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RESEARCH ARTICLE

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL PHYSICAL PROPERTIES USING SOYBEAN (*Glycine max* (L.)MERILL) AS INDICATOR CROP UNDER TEMPERATE CONDITIONS

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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 under 18 treatment combinations viz., three levels of recommended inorganic fertilizers (50, 75 and 100% 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, FYM (10 t ha^{-1}) was found superior over Dalweed (10 t ha^{-1}). Dual inoculation with Rhizobium + PSB also showed significantly superior results in improved soil physical properties over no-inoculation.

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 efficient soil health management 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 (Gaikwad and Puranik, 1996). Integration of organic and inorganic sources of nutrients alongwith biofertilizers is found found to give higher productivity and monetary returns in soybean (Singh and Rai, 2004; Bhattacharyya *et al*., 2008). Further the organic sources unlike inorganic ones have substantial residual effect on succeeding crops (Duraisami and Mani, 2001; Shivakumar and Ahlawat, 2008).

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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.

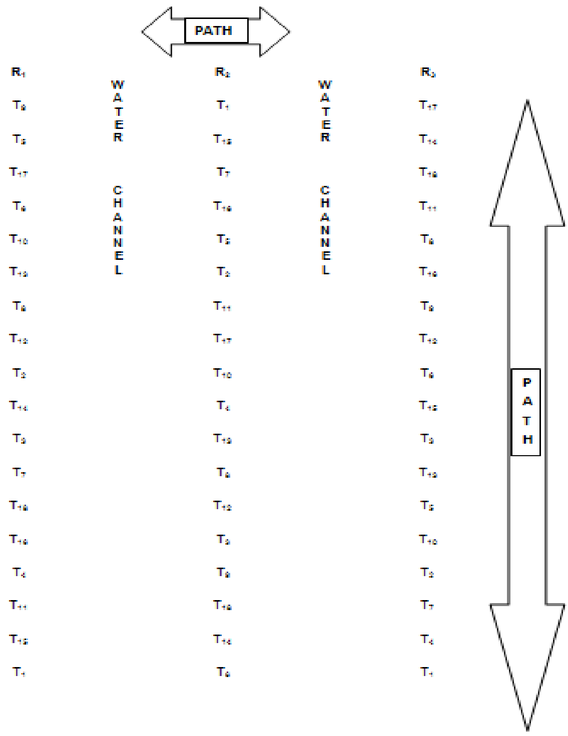
MATERIALS AND METHODS

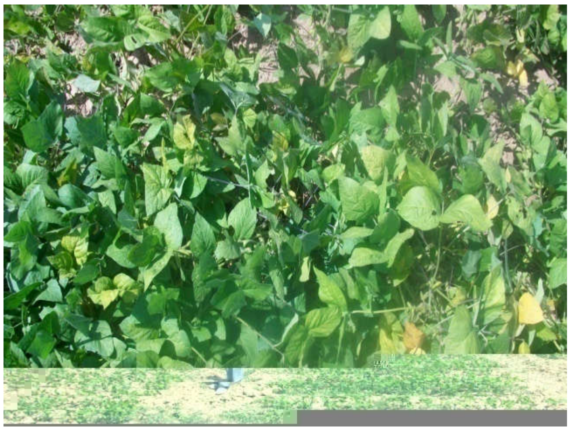
The Field experiment "Effect of integrated nutrient management for soybean *(Glycine max* L. Merill) under temperate conditions" was conducted during kharif seasons of 2009 and 2010 at Krishi Vigyan Kendra,Shuhama,Srinagar, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir . . The site is situated 26 km away from city centre and lies between $340^o.8'$ N latitude and 74^o $83'$ E longitude at an altitude of 1587 meters above the mean sea level.The soil of the experimental field was silty clay loam having pH 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. 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)

RECOMMENDED DOSE= 40:60:20:05 ($N:P_20_5:K_20:Zn$)

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 of seeds. A slurry of *Rhizobium* and PSB inoculant was made in concentrated Gur solution (20 per cent) 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 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. The treatments were allocated randomly in three replications. The pH of the soil was determined in soil:water suspension (1:2.5) with the help of systronics glass electrode pH-meter (Jackson, 1973). After determining pH, the soil-water suspension was kept overnight in undisturbed condition and electrical conductivity was measured by Electrical Conductivity Meter. (Jackson, 1973).Bulk density was estimated by clod coating method as described by Black (1965).It was determined by leaching the soil with neutral normal ammonium acetate method as described by Jackson (1973). Organic carbon was estimated by wet digestion method of Walkey and Black (1934).





RESULTS AND DISCUSSION

The results regarding the effect on soil properties due to Integrated Nutrient Management are presented as:

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. The slight change in pH with the application of organics manures. The soil pH decreased (6.95) followed by Dalweed (7.01) and (7.20) no manure. This may be due to acid equivalent which might have a direct effect on increased soil acidity (Pathak *et al.*, 2005). Zende (1968) also reported slightly decreased in pH with organic manures. This might be due to release of organic acids during decomposition of these organic manures which resulted decline in soil pH. The effect of inoculation with bio-fertilizers was statistically non-significant.

Electrical conductivity

The data pertaining to the effect of different treatments on electrical conductivity during two years is presented in Table 2. The data presented in the Table 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 was increased significantly with increase in recommended inorganic fertilizers levels. The water soluble slats increased with application of organic manures. The plot which received FYM showed highest electrical conductivity (0.287 dSm^{-1}) over initial values control other treatments which are 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

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		

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				

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			

population in philosopher zone which enhanced microbial decomposition of organic matter and thus leading to increase electrical conductivity (Prasanna, 1991). Similar results were above earlier reported by Babu *et al.* (2007).

Bulk density (mg m^{-3})

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

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
		Uninoculated (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	= 0.009				

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				

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 to that the organic matter resulted in considerable increase in polysaccharides and microbial gum synthesis in the soil. The microbial decomposition product being resistant to further decomposition and act as binding. This might help in soil aggregation resulting lower bulk density of soil. Similar results has also been earlier reported by Mishra *et al.* (1998), Sarkar *et al.* (1997) and Sharma and Gupta (1998).

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 (%). From the data presented in Table, it was found that 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. 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 result are in conformity with findings of Parmar and Vinod (2001). The application of organics, there was a build up of organic carbon in soil which could be due to enhanced root growth, resulting more organic residues in soil, which after decomposition might have increase the soil organic carbon content. These findings are in conformity with findings of Kumpawat and Jat (2005), Balyan *et al.* (2006c) and Brar *et al.* (1998).

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 presented in Table revealed that CEC in soil was found non significant with increasing 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 to application of inorganic fertilizers was statistically non-significant. 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 (Verma *et al.*, 1990). Gangopadhayay *et al.* (1990) observed increase in cation exchange capacity with rise in elevation. inoculation with bio-fertilizers significantly increase CEC, which might be due to release of soluble inorganic phosphates and secretion of organic acids which may form chelates with the Fe and Al resulting solublization of phosphates. These results are in conformity with findings of Laxminarayana (2001).

CONCLUSION

Based on the results obtained it can be concluded that Integrated use of different sources of nutrients not only enhance the yield but to a larger extent they maintain soil health and improve soil properties and also inputs costs are reduced as compared to individual usage of chemicals only.

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