The Pharma Innovation Journal 2023; SP-12(10): 1218-1221

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(10): 1218-1221

www.thepharmajournal.com
Received: 01-08-2023
Accepted: 04-09-2023

Impact of nutrient management practices and soybean based cropping systems on soil fertility status

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Abstract
The field experiment was conducted during three seasons (*Kharif, Rabi* and *Summer*) in the two consecutive years 2021-22 to 2022-23 at Instructional Research Farm, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. The experiment was laid out in split plot design with 24 treatment combinations of six different nutrient management practices and 4 cropping systems. The allocation of various treatments to different plots was done randomly with three replications. Under main plot, NM_1 (100% organic), NM_2 (50% Organic NM + NF inputs Beejamrit + Ghanjeevamrit + Jeevamrit), NM_3 (50% Organic NM + 50% Inorganic NM), NM_4 (25% Organic NM + NF inputs Beejamrit + Ghanjeevamrit + Jeevamrit + 25% Inorganic NM), NM_5 (Farmer practices), NM_6 (100% Inorganic NM). CS_1 (Soybean-wheat), CS_2 (Soybean-berseem), CS_3 (Soybean-mustard-green gram), CS_4 (Soybean-lentil-sorghum) allotted under sub-plot. The result revealed that the Available nitrogen was maximum (272.25 kg ha^{-1}) under 100% nutrient management with soybean-mustard-wheat cropping system followed by INM (50% org + 50% inorg) i.e. (268.50 kg ha^{-1}), and 50% org + NF inputs (264.66 kg ha^{-1}). The phosphorus and potassium was maximum i.e. 13.48 kg ha^{-1} and 292.08 kg ha^{-1} under 100% organic nutrient management with soybean-berseem cropping system.

Keywords: Soybean based cropping systems, nutrient management, nitrogen, phosphorus and potassium

Introduction
Soybean based cropping systems are important for sustaining agricultural production and also maintain soil fertility with an ecological balance. This system also reduces the dependency on chemical fertilizers and help in monetary saving. Sustaining production and productivity of any system is of paramount importance by improving the soil physical, chemical and biological properties (Karunakaran and Bahera, 2017) [4]. Application of organic material along with inorganic fertilizers into the soils leads to increase in productivity of the cropping system enhance the use efficiency of fertilizer input and sustain the soil health for longer period (Jat *et al*., 2015) [3]. Organic manures are a potential source of micronutrients and improve soil structure by providing binding effect to soil aggregates, increase water holding capacity and improve buffering capacity of soils

Integrated nutrient management refers to the maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the benefit manner. The objective of Integrated nutrient management improves the available nutrient status of the soil with the incorporation of FYM alone or in combination with chemical fertilizer could be attributed to the slow decomposition of organic manure producing acids and enhancing soil biological activity. That is provide congenial soil physical conditions, conserve soil nitrogen and increase the availability of other nutrients. Besides, adoption of proper input-management technologies, diversification or intensification through crops of diverse nature may be a good proposition to break the monotony of the system (Tripathi and Singh 2008) [9]. Therefore, crop diversification is going to play major role for sustaining the productivity, while conserving the natural resources and utilizing them more efficiently in the long run.

Methods and Materials
The field experiment was conducted during three seasons (*Kharif, Rabi* and Summer) in the two consecutive years 2021-22 to 2022-23 at Instructional Research Farm, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India.

The experiment was laid out in split plot design with 24 treatment combinations of six different nutrient management practices and 4 cropping systems. The allocation of various treatments to different plots was done randomly with three replications. Nutrient management practices were taken as main plot and cropping system taken as sub plot. Main plot, NM_1 (100% organic), NM_2 (50% Organic NM + NF inputs), NM_3 (50% Organic NM + 50% Inorganic NM), NM_4 (25% Organic NM + NF inputs + 25% Inorganic NM), NM_5 (Farmer practices), NM_6 (100% Inorganic NM). Sub-plot CS_1 (Soybean-wheat), CS_2 (Soybean-berseem), CS_3 (Soybean-mustard-green gram), CS_4 (Soybean-lentil-sorghum). The physico-chemical properties of soil were estimated by the standard method.

Soil of the experimental field soil was sandy in texture, slightly alkaline in reaction (pH 7.28) with medium OC content (0.68%), high EC (0.381 dSm^{-1}) and analyzing low in available Nitrogen (258 kg ha^{-1} N), Medium in available Phosphorus (13.5 kg ha^{-1} P) and medium available potassium (284 kg ha^{-1}K) starting the present experiment during *Kharif* 2021 (Table 2). The status of soil slightly varied under different treatments (cropping system) over the initial status after harvest of the *Rabi* and *Summer* crops during 2022-2023.

Results and Discussion

Nitrogen

Due to application of different nutrient management practices and cropping systems the available soil nitrogen changes.

It was observed that maximum available soil nitrogen was found under 100% organic nutrient management (272.25 kg ha^{-1}) followed by INM (50% org + 50% inorg) i.e. (268.50 kg ha^{-1}), 50% org + NF inputs (264.66 kg ha^{-1}) and INM (25% org + 25% inorg) + NF inputs (262.91 kg ha^{-1}). This could be attributed to increased rate of mineralization of organic matter in the soil which was enhanced by the addition of organic manure (FYM) and hence caused a build-up of NH_4-N and NO_3-N in soil (Shilpashree *et. al*., 2012). Whereas the lowest build-up of available soil nitrogen was under farmer practices (251.66 kg ha^{-1}) respectively.

Concerning the effect of cropping sequence on available soil nitrogen, the soybean-mustard-green gram showed the higher value of available soil nitrogen (263.55 kg ha^{-1}) and no significant difference were found between soybean-berseem cropping system (263.88kg ha^{-1}) and soyean wheat cropping system (263.27kg ha^{-1}). The lower value of available soil nitrogen (263.11 kg ha^{-1}) was marked under soybean-lentil-sorghum (f) cropping system. Oelmann *et al.* (2007) [5] observed that presence of legumes correlated positively with soil NO_3-N concentrations because of atmospheric N_2 fixation, whereas fodder sorghum being a non-legume and exhaustive crop which depleted more N at harvest.

The interaction effect between different nutrient management and cropping systems was found to be significant. Soybean-mustard-green gram cropping system with the application of 100% organic nutrient management recorded the higher available nitrogen

Phosphorus

The effect of different nutrient management on available soil phosphorus showed significant variation but not affected by cropping systems.

It was revealed that the application of 100% organic nutrient management showed maximum (13.48 kg ha^{-1}) available soil phosphorus followed by 100% inorganic nutrient management (12.59 kg ha^{-1}) and INM (25% org + 25% inorg) + NF inputs i.e. (12.23 kg ha^{-1}). The addition of FYM increased P content and possibly by increasing retention of P in soil through release of various organic acid and CO_2 during process of decomposition of organic matter (Rajkhowa *et al*., 2003) [6]. And the lowest available soil phosphorus was observed under farmer practices (11.60 kg ha^{-1}) respectively.

On the other hand, the higher value of available soil phosphorus was found under soybean-berseem cropping system (12.38 kg ha^{-1}) which was statistically at par with soybean-mustard-green gram cropping system (12.32 kg ha^{-1}) and followed by soybean-wheat (12.30 kg ha^{-1}) cropping system. Singh *et al*., 2002 [8] reported that the inclusion of legume crop in the sequence increase the available phosphorus in the soil due to better physico-chemical properties and microbial population in soil which helped to solublized fixed P in soil. The soybean-lentil-sorghum cropping system had lowest value (12.28 kg ha^{-1}) of available soil phosphorus. It may be due to lower uptake of phosphorus by the crop.

The interaction effect between different nutrient management practices and cropping systems on bacterial population was found to be non-significant.

Potassium

The data revealed that the available potash was significantly affected by different nutrient management practices and soybean based cropping systems.

It was found that the value of available potash was maximum under 100% organic nutrient management (292.08 kg $ha^{-1)}$ which was followed by 50% organic + NF (290.50 kg $ha^{-1)}$,INM (25% 0rg + 25% inorg + NF inputs) (287.25 kg ha^{-1}), INM (50% org + 50% inorg) (285.91 kg ha^{-1}) and Inorganic nutrient management (283.66 kg ha^{-1}). The increase in available K under integrated treatments ascribed to more release of non-exchangeable K from the soils as FYM increased soil cation exchange capacity (Bhattacharyya *et al*., 2008; Blake *et al*., 1999) [1, 2] and also reduced fixation of K in soil. And the lowest value of available potash was observed in farmer practices (281.25 kg ha^{-1}), respectively.

The available potash was slightly changed with different soybean based cropping systems. The soybean-berseem cropping system showed the higher value of available potash (287.55 kg ha^{-1}) while there is no significant difference was found between soybean-mustard-green gram (287.05 kg ha^{-1}) and soybean-wheat (286.61 kg ha^{-1}) cropping system. Whereas the lowest value of potash (285.88 kg ha^{-1}) was registered under soybean-lentil-sorghum (f) cropping system. Gangwar and Ram (2005) [10] reported that the available potassium in the soil increased due to inclusion of leguminous crops in the sequence.

The interaction effect between different nutrient management and cropping systems found to be non-significant.

Table 1: Effect of nutrient management and cropping systems on nitrogen.

Nutrient management	Cropping systems (kg ha^{-1}) Initial status 260				
	CS1	CS2	CS3	CS4	Mean
100% org	272.66	272.33	273.00	271.00	272.25
50% org + NF inputs	265.00	264.33	265.00	264.33	264.66
INM (50% org + 50% inorg)	268.33	268.66	268.00	269.00	268.50
INM (25% org + 25% inorg) + NF inputs	262.66	263.33	263.66	262.00	262.91
Farmer practices	250.66	251.33	252.00	252.66	251.66
100% inorg	260.33	261.33	261.66	259.66	260.75
Mean	263.27	263.55	263.88	263.11	
				Interaction	
	Nutrient Management	Cropping System	Factor B at same level of A		Factor A at same level of B
SEm±	0.18	0.15	0.36		0.37
CD (p =0.05)	0.57	0.44	1.10		1.09

Where, CS1 is Soybean-wheat, CS2 is Soybean-berseem (F + S), CS3 is Soybean-mustard-green gram, CS4 is Soybean-lentil-sorghum (fodder)

Table 2: Effect of nutrient management and cropping systems on phosphorus.

Nutrient management	Cropping systems (kg ha^{-1}) Initial status 11.50				
	CS1	CS2	CS3	CS4	Mean
100% org	13.42	13.66	13.44	13.39	13.48
50% org + NF inputs	11.93	11.99	11.96	11.89	11.94
INM (50% org + 50% inorg)	12.09	12.11	12.10	12.05	12.09
INM (25% org + 25% inorg) + NF inputs	12.22	12.26	12.23	12.19	12.23
Farmer practices	11.58	11.61	11.61	11.59	11.60
100% inorg	12.59	12.63	12.61	12.55	12.59
Mean	12.30	12.38	12.32	12.28	
				Interaction	
	Nutrient Management	Cropping System	Factor B at same level of A		Factor A at same level of B
SEm±	0.03	0.02	0.04		0.05
CD (p =0.05)	0.10	0.08	N/S		N/S

Where, CS1 is Soybean-wheat, CS2 is Soybean-berseem (F + S), CS3 is Soybean-mustard-green gram, CS4 is Soybean-lentil-sorghum (fodder)

Table 3: Effect of nutrient management and cropping systems on potassium.

Nutrient management	Cropping systems (kg ha^{-1}) Initial status 282				
	CS1	CS2	CS3	CS4	Mean
100% org	291.66	292.66	292.33	291.66	292.08
50% org + NF inputs	289.33	291.66	290.66	290.33	290.50
INM (50% org + 50% inorg)	286.00	286.66	286.00	285.00	285.91
INM (25% org + 25% inorg) + NF inputs	287.33	288.33	287.66	285.66	287.25
Farmer practices	281.00	282.33	281.66	280.00	281.25
100% inorg	284.33	283.66	284.00	282.66	283.66
Mean	286.61	287.55	287.05	285.88	
				Interaction	
	Nutrient Management	Cropping System	Factor B at same level of A		Factor A at same level of B
SEm±	0.17	0.17	0.34		0.41
CD (p =0.05)	0.55	0.50	N/S		N/S

Where, CS1 is Soybean-wheat, CS2 is Soybean-berseem (F + S), CS3 is Soybean-mustard-green gram, CS4 is Soybean-lentil-sorghum (fodder)

Conclusion

Based on the results it can be concluded that the nutrient content of soil slightly changes from the initial status due to different nutrient management practices and cropping systems. The nitrogen was maximum (272.25 kg ha^{-1}) under 100% nutrient management with soybean-mustard-wheat cropping system. The phosphorus and potassium was maximum i.e. 13.48 kg ha^{-1} and 292.08 kg ha^{-1} under 100% organic nutrient management with soybean-berseem cropping system.

Acknowledgement

I would like to express my gratitude to Dr. P.B. Sharma Professor & Head, Department of Agronomy for guiding me during the entire research work.

Conflict of interest: None

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