. So the results suggested that, rapid change in soil pH in legume residues and plant materials applied pots were related to the concentration of excess cations and decomposition of the materials and the application of crop residues cause of acidification and slow down the soil pH (Tang *et al.,* 1999).

Table-2. Effect of different legumes residues on change in soil pH and EC (dS^{m-1})

Treatment combination		Days of incubation											
		7 days		14 days		21 days		28 days		35 days		42 days	
		pH	EC	pH	EC	pH		pH		pH		pH	EC
T_1	Control	7.0	0.98	7.0	0.99	7.1	0.99	7.0	0.98	7.2	0.95	7.1	0.96
T_2	Pigeon @30t/ha	7.3	0.99	7.4	1.00	7.7	1.00	7.7	0.99	7.8	0.99	7.4	1.00
T_3	Pigeonpea@60t /ha	7.4	1.00	7.3	1.02	7.8	1.02	7.5	1.02	7.2	1.00	7.5	0.99
T_4	Lentil@30t/ha	7.2	0.99	7.1	1.02	7.4	0.99	7.5	1.01	7.5	0.99	7.8	1.00
T_5	lentil@60t/ha	7.5	0.99	7.2	0.99	7.5	1.00	7.7	1.00	7.3	1.00	7.8	1.00
T_6	pea@30t/ha	7.3	1.00	7.0	1.00	7.3	1.00	7.3	1.00	7.8	1.02	7.4	1.01
T_7	pea@60t/ha	7.3	1.00	7.3	1.00	7.8	1.00	7.5	1.00	7.8	1.00	7.8	1.02
	CD(P=0.05)	0.12	N.S.	0.06	N.S.	0.1	N.S.	N.S	N.S.	0.9	N.S.	0.1	N.S.

Electrical Conductivity of soil (EC)(dSm^{-1})

The electrical conductivity values (table-2) revealed that there was no marked difference was found among the treatment combination of legume residues with pigeon pea, Lentil, and pea. EC of soil under study were ranged from 0.99 to 1.02 dsm^{-1} indicated among the six stage of experiment. Although a slight declined value of EC was observed in among the treatments at all the stage at 7, 14, 21, 28, 35 and 42 days. The higher EC value was noticed in treatment of application pea residues with high dose might be due to addition of Na and other salts which has already contained by legume residues (Alamgir *et al.*, 2012, Lynch *et al.,* 2016).

Organic carbon (%)

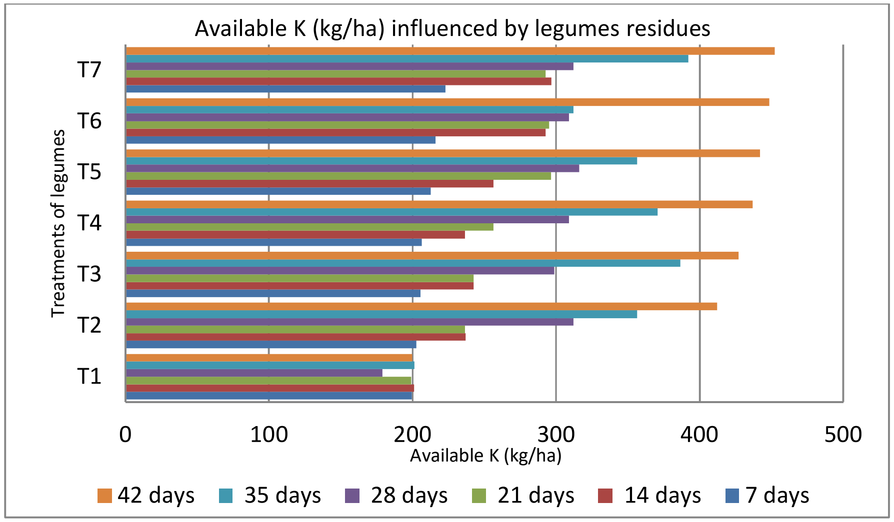
Organic carbon value (table 4) at 7, 14, 21, 28, 35, and 42 days under the effects of different legume residues in alluvial soil. The organic carbon content increased substantially due to legume residues either alone in combination with different organic control. Organic carbon content was significantly higher organic carbon content, but legume residues treatment did not show any beneficial effect on organic carbon enrichment. However, in combination with higher does improved the organic carbon content of the soil, then control. Oxidizable soil organic carbon content was maximum in residues (pea) treatment (0.40%) was significantly more then all other treatments. The additive effects of pea in maintaining higher organic carbon level might be due to its less rapid decomposition under the prevalent wet temperate condition. The increase in soil organic carbon content with pea system has also been reported previously. Organic carbon content was low (T1, T2, T3, T4) at all statges initially and decreased further in different treatments, except in which (T5) received pea recommended dose of lentil. Kumar *et al.* (2011) reported that the application of organic materials in soil, organic carbon is significantly higher in plor received 100% NP over the one-year, receiving only 100% No or control plot continuous application of organic manure along or in combination with inorganic fertilizer enriched the soil with total organic carbon. In fact increasing dose of legume residues observed gradual increase the organic carbon content in soil might be legume residues contained very small quantity. crop residue to the soil favorable effect on pH and important role in soil fertility and cycling of elements in the soil may have in addition to the role of the organic matter

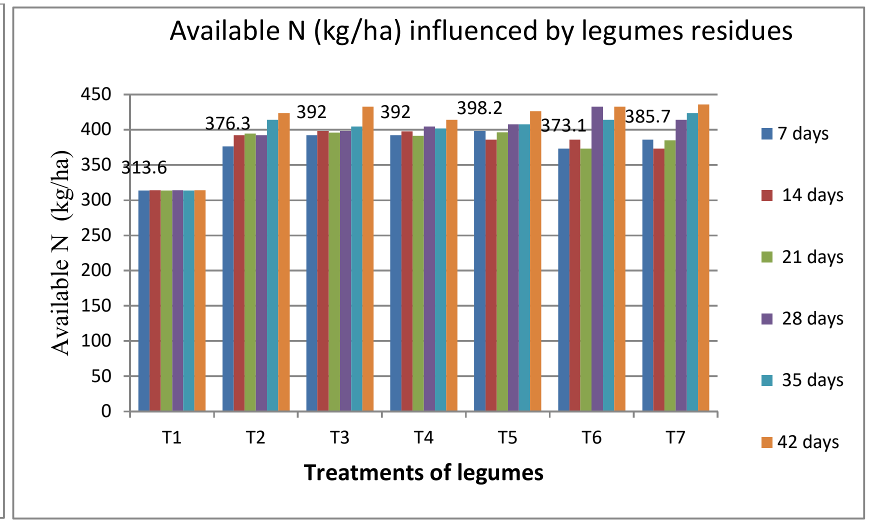
Table -4. Effect of different legumes residues on change in soil organic carbon

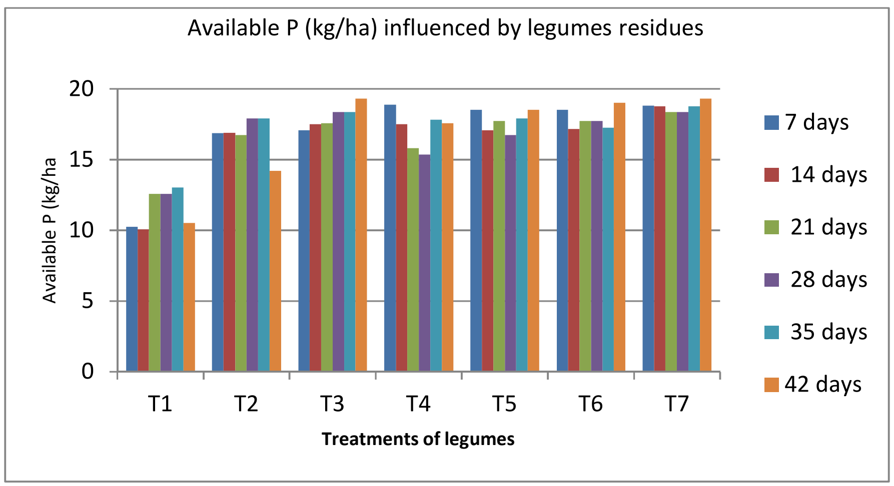
Treatment Combination		Days of incubation					
		7 days	14 days	21 days	28 days	35 days	42 days
T_1	Control	0.22	0.23	0.25	0.24	0.23	0.23
T_2	Pigeon pea@30t/ha	0.25	0.25	0.30	0.32	0.32	0.77
T_3	Pigeon pea@60t/ha	0.34	0.37	0.37	0.37	0.38	0.38
T_4	Lentil@30t/ha	0.33	0.34	0.35	0.35	0.37	0.39
T_5	Lentil@60t/ha	0.35	0.34	0.35	0.35	0.38	0.40
T_6	Pea@30t/ha	0.35	0.39	0.34	0.37	0.33	0.35
T_7	Pea@60t/ha	0.37	0.34	0.37	0.38	0.38	0.40
	CD(P=0.05)	0.09	N.S.	N.S.	0.04	0.03	0.03

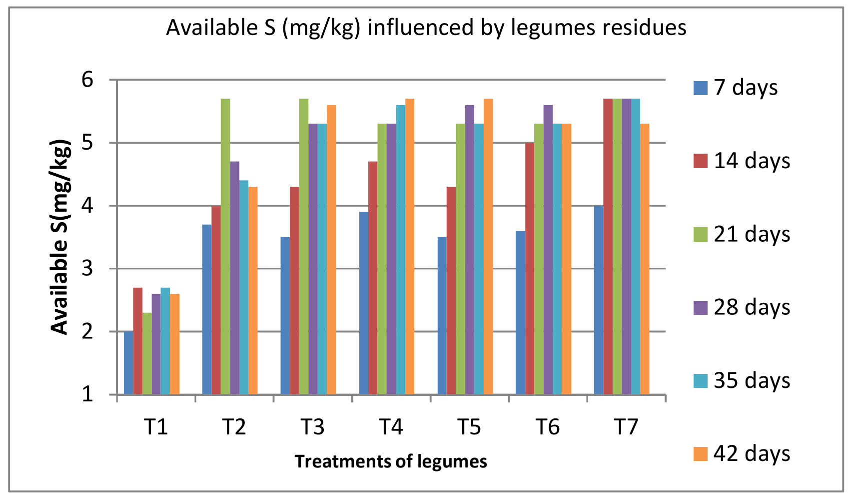
Available nitrogen (kg ha^{-1})

The data (fig-2) revealed that available nitrogen content in soil of all treatments were found in gradual increased along with stage of experimental up to 42 days from 313.6 to 435.90 kg ha^{-1} throughout the experiment stage. However, available N content was found maximum in T_7 of 460 kg ha^{-1} at 42 days than crop residue incorporated enhanced.


Available K (kg/ha) influenced by legumes residues
Treatments of legumes
T7
T6
T5
T4
T3
T2
T1
0
100
200
300
400
500
Available K (kg/ha)
42 days
35 days
28 days
21 days
14 days
7 days


Available N (kg/ha) influenced by legumes residues
Available N (kg/ha)
450
400
350
300
250
200
150
100
50
0
313.6
376.3
392
392
398.2
373.1
385.7
T1
T2
T3
T4
T5
T6
T7
Treatments of legumes
7 days
14 days
21 days
28 days
35 days
42 days


Available P (kg/ha) influenced by legumes residues
Available P (kg/ha
20
15
10
5
0
T1
T2
T3
T4
T5
T6
T7
Treatments of legumes
7 days
14 days
21 days
28 days
35 days
42 days


Available S (mg/kg) influenced by legumes residues
Available S(mg/kg)
6
5
4
3
2
1
T1
T2
T3
T4
T5
T6
T7
Treatments of legumes
7 days
14 days
21 days
28 days
35 days
42 days

Content was maximum at 6th stage 423 and 432.76 kg ha^{-1} while control pot was showed lowest (313.6, 313.8, 313.6, 313.7 and 313.9 kg ha^{-1} respectively). After 1st stage of experiment increase the available nitrogen with legume residues might be due to direct incorporation of nitrogen through manure and the residue of legume to the available pool of the soil at 7 days, T_1 was showed available N ranged from 313.6 to 313.9 kg ha^{-1} at stage two to stage five T_3 was showed similar trand of decreasing 392.00 kg ha^{-1} (stage-1) to 432.768 (stage-III) and at 14 Days, 28 Days and stage Vth (35 Days) was not much more decreased. Favorable soil conditions under legume residues might have helped the mineralization of soil N leading to build-up of higher available N (Dalia, 2015). The available nitrogen content was not increased by the application of high dose of legume residues due to low initial value in respect of nitrogen mineralization. Although, pigeon pea, lentil, pea were found to increase greater available N might be due to mineralization and there where Legume residues act as activator of catalyst to enhance the transformation process and C/N ratio (Fosu, *et al.* 2007).

Available phosphorus (kgha^{-1})

Available phosphorus content (Fig.3) was observed on 7.14, 21, 28, 35 and 42 days of experiment with different legume residues. Among the treatment combination of pigeon pea, lentil and pea were showed small variation in amount of available phosphorus in all stages. A gradual increase was found from 7 days to 14 days, 21 day, 28 days, 35 days, 42 days showed greater amount (19.32 kg ha^{-1}) in T_1 and it was decreased of 10.26 kg ha^{-1}. Available P content was increased by 16.72 (T_2) to 18.51 (T_4) times over initial level with continuous use of legume residues at 42 days. Increase in available P was observed with legume residues (lentil) application (T_4) and decrease when (T_6 and T_7) over the control. At 21 days and 28 days stages in pigeon pea enhanced availability of soil available P was found in T_4, T_5, T_6 and T_7 over the control at all the stage of experiment might be initial value of lentil and pea. It has might be production of organic acids during microbial decomposition of the pigeon pea, lentil and pea in soil and decrease in soil pH (Abera *et al.,* 2014). Increased in the available P might be attributed to the decomposition of organic matter accompanied by the release of abundant quantities of CO_2. It has been notched that in calcareous soils; CO_2 production plays a dominant role in enhancing the phosphate availability. Organic matter forms a protective cover on sequioxides and this facilitates reduction in the phosphate fixing capacity of soil. A larger build up in available P with pigeon pea and Lentil might be attributed to the influence of organic acid in increasing the P in soil through application of cations like Ca^{2+} and Mg^{2+} which are mainly responsible for the fixation of phosphorus in calcareous soil (Yaspal *el al.* 1993) available phosphorus in soil then alone gradual increase doses of legume residues.

Available Potassium (kg ha^{-1})

Available potassium content (fig.1) in deferent treatment combination of legume residues with and without organic materials at 7, 14, 28, 35, 42 days experiment stages. Available potassium was decreased with increasing stage from 1st stage (7 days) in all treatment combination the maximum (452.26 kg ha^{-1}) release was mearured at 1st stage with incorporation of @60 t ha^{-1} pigeon pea lentil (T_7) then T_6 and over the incorporation with @30 t ha^{-1} pea. Similarly at all stages of experiment, greater amount of available potassium was found in alone application of high dose pea treatment than lentil incorporated (T_3) was found greater release at all stage of experiment addition of pea in to the soil increased the available K status and hence its availability. A positive effect of legume residues addition on potassium content of soil was also reported by Lal *et.al.* (1996). Increase in available potassium due to pigeon pea, lentil, pea be attributed to the direct addition of potassium to the available pool of the soil. Beneficial effect of legume residues manuring on available potassium might be attributed to the reduction of fixation and release of K due to interaction of organic matter with clay besides the direct K addition to the available K pool of the soil. The beneficial enhancement of available potassium might be addition and release of potassium due to organic acid interaction then other organic materials. In spite of initial value of exchangeable potassium in legume residues might be attributed to increase in soil also.

Available sulphur (mg/kg)

The available sulphur content (fig.4) was gradual increased with stage of experiment in all treatment combination. At 1st stage (7 days) of experiment, alone application of higher (T_7) dose pea showed significantly high value (5.756 mg/kg) than T_6 and T_1. The similar pattern was observed at all stages of experiment. A greater amount of available S was found in stage third and at par value at stage 6th. The continuous release of greater extant of available sulphur by the application of pigeon pea residues in soil then Lentil and pea might be due to prolong the phosphate solubilization use of organic manure and sulphur containing fertilizer have led to low sulphur content in these stage. Several soil factors influence the availability of sulphur and hence the status of different froms of sulphur in soil varied widely with soil type. Infact application of legume residues (pea) @30 t ha^{-1} with lentil considerable increased the available sulphur in soil.

Conclusion

Incorporation of legumes residues were ranging from T_7 to T_1 indicated not much more significant difference among the treatment of experiment for EC but found to decrease soil pH. Organic carbon content was significantly increase in pigeon pea, lentil and pea @ 30 t/ha & @60 t/ha treatment than all other treatments. The legume residues and materials were indicated greater available N in T_6 at 42 days and increase the available nitrogen with pigeon pea lentil and pea treatment might be due to direct incorporation of nitrogen through pea @ 30 t/ha but highly effective was found @60 t/ha to the available N pool of the soil. The treatment combination of legume residues materials showed small variation in amount of available phosphorus in all stage with gradual increase. The greater available K content was noticed in the maximum at 42 days with incorporation of pea T_7 (@60 t/ha) but the gradual pattern was observed in sequence as legume residues (pigeon pea, lentil and pea) over the control.The available sulphur content was found gradual increased from 7th days of experiment. Application of high does of pea T7 showed significantly increase high value of available S than T_1 and T_3. Legume residues as appeared to in soil properties to greater extent. So, legume residues as pigeon pea, lentil and pea were showed as elastic change in the chemical properties of soil due to addition of observed and their chemical reaction. Soil responsible cause for legume residues might be supply of oxygen. Among the legume residues sources the application of 60 t/ha and their other lower does were found suitable to the physical and chemical properties of soil. The Legume residues (pigeon pea, Lentil and pea) treatment combination @60 t/ha were also considerable.

Acknowledgement- Authors are thankful to Dr. B.R. Maurya, Professor and Head, Dr. S.K. Singh, Professor, Dr. P.K. Sharma, Dr. Y.V. Singh, Department of Soil Science and Agriculture Chemistry, I.Ag. Sci., B. H. U., Varanasi for providing facilities of micronutrients analyses during the course of investigation.

References

1. Abera, G.; Meskel, E.W. and Bakken, L.R. (2014), unexpected high decomposition of legume residues in dry season soil from tropical coffee plantations and crop lands. Agronomy for Sustainable Development, 667-676.
2. Alamgir, Md. Ann mcniill caixician Tang and Petra Marschner (2012). Change in soil P pools during legume residues decomposition. *Soil Biolog and Biochemistry*. 3, 236-242.
3. Benbi, D.K; Bawa, S.S. and Kumar, K. (1998).Influence of farm yard manure, inorganic fertilizers and weed control, practices on some soil physical properties in a long-term experiment. *Soil Use and Management,* 14: 52-54.
4. Chandra, R. (2011). Effect of summer crop and their residues management on yield of succeeding wheat and soil properties. *Journal of the Society of Soil Science*, 59(1):37-42.
5. Chuman, B.S. and Sur, H.S. (2006). Effect of manuring on soil properties and yield of rain fed wheat. *Journal of the Indian Society of Soil Science*, 54(1): 6-11.
6. Dalias, P. (2015). Grain legume effects on soil nitrogen mineralization potential and wheat productivity in a Mediterranean environment. *A Review of Agrongmy and Soil Science*, 461-473.
7. Fosu, M. Ronald, Paul, L.G. and Velk S. (2007). Mineralization and microbial biomass dynamics during decomposition of four leguminous residues. *Journal of Biological Science,* 7 (4): 632-637
8. Gomez, K. A. and Gomez A.A. (1984). Statistical Methods for Agriculture Research (II End), Pub. by Wiley and Sons, New York.
9. Jackson, M.L. (1973). Soil Chemical Analysis, *Prentice Hall of India Pvt. Ltd.,* New Delhi.
10. Kanwar, J.S. and Chopra, S.L.(1998). Analytical Agricultural Chemistry (Ed.), Kalyani Publication, New Delhi

11. Kumar, K. and K., Goh (1999). Crop residues and management practice effect on soil quality, soil nitrogen dynamic crop yield and nitrogen recovery. *Advances in Agronomy* 68: 197-319.
12. Lal, J.K., Mishra, B. and Sarkar, D. (1996). Effect of earthworm on soil microbiology and enzymatic activity. *Journal of Indian Society of Soil Science* 42: 77-80.
13. Lynch, M.J., M.J. Mulvaney, S.C. Hodges, T.L. Thompson and W.E. Thomason (2016). Decomposit ion nitrogen and carbon mineralization from food and cover crop residues in the central plateau of Haiti, Sprinerplus 5 (1): 973.
14. Piper, C.S. (1966) Soil and Plant Analysis. Inter. Science Publisher, New York.
15. Sakala, D.; Georg C. and Ken G. (2004). Interactions between residues of maize and pigeon pea and mineral N- mineralization. *Soil Biology and Biochemistry*, 32 (5): 679-688.
16. Singh, Dhyan; Chhonkar, P.K. and Dwedi, B.S. (2005). Manual for Analysis of Soil, Water and Plant (Ed.), West Willie and Sons Publication, New Delhi.
17. Tandon, H.L.S. (2005). Methods of Analysis of Soil, Water, Plant, Manure and Fertilizers (Ed.), Fertilizers Development and Consultation Organization, New Delhi.
18. Tang, C. and Yu, Q. (1991). Impact of chemical composition of legume residues and initial soil pH on pH change of a soil after residue incorporation. *Plant and Soil*, 215, 29-38.
19. Tang, C.S.; Parling, G.P.; Mclay, C.D.A. and Raphail, C. (1999). Effect of short term legume residual decomposition on soil acidity. Aust. J. Soil Res., 37: 561-573.
20. Yan, F.; Schubert, S. and Mengel, K. (1996). Soil pH increase due to biological de carboxylation of organic anions. *Soil Biology and Biochemistry*, 28 617-624.
21. Yashpal, V.; Gaur, A.C. and Milap Chand (1993). Available soil phosphorus in relation to sesbania green manure incorporation in calcareous soils. *Journal of the Indian Society of Soil Science,* 41: 47-50.

Received on 16.05.2016 and accepted on 30.05.2016