***Original Research Article***

**Effect of *In-Situ* Moisture Conservation Practices and Nitrogen Levels on Post-Harvest Soil Nutrient Status in Maize and Pigeonpea under Rainfed Alfisols**

**ABSTRACT**

**Aim:** To study the impact of *in-situ* moisture conservation practices and nitrogen levels on post-harvest soil nutrient status in maize and pigeonpea under rainfed Alfisols

**Study design:** Double split plot design

**Place and Duration of Study:** Gunegal Research Farm (GRF), ICAR- Central Research Institute on Dryland Agriculture, Hyderabad during *kharif* season of 2022-23 and 2023-24

**Methodology:** A replicated trial was conducted in double split plot design with four *in-situ* moisture conservation practices (flatbed sowing, flatbed with CF, raised bed with CF and paired row with CF) in main plots, two crops (maize and pigeonpea) in subplots and four nitrogen levels (control, 75 % RDN, 100 % RDN and 125 % RDN) in sub-sub plots. The physico-chemical properties of soil *viz.,* pH, EC, OC available nitrogen, phosphorus and potassium were analyzed by different methods as per standard procedures.

**Results:** The results revealed that the flatbed with CF has shown highest soil available nitrogen, phosphorus and potassium than flatbed sowing and it was at par with raised bed with CF and paired row with CF. Among different crops pigeonpea recorded higher available nutrients as compared to maize. Among the nitrogen levels, 125 % RDN application recorded higher soil available nutrients than 100 % RDN, 75 % RDN and control.

**Conclusion:** Pigeonpea with moisture conservation practices (flatbed with CF, raised bed with CF and paired row with CF) along with 125 % RDN application improves the soil chemical properties under rainfed conditions.

***Keywords:*** *In-situ moisture conservation practices, maize, nitrogen levels, pigeonpea, post*

 *harvest soil nutrients*

**INTRODUCTION**

“Rainfed agriculture constitutes 80 % of global agriculture, and plays a critical role in achieving global food security. In India, Alfisols covers an area of 42 M ha, and rainfed region have major area of Alfisols” (Bhattacharyya *et al.,* 2013). Rainfed crops in Alfisols are always susceptible to deficient soil moisture conditions due to its poor water retention characteristics with very low infiltration rate (Pathak *et al.,* 2013). “Besides moisture deficiency rainfed soils are also characterized by nutrient deficiency. Indian soils are mostly deficient in terms of nitrogen. Nitrogen is the most yield restraining nutrient in crop production at global level. In addition to this the nitrogen use efficiency is low especially in rainfed conditions” (Guo *et al.,* 2016) due to moisture deficiency. Both nutrient and moisture deficiency reduces crop productivity. To reduce the impact of moisture deficiency conservation of the excess rainfall within the field through *in-situ* moisture conservation practices are need of the hour. Therefore *in-situ* moisture conservation practices in combination with appropriate nutrient management strategies play a major role for improving the input use efficiency and crop production under rainfed farming.

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Maize is highly responsive to nitrogen application and productivity increases with appropriate moisture conservation and nitrogen management practices under rainfed farming. Pigeonpea (*Cajanus cajan* L.) is the second most important pulse crop next to chickpea in India. Since, it has deep rooted system it is tolerant to drought and suitable for dryland farming. Its ability to produce economic yield under limited moisture condition makes it as crop of dryland agriculture. But the productivity of pigeonpea is low under rainfed conditions due to moisture stress at critical growth stages. The yield gap can be reduced only through efficient water and nutrient management practices. The nutrient removal by the crops impacts the fertility status of the soil. Maize is a nutrient exhaustive crop and nutrient mining by intensively grown nutrients exhaustive crops are the major threats to sustainable production. Post-harvest soil nutrient analysis is useful for assessment of soil nutrient status. Keeping this in view, the above investigation was carried out with an objective to study the impact of *in-situ* moisture conservation practices and nitrogen levels on post-harvest nutrient status in maize and pigeonpea under rainfed Alfisols”

**MATERIAL AND METHODS**

The field experiment was carried out during two consecutive years 2022-23 and 2023-24 at Gunegal, Research farm, Central Research Institute for Dryland Agriculture, Santhoshnagar, Hyderabad. The rainfall received from July to December during 2022 and 2023 was 799.5 mm in 46 rainy days and 440.7 mm in 25 rainy days respectively. The soil of the experimental field was sandy loam in texture and slightly acidic in reaction with pH of 6.4 and EC of 0.13 dSm-1. The N, P2O5 and K2O and organic carbon content of soil was, low (144.65 kg ha-1), medium (28.54 kg ha-1) and medium (236.53 kg ha-1) and medium (0.64 %), respectively.Experiment was laid out in double split plot design with the *in-situ* moisture conservation practices as main plots *viz.,* flat bed sowing (I1), flatbed with conservation furrow (CF) (I2), raised bed with conservation furrow (CF) (I3) and paired rows with conservation furrow (CF) (I4), crops *viz.,* maize (C1) and pigeonpea (C2) in sub plots and nutrient management practices *viz.,* Control (without fertilizer) (N1), 75 % RDN (N2), 100 % RDN (N3) and 125 % RDN (N4) in sub-sub plots. The maize hybrid used for the investigation was DHM-117 and pigeonpea variety was WRGE-97. Recommended dose of P2O5 and K2O of 100:60:60 kg ha-1 and nitrogen for maize were applied as per the treatments in the form of Urea, DAP and MOP respectively. Entire dose of phosphorus and potassium and 1/3rd dose of nitrogen was applied as basal and remaining 2/3rd dose of nitrogen was as top dressed in two equal splits. All the recommended agronomic practices were followed and appropriate weed, pest and disease management options were followed.

Soil samples were collected at 0-15 and 15-30 cm depth from each treatment after harvest of crops. Samples were shade dried and passed through 2 mm sieve and used for the soil chemical analysis. The physico-chemical (pH, EC and OC) and chemical properties of soil *viz.,* available nitrogen, phosphorus and potassium were analyzed by different methods as per standard procedures. Soil reaction was determined in 1:2.5 soil water suspension using combined Glass electrode method (Jackson, 1973).The EC was determined in 1:2.5 soil water suspension using digital electrical conductivity meter as described by Jackson (1973) and was expressed as dSm-1. Organic carbon content in the soil was determined by Walkley and Black’s modified method (Walkley and Black, 1934) and expressed in percentage. Available nitrogen in the soil was estimated by Foss N automatic analyzer (Foss Nitrogen). 5 g soil was taken in the Kjeldhal flask, 10 ml of 0.32 % alkaline KMNO4 and 2.5 % NaOH were added and the contents were distilled. The liberated ammonia was absorbed in boric acid and mixed indicator solution. Soil nitrogen was estimated by titrating the above sample mixture against standard 0.01 N H2SO4 till the bluish green color changed to original pink color and available N was expressed in kg ha-1.Available phosphorus in the soil was extracted by extracting the soil with Olsen’s extractant (0.5 N NaHCO3 with pH 8.5). The phosphorus content in the extract was determined by L-ascorbic acid method (Olsen *et al.,* 1954). The intensity of colour was measured with spectrophotometer at 420 nm and was expressed in kg ha-1.Available potassium in the soil was estimated by neutral normal ammonium acetate method (Jackson, 1973) and presented in kg ha-1. Soil analysis was done after harvest of crops after second year of study and the data after second of year of the experiment was represented here.Statistical analysis for all parameters was carried out with the help ofSAS software 9.2. ANOVA was computed and mean difference was made using least significant difference (LSD) at P≤0.05 level of significance.

**RESULTS AND DISCUSSION**

**Impact of *In-Situ* Moisture Conservation Practices on Post Harvest Soil Nutrient Status**

*In-situ* moisture conservation practices could not exert any significant influence on pH, EC and OC after harvest of crops during second year of the experiment. The available nitrogen, phosphorus and potassium were significantly influenced by different *in-situ*moisture conservation practices at 0-15 cm depth only while it was non significant at 15-30 cm depth of soil.

“Among the *in-situ* moisture conservation practices, the higher available nitrogen, phosphorus and potassium in the soil after harvest of maize and pigeonpea were recorded in flatbed with CF which was on par with raised bed with CF and paired row with CF. This might be due to that *in-situ* moisture conservation practices had higher crop growth and root biomass. The increase in root biomass led to higher soil microbial activity, this in turn helped to increase mineralization and increased soil available nutrient status. Lower soil available nitrogen, phosphorus and potassium after harvest was recorded in flatbed sowing” (Yadav *et al.,* 2023 and Gaurav *et al.,* 2018) in maize and Singh *et al.* (2018) recorded in pigeonpea.

**Impact of Crops on Post Harvest Soil Nutrient Status**

The crops did not significantly influence the soil pH, EC and OC after harvest of crop. The soil available nitrogen, phosphorus and potassium at 0-15 cm depth and available nitrogen at 15-30 cm depth were significantly influenced by the crops, while soil available phosphorus and potassium at 15-30 cm depth were non significant. Among the crops, pigeonpea recorded significantly higher soil available nitrogen, phosphorus and potassium after harvest compared to maize after second year. Pigeonpea recorded 4.2, 9.2 and 5.1 % higher available nitrogen, phosphorus and potassium over maize respectively at 0-15 cm soil depth. The higher soil available nitrogen, phosphorus and potassium is because pigeonpea being a legume crop fixes atmospheric N2 fixation,besides N2 fixationthere is a large quantity of addition of pigeonpea leaf fall which is left in the field after harvest. This might have increased soil nutrient status. These results are in line with the findings of Mugi-Ngenga *et al.* (2021).

**Impact of Nitrogen Levels on Post Harvest Soil Nutrient Status**

Nitrogen levels did not exert any significant influence on the soil pH, EC and OC after harvest of crops. The post harvest soil available nitrogen, phosphorus and potassium was significantly influenced by nitrogen levels at 0-15 cm, while it was non significant at 15-30 cm soil depth aftersecond year of the study.Nitrogen levels in pigeonpea significantly influenced the soil available nitrogen, phosphorus and potassium after harvest of crops aftersecond year of the experiment. Among the nitrogen levels, significantly higher soil available nitrogen, phosphorus and potassium in the soil after harvest was recorded with application of 125 % RDN and it was significantly superior over 100 % RDN application. This might be due to considerable quantities of nitrogen left over in the field due to increased N addition and the easy availability of nitrogen for the crop might have helped in enhanced absorption of phosphorous and potassium. These results were in accordance with the findings of Kumar and Thomas (2022), Ganapathi *et al.* (2018). Significantly lower soil available nutrient status was recorded in control. This might be due to subsequent removal of nutrients from soil by crop coupled with no external input addition respectively. The interaction effect between moisture conservation practices, crops and nitrogen levels on soil physico-chemical properties and post harvest soil available nitrogen, phosphorus and potassium at two soil depths i.e., 0-15 and 15-30 cm was non significant.

**CONCLUSIONS**

The moisture conservation practices in synergy with higher dose of nitrogen application improves the soil fertility and maintains the soil nutrient balance even after the substantiate amount of nutrient removal by crops. Overall pigeonpea with moisture conservation practices (flatbed with CF, raised bed with CF and paired row with CF) along with 125 % RDN application improves the soil chemical properties under rainfed conditions.

**Table 1. Soil pH, EC and organic carbon after harvest as influenced by*in-situ* moisture conservation practices, crops and**

 **nitrogen levels during 2023-24**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **pH** | **Electrical conductivity (dS m-1)** | **Organic carbon (%)** |
| **0-15 cm** | **15-30 cm** | **0-15 cm** | **15-30 cm** | **0-15 cm** | **15-30 cm** |
| ***In-situ* moisture conservation practices (I)** |
| I1: Flatbed | 6.21 | 6.32 | 0.09 | 0.11 | 0.63 | 0.58 |
| I2: Flatbed with CF | 6.17 | 6.19 | 0.11 | 0.13 | 0.63 | 0.58 |
| I3: Raised bed with CF | 6.24 | 6.25 | 0.09 | 0.13 | 0.63 | 0.59 |
| I4: Paired row with CF | 6.19 | 6.06 | 0.08 | 0.11 | 0.65 | 0.59 |
| SEm ± | 0.079 | 0.094 | 0.013 | 0.006 | 0.013 | 0.022 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| **Crops (C)** |
| C1: Maize | 6.24 | 6.13 | 0.08 | 0.12 | 0.63 | 0.58 |
| C2: Pigeonpea | 6.16 | 6.28 | 0.10 | 0.13 | 0.63 | 0.59 |
| SEm ± | 0.066 | 0.052 | 0.009 | 0.007 | 0.015 | 0.020 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| **Nitrogen levels (N)** |
| N1: Control | 6.19 | 6.05 | 0.11 | 0.12 | 0.62 | 0.61 |
| N2: 75 % RDN | 6.26 | 6.28 | 0.10 | 0.13 | 0.64 | 0.58 |
| N3: 100 % RDN | 6.22 | 6.26 | 0.09 | 0.12 | 0.64 | 0.57 |
| N4: 125 % RDN | 6.14 | 6.23 | 0.08 | 0.12 | 0.64 | 0.57 |
| SEm ± | 0.064 | 0.058 | 0.013 | 0.007 | 0.013 | 0.030 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| **Interaction** |
| ***In-situ* moisture conservation with Crops (I at C)** |
| SEm ± | 0.133 | 0.105 | 0.018 | 0.014 | 0.029 | 0.041 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| ***In-situ* moisture conservation with Nitrogen levels (I at N)** |
| SEm ± | 0.148 | 0.135 | 0.030 | 0.015 | 0.030 | 0.070 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| **Crops with Nitrogen levels (C at N)** |
| SEm ± | 0.090 | 0.083 | 0.018 | 0.009 | 0.018 | 0.043 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| ***In-situ* moisture conservation with x Crops x Nitrogen levels (I x C x N)** |
| SEm ± | 0.209 | 0.191 | 0.043 | 0.002 | 0.042 | 0.099 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |

**Table 2. Post harvest soil nutrient status as influenced by*in-situ* moisture conservation practices, crops and nitrogen levels**

 **during 2023-24**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Nitrogen (kg ha-1)** | **Phosphorus (kg ha-1)** | **Potassium (kg ha-1)** |
| **0-15 cm** | **15-30 cm** | **0-15 cm** | **15-30 cm** | **0-15 cm** | **15-30 cm** |
| ***In-situ* moisture conservation practices (I)** |
| I1: Flatbed | 144 | 148 | 22.29 | 20.60 | 195 | 213 |
| I2: Flatbed with CF | 175 | 153 | 29.51 | 23.07 | 245 | 216 |
| I3: Raised bed with CF | 170 | 150 | 29.30 | 20.35 | 237 | 212 |
| I4: Paired row with CF | 169 | 148 | 28.32 | 23.26 | 238 | 229 |
| SEm ± | 2.1 | 9.2 | 0.538 | 1.909 | 3.3 | 32.8 |
| CD (P = 0.05) | 7 | NS | 1.86 | NS | 12 | NS |
| **Crops (C)** |
| C1: Maize | 161 | 143 | 26.02 | 21.14 | 223 | 208 |
| C2: Pigeonpea | 168 | 157 | 28.68 | 22.50 | 235 | 227 |
| SEm ± | 1.6 | 4.1 | 0.429 | 0.909 | 3.4 | 11.0 |
| CD (P = 0.05) | 5 | 13 | 1.40 | NS | 11 | NS |
| **Nitrogen levels (N)** |
| N1: Control | 139 | 143 | 22.48 | 20.67 | 203 | 215 |
| N2: 75 % RDN | 158 | 149 | 25.74 | 22.28 | 219 | 218 |
| N3: 100 % RDN | 173 | 154 | 29.24 | 21.95 | 236 | 216 |
| N4: 125 % RDN | 188 | 153 | 31.96 | 22.38 | 257 | 221 |
| SEm ± | 2.3 | 6.4 | 0.977 | 1.523 | 5.9 | 10.8 |
| CD (P = 0.05) | 7 | NS | 2.78 | NS | 17 | NS |
| **Interaction** |
| ***In-situ* moisture conservation with Crops (I at C)** |
| SEm ± | 3.1 | 8.2 | 0.86 | 1.82 | 6.8 | 22.1 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| ***In-situ* moisture conservation with Nitrogen levels (I at N)** |
| SEm ± | 5.4 | 14.9 | 2.26 | 3.52 | 13.6 | 25.0 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| **Crops with Nitrogen levels (C at N)** |
| SEm ± | 3.3 | 9.1 | 1.38 | 2.15 | 8.3 | 15.3 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| ***In-situ* moisture conservation with x Crops x Nitrogen levels (I x C x N)** |
| SEm ± | 7.6 | 21.0 | 3.19 | 4.98 | 19.3 | 35.4 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |

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**REFERENCES**

Bhattacharyya, T., Pal, D.K., Mandal, C., Chandran, P., Ray, S.K., Sarkar, D., et al. 2013. Soils of India: historical perspective, classification and recent advances. *Current Science*. 104(10): 1308-1325.

Pathak, P., Sudi, R., Wani, S.P and Sahrawat, K.L. 2013. Hydrological behavior of Alfisols and Vertisols in the semi-arid zone: Implications for soil and water management. *Agricultural Water Management*. 118: 12-21.

Guo, C., Li, P., Lu, J., Ren, T., Cong, R and Li, X. 2016. Application of controlled release urea in rice reducing environmental risk while increasing grain yield and improving nitrogen use efficiency. *Communications in Soil Science and Plant Analysis*. 47: 1176-1183.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall India Private Limited, New Delhi. p:41.

Walkley, A and Black, C.A. 1934. Estimation of organic carbon by chromic acid titration method. *Soil Science.* 37: 29-38.

Olsen, S.R., Cole, C.L., Watanable, F.S and Dean, D.A. 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate.*United States Development Agency. 939.

Yadav, R., Goyal, V., Bhardwaj, K.K and Sangwan, O. 2023. Nutrient content and post-harvest soil fertility as influenced by methods of planting and nutrient management techniques in cotton based cropping system. *Journal of Cotton Research and development.* 37(1): 63-74.

Gaurav, Verma, S.K., Meena, R.S., Maurya, A.C and Kumar, S. 2018. Nutrients uptake and available nutrients status in soil as influenced by sowing methods and herbicides in kharif maize (*Zea mays* L.). *International Journal of Agriculture, Environment and Biotechnology.* 11(1): 17-24.

Singh, Y.P., Singh, S., Nanda, P and Singh, A.K. 2018. Impact of establishment techniques and maturity duration of pigeon pea cultivars on yield, water productivity and properties of soil. *Agricultural Research.* 7(3):271-279.

Mugi-Ngenga, L., Zingore, E., Bastiaans, S., Anten, N.P.R and Giller, K.E., 2021. Farm-scale assessment of maize–pigeonpea productivity in Northern Tanzania. *Nutrient Cycling in Agroecosystems.* 120: 177-191.

Kumar, B and Thomas, T. 2022. Effect of different levels of nitrogen and phosphorus on the growth and yield of maize (*Zea mays* L.) and on physico-chemical properties of post-harvest soil. *The Pharma Innovation Journal.* 11(1): 391-394.

Ganapathi, S., Bharathi, S., Rekha, M.S and Jayalalitha, K. 2018. Effect of nutrient management and moisture conservation practices on plant NPK content (%), plant uptake at harvest and post-harvest soil fertility under rainfed Bt. cotton. *Journal of Pharmacognosy and Phytochemistry*. 7(5): 2829-2832.