Research Article

Effect of integrated nutrient management on soil physical properties using Soybean (Glycine max (L.) Merill) as indicator crop under temperate conditions

Aziz M.A[1], Tahmina Mushtaq[2], Mushtaq Ahmad[2], Eajaz Ahmad Dar[3]*, S S Mahdi[1], A M I Qureshi[1], and I A Jahangir[1]

[1]Mountain Research Centre for Field Crops, Khudwani, 192101
[2]Mountain Agriculture Research & Extension Station, Kargil-194103
[3]Krishi Vigyan Kendra, Kargil-194103
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar-190025, J&K, India

Abstract

A field experiment was conducted at KVK, Srinagar during two consecutive *Kharif* seasons of 2008-09 and 2009-10 to study the effect of integrated nutrient management for Soybean (Glycine max L.) under temperate conditions. The experiment was laid out with 18 treatment combinations viz., three levels of recommended inorganic fertilizers [50, 75 and 100% Recommended Dose (RD)], three levels of organic manures (control, FYM 10 t ha^{-1} and Dalweed 10 t ha^{-1}) and two levels of biofertilizers (control and dual inoculation with Rhizobium + PSB) in randomised complete block design with three replications. Soil physical properties were enhanced by application of recommended inorganic fertilisers except for bulk density. Organic manures also enhanced the physical properties of the soil. Among organic manures, FYM (10 t ha^{-1}) was found superior over Dalweed (10 t ha^{-1}). Dual inoculation with Rhizobium + PSB also showed significantly superior results with improved soil physical properties over no-inoculation.

Keywords: INM, Inorganic fertilizers, Organic manures, Soil properties, Soybean

***Correspondence**
Author: Eajaz Ahmad Dar
Email: darajaz9@gmail.com

Introduction

Agricultural practices that improve soil quality and agricultural sustainability have received much attention from researchers and farmers. The role of organic fertilizers in plant nutrition is now attracting the attention of agriculturists and soil scientists throughout the world. Chemical fertilizers no doubt have boosted the crop growth and yield, but to larger extent, they have contributed to soil deterioration. Integration of different sources of nutrients has a promising effect on soil health and sustained productivity. Integrated nutrient management (INM) involves the use of manures, biofertilizers and chemical fertilizers to achieve sustained crop production and maintain better soil health. INM is best approach for better utilization of resources and to produce crops with less expenditure.

In recent years, a concept of integrated nutrient supply involving use of organic manures and inorganic fertilizers has been developed to obtain sustained agricultural production [1]. Integration of organic and inorganic sources of nutrients along with biofertilizers is found to give higher productivity and monetary returns in soybean [2, 3]. Further the organic sources unlike inorganic ones have substantial residual effect on succeeding crops [4, 5]. Keeping in view the importance of integrated nutrient management, the present investigation was undertaken on soybean with the objective to study the effect of integrated nutrient management on physico-chemical properties of soil.

Material and Methods

The Field experiment "Effect of integrated nutrient management for soybean (Glycine max L. Merill) under temperate conditions" was conducted during *Kharif* seasons of 2009 and 2010 at Krishi Vigyan Kendra, Shuhama, Srinagar, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. The soil of the experimental field was silty clay loam having pH of 7.8, was medium in organic carbon (0.70%), available P_2O_5 (15.36kg ha^{-1}), available K_2O (120.62 kg ha^{-1}) and was low in available N (125.52 kg ha^{-1}). The experiment was laid out in 3 x 3 x 2 factorial randomized block design with 3 levels of inorganic fertilizer, 3 levels of organic manure and 2 levels of biofertilizers, replicated three times. Chemical fertilizer comprised of three levels C_1 (50% RD of N,P,K,Zn),C_2 (75% RD of N,P,K,Zn), C_3 (100% RD of N,P,K,Zn). The recommended dose is 40:60:20:05 ($N:P_2O_5:K_2O:Zn$).

Farmyard manure (0.58% N, 0.34% P, 0.60% K) at the rate of 10 t ha^{-1} and Dalweed (0.35% N, 0.23% P, 0.40% K) at the rate of 10 t ha^{-1} were incorporated treatment-wise in the soil 15 days before sowing. Slurry of Rhizobium and PSB inoculant was made in concentrated Gur solution (20%) which was prepared by boiling and subsequent cooling before adding Rhizobium culture and PSB. The seeds to be treated with Rhizobium and PSB inoculants, as per the treatments, were thoroughly mixed with inoculant slurry in such a way that all the seeds were uniformly coated with Rhizobium and PSB inoculant, respectively and then allowed to dry in the shade before sowing. The Rhizobium and PSB were applied at the rate of 5 g kg^{-1} seed.

The pH of the soil was determined in soil:water suspension (1:2.5) with the help of systronics glass electrode pH-meter [6]. After determining pH, the soil-water suspension was kept overnight in undisturbed condition and electrical conductivity was measured by Electrical Conductivity Meter [6]. Bulk density was estimated by clod coating method as described by [7]. It was determined by leaching the soil with neutral normal ammonium acetate method as described by [6]. Organic carbon was estimated by wet digestion method of [7].

Results and Discussion

Soil pH

The data pertaining to the effect of the integrated nutrient management on soil pH after harvest of crop are presented in **Table 1**. The data showed that pH remained by and large in neutral range. Treatment combinations of chemical, FYM and with and without inoculation of Rhizobium and PSB showed a decrease in pH over other all treatment combinations.

The data pertaining to the effect of INM nutrient sources on soil reaction (pH) revealed that no significant change in pH of soil was observed. The values ranged from 7.04 to 7.05 with increase in the recommended dose of inorganic fertilizers, where as initial soil pH was 7.04. There was a slight change in pH with the application of organics manures. The soil pH decreased to 6.95 with FYM application followed by Dalweed (7.01) and (7.20) with no manure. This may be due to acid equivalent which might have a direct effect on increased soil acidity [8]. [9] also reported slight decrease in pH with organic manures. This might be due to release of organic acids during decomposition of these organic manures which resulted in decline in soil pH. The effect of inoculation with bio-fertilizers was statistically non significant.

Table 1 Effect of Integrated Nutrient Management on soil pH after harvest of crop (1:2.5) {Pooled Data of Two Years}

Chemical fertilizers	**Organic manures**	**Bio-inoculation**		**Mean**	**Factor means for organic manures**
		Uninoculated (I_0)	**Inoculated (Rhizobium + PSB) (I_1)**		
50 % RD (C_1)	No manure (F_0)	7.15	7.17	7.16	F_0 = 7.20
	FYM @ 10 t ha^{-1} (F_1)	6.96	6.94	6.95	
	Dalweed @ 10 t ha^{-1} (F_2)	7.00	7.01	7.01	
	Mean	7.04	7.04	7.04	
75 % RD (C_2)	No manure (F_0)	7.24	7.20	7.22	F_1 = 6.95
	FYM @ 10 t ha^{-1} (F_1)	6.96	6.93	6.94	
	Dalweed @ 10 t ha^{-1} (F_2)	7.01	7.02	7.02	
	Mean	7.07	7.05	7.06	
100 % RD (C_3)	No manure (F_0)	7.18	7.25	7.21	F_2 = 7.01
	FYM @ 10 t ha^{-1} (F_1)	6.96	6.93	6.94	
	Dalweed @ 10 t ha^{-1} (F_2)	7.00	7.00	7.00	
	Mean	7.04	7.06	7.05	
Factor means for bio-inoculation		7.05	7.05		

Electrical conductivity

The data presented in the **Table 2** revealed that there was increase in electrical conductivity with increase in levels of recommended chemical fertilizers. The maximum electrical conductivity (0.280 dS m^{-1}) was recorded with 100 per cent of recommended chemical fertilizers. Application of FYM increased electrical conductivity (0.287 dS m^{-1}) over Dalweed and no manure. Higher electric conductivity was recorded in the treatment combinations of chemical fertilizers, FYM alongwith and without inoculation.

The effect of inorganic fertilizers on electrical conductivity after harvest of crop increased significantly with increase in recommended inorganic fertilizers levels. The water soluble salts increased with application of organic manures. The plot which received FYM showed highest electrical conductivity (0.287 dSm^{-1}) over initial values than other treatments which may be due to decomposition of organic matter in soil. Application of bio-fertilizers also showed significantly superior results over no inoculation. This may be attributed to increase of microbial population in rhizosphere zone which enhanced microbial decomposition of organic matter and thus leading to increase electrical conductivity. Similar results were reported by [10].

Table 2 Effect of Integrated Nutrient Management on soil EC after harvest of crop (d S m^{-1}) {Pooled Data of Two Years}

Chemical fertilizers	**Organic manures**	**Bio-inoculation**		**Mean**	**Factor means for organic manures**
		Uninoculated (I_0)	**Inoculated (Rhizobium + PSB) (I_1)**		
50 % RD (C_1)	No manure (F_0)	0.24	0.26	0.25	F_0 = 0.26
	FYM @ 10 t ha^{-1} (F_1)	0.27	0.29	0.28	
	Dalweed @ 10 t ha^{-1} (F_2)	0.25	0.27	0.26	
	Mean	0.25	0.27	0.26	
75 % RD (C_2)	No manure (F_0)	0.26	0.26	0.26	F_1 = 0.28
	FYM @ 10 t ha^{-1} (F_1)	0.27	0.29	0.28	
	Dalweed @ 10 t ha^{-1} (F_2)	0.25	0.27	0.26	
	Mean	0.26	0.28	0.27	
100 % RD (C_3)	No manure (F_0)	0.26	0.27	0.26	F_2 = 0.27
	FYM @ 10 t ha^{-1} (F_1)	0.27	0.31	0.29	
	Dalweed @ 10 t ha^{-1} (F_2)	0.26	0.29	0.28	
	Mean	0.26	0.29	0.28	
Factor means for bio-inoculation					

$CD_{(P=0.05)}$
Chemical = 0.003, Chemical x Organic = NS, Organic = 0.003, Chemical x Inoculation = NS, Inoculation = 0.003, Chemical x Organic x Inoculation = NS, Organic x Inoculation = 0.005

Bulk density

The data pertaining to the effect of different treatments on bulk density (Mg m^{-3}) have been presented in **Table 3**. The data showed that bulk density increased with increase in recommended chemical fertilizers but does not vary significantly. Addition of FYM @ 10 t ha^{-1} significantly decreased the bulk density (1.22 Mg m^{-3}) than that of Dalweed and no manorial application.

Amongst all the treatment combinations, treatment of chemical fertilizers, FYM alongwith and without inoculation showed lowest bulk density.

The data pertaining to bulk density revealed that with increasing levels of recommended inorganic fertilizers, there was no significant changes in bulk density of soil.

The bulk density was significantly lowered with application of FYM (10 t ha^{-1}) followed by Dalweed (10 t ha^{-1}) over no manure. A well aggregated soil has lower bulk density compared with dispersed and poorly structured soil. It could be due the fact that organic matter resulted in considerable increase in polysaccharides and microbial gum synthesis in the soil. The microbial decomposition product being resistant to further decomposition acts as binding material. This might help in soil aggregation resulting in lower bulk density of soil. Similar results has also been earlier reported by [11-13].

Organic carbon

The data pertaining to the effect of different treatments on organic carbon (%) have been presented in **Table 4**. The data shows that recommended chemical fertilizer levels significantly influenced organic carbon (%). The highest organic carbon (0.83%) was observed at 100 per cent of recommended chemical fertilizers. Application of FYM increased organic carbon (0.85%) over Dalweed (0.78%) and no manure (0.75%).

Inoculation with Rhizobium and PSB showed higher organic carbon (0.84%) over no inoculation (0.74%). Among all treatment combinations, 100 per cent recommended chemical fertilizers, FYM alongwith inoculation showed highest organic carbon of 0.87 per cent.

Table 3 Effect of Integrated Nutrient Management on soil BD after harvest of crop (mg m^{-3}) {Pooled Data of Two Years}

Chemical fertilizers	Organic manures	Bio-inoculation		Mean	Factor means for organic manures
		Uninoculated (I_0)	Inoculated (Rhizobium + PSB) (I_1)		
50 % RD (C_1)	No manure (F_0)	1.35	1.34	1.34	F_0 = 1.32
	FYM @ 10 t ha^{-1} (F_1)	1.25	1.21	1.23	
	Dalweed @ 10 t ha^{-1} (F_2)	1.31	1.26	1.28	
	Mean	1.30	1.27	1.28	
75 % RD (C_2)	No manure (F_0)	1.34	1.30	1.32	F_1 = 1.22
	FYM @ 10 t ha^{-1} (F_1)	1.24	1.20	1.22	
	Dalweed @ 10 t ha^{-1} (F_2)	1.30	1.24	1.27	
	Mean	1.29	1.24	1.27	
100 % RD (C_3)	No manure (F_0)	1.33	1.28	1.30	F_2 = 1.26
	FYM @ 10 t ha^{-1} (F_1)	1.23	1.20	1.21	
	Dalweed @ 10 t ha^{-1} (F_2)	1.27	1.23	1.25	
	Mean	1.27	1.23	1.25	
Factor means for bio-inoculation		1.28	1.24		

$CD_{(P=0.05)}$
Chemical = 0.003, Chemical x Organic = 0.006, Organic = 0.003, Chemical x Inoculation = NS, Inoculation = 0.002, Chemical x Organic x Inoculation = 0.008, Organic x Inoculation = NS

Table 4 Effect of Integrated Nutrient Management on soil OC after harvest of crop (%) {Pooled Data of Two Years}

Chemical fertilizers	Organic manures	Bio-inoculation		Mean	Factor means for organic manures
		Uninoculate d (I_0)	Inoculated (Rhizobium + PSB) (I_1)		
50 % RD (C_1)	No manure (F_0)	0.68	0.75	0.72	F_0 = 0.75
	FYM @ 10 t ha^{-1} (F_1)	0.81	0.87	0.84	
	Dalweed @ 10 t ha^{-1} (F_2)	0.72	0.80	0.76	
	Mean	0.74	0.81	0.77	
75 % RD (C_2)	No manure (F_0)	0.70	0.77	0.73	F_1 = 0.85
	FYM @ 10 t ha^{-1} (F_1)	0.83	0.85	0.84	
	Dalweed @ 10 t ha^{-1} (F_2)	0.73	0.80	0.76	
	Mean	0.75	0.80	0.78	
100 % RD (C_3)	No manure (F_0)	0.70	0.89	0.79	F_2 = 0.78
	FYM @ 10 t ha^{-1} (F_1)	0.83	0.93	0.88	
	Dalweed @ 10 t ha^{-1}(F_2)	0.74	0.89	0.81	
	Mean	0.75	0.90	0.83	
Factor means for bio-inoculation		0.75	0.84		

$CD_{(P=0.05)}$
Chemical = 0.006, Chemical x Organic = 0.001, Organic = 0.006, Chemical x Inoculation = 0.009, Inoculation = 0.005, Chemical x Organic x Inoculation = 0.015, Organic x Inoculation = 0.00

Increase in inorganic fertilizer application significantly increased organic carbon content in soil up to 100 per cent of recommended inorganic fertilizer. The increase in soil organic content may be attributed that atmospheric nitrogen is being fixed in soil on account of higher bacterial population, leading to better root biomass and mineralization of organic nitrogen with fertilizer application. These results are in conformity with findings of [14].

With the application of organics, there was a build up of organic carbon in soil which could be due to enhanced root growth, resulting in more organic residues in soil, which after decomposition might have increase the soil organic carbon content. These findings are in conformity with findings of [15-17].

Cation exchange capacity

The data pertaining to the effect of different treatment on CEC ($Cmol_c$ kg^{-1}) after harvest have been presented in **Table 5**. The data revealed that CEC in soil was not influenced significantly with increase in levels of recommended chemical fertilizers.

The CEC of soil increased significantly from 13.92 Cmol$_c$ kg^{-1} (with no manure) to 14.28 Cmol$_c$ kg^{-1} (with application of FYM @ 10 t ha^{-1}). The CEC significantly increased with inoculation over no inoculation.

From all treatment combinations, 100 per cent recommended chemical fertilizer dose, FYM and inoculation showed significantly higher CEC over 100 per cent recommended fertilizer dose, no manure and no inoculation. The data pertaining to the effect of integrated nutrient management on cation exchange capacity of soil revealed that change in cation exchange capacity of soil by application of inorganic fertilizers was statistically non-significant.

Table 5 Effect of Integrated Nutrient Management on soil CEC after harvest of crop (Cmol$_c$ kg^{-1})
{Pooled Data of Two Years}

Chemical fertilizers	**Organic manures**	**Bio-inoculation**		**Mean**	**Factor means for organic manures**
		Uninoculated (I_0)	**Inoculated (Rhizobium + PSB) (I_1)**		
50 % RD (C_1)	No manure (F_0)	13.86	13.95	13.90	F_0 = 13.92
	FYM @ 10 t ha^{-1} (F_1)	14.11	14.36	14.23	
	Dalweed @ 10 t ha^{-1} (F_2)	13.90	13.90	13.90	
	Mean	13.95	14.07	14.01	
75 % RD (C_2)	No manure (F_0)	13.88	13.98	13.93	F_1 = 14.28
	FYM @ 10 t ha^{-1} (F_1)	14.15	14.42	14.28	
	Dalweed @ 10 t ha^{-1} (F_2)	13.87	14.03	13.95	
	Mean	13.96	14.14	14.05	
100 % RD (C_3)	No manure (F_0)	13.89	13.99	13.94	F_2 = 13.95
	FYM @ 10 t ha^{-1} (F_1)	14.21	14.45	14.33	
	Dalweed @ 10 t ha^{-1} (F_2)	13.88	14.13	14.00	
	Mean	13.99	14.19	14.09	
Factor means for bio-inoculation		13.97	14.13		

CD$_{(P=0.05)}$
Chemical = NS Chemical x Organic = NS Organic = NS Chemical x Inoculation = NS Inoculation = NS Chemical x Organic x Inoculation = NS Organic x Inoculation = NS

However, the effect of application of organics and inoculation were significantly superior. The low cation exchange capacity can be attributed due to low organic matter and high cation exchange capacity due to higher organic matter content. This may be due to increase in growth of root mass as well as above ground parts. The nutrient supplying power of soil greatly depends on cation exchange capacity besides it influences the physical properties of the soil [18].

Conclusion

Based on the results, it can be concluded that integrated use of different sources of nutrients maintains soil health and improve soil properties with reduction in inputs costs as compared to individual usage of chemicals only.

References

[1] Gaikwad SS, Puranik RB (1996) Effect of pressmud cake (PMC) and fertilizer on the yield and uptake of secondary nutrients by soybean (Glycine max L.) in entisol. Journal of Soils and Crops 6: 190-193.
[2] Singh R, Rai RK (2004) Yield attributes, yield and quality of soybean (Glycine max) as influenced by integrated nutrient management. Indian Journal of Agronomy 49: 271-274.
[3] Bhattacharyya R, Kundu S, Prakash R, Gupta HS (2008) Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean-wheat system of the Indian Himalayas. European Journal of Agronomy 28: 33-46.
[4] Duraisami VP, Mani AK (2001) Residual effect of inorganic nitrogen, composted coir pith and biofertilizer on yield and uptake of soybean in on inceptisol. Madras Agricultural Journal 88: 277-280.
[5] Shivakumar BG, Ahlawat IPS (2008) Integrated nutrient management in soybean (Glycine max)–wheat (Triticum aestivum) cropping system. Indian Journal of Agronomy 53: 273-278.
[6] Jackson ML (1973) Soil Chemical Analysis. Prentice Hall of India, New Delhi.
[7] Walkley A, Black JA (1934) An examination of the method for determining soil organic matter and proposed modification of chromic acid titration methods. Soil Science 37: 29-39.

[8] Pathak SK, Singh SB, Jha RN, Sharma RP (2005) Effect of Nutrient Management on nutrient uptake and changes in soil fertility in maize (Zea mays) wheat (Triticum aestivum) cropping system. Indian Journal of Agronomy 50: 269-273.
[9] Zende GK (1968) Improvement of saline and alkali soils in Maharashtra. Research Bulletin 13.Department of Agriculture Maharashtra.
[10] Babu MVS, Reddy MC, Subramanyam A,Balaguravaih D (2007) Effect of integrated use of organic and inorganic fertilizers on soil properties and yield of sugarcane. Journal of the Indian Society of Soil Science 55: 161-166.
[11] Mishra M, Patjoshi AK, Jena D (1998) Effect of biofertilization on production of maize. Indian Journal of Agronomy 43: 307-310.
[12] Sarkar AK, Lal Suresh, Singh BP (1997) Balanced fertilizer use in red and laterite soils. Fertilizer News 42: 49.
[13] Sharma MP, Gupta GP (1998) Effect of organic materials on grain yield and soil properties in maize wheat cropping system. Indian Journal of Agricultural Sciences 68: 715-717.
[14] Parmar DK, Vinod S (2001) Nitrogen requirement of single hybrid maize-wheat system under rainfed conditions. Indian Journal of Agricultural Sciences 71: 252-254.
[15] Kumpawat BS, Jat ML (2005) Profitable and energy efficient integrated nutrient management practices for maize-mustard cropping system in Southern Rajasthan. Current Agriculture 29: 97-102.
[16] Balyan JK, Singh P, Kumpawat BS, Jain LK (2006) Effect of integrated nutrient management on maize growth and its nutrient uptake. Current Agriculture 30: 79-82.
[17] Brar BS, Pasricha MS (1998) In long-term soil fertility management through integrated plant nutrient supply system, Indian Institute of Soil Science, Bhopal pp 154.
[18] Verma SK, Shyampura RL, Jain SP, TarseamLal (1990) The soils of Anantnag and Pulwama districts (J&K) for land use planning. National Bureau of Soil Survey and Land Use Planning, India. ISBN : 81-85460-04-03, NBSS, Publication 26.

Publication History
Received 14th Jan 2019
Revised 10th Feb 2019
Accepted 04th Mar 2019
Online 30th Mar 2019