Influence of different level of NPK and Rhizobium on Physico-chemical Properties of soil, growth and yield attribute of Blackgram (*Vignamungo*L. *Var*:Shekhar-2)

ABSTRACT

An experiment was conducted "to determine theinfluence of different level of NPK and Rhizobium on physico-chemical properties of soil, growth and yield attribute to black gram (*Vigna mungo* L. var. Shekhar-2) during Zaid season 2023-2024 at the Research farm Department of Soil Science and Agricultural Chemistry, Naini Agriculture Institute , SHUATS, Prayagraj The design applied was 3x3 factorial randomized complete block design having three levels of NPK @ 0, 50 and 100 % ha^{-1} and three levels of Rhizobium @ 0, 50 and 100 % ha^{-1} respectively. The soil samples from experimental site before conducting research operation, revealed that, soil is of sandy loam texture with neutral to alkaline in reaction and significantly highest in treatment T_1.The result shows that application of different levels combination of inorganic fertilizers and improved soil chemical properties of black gram. **Keywords**: Black gram, Soil, NPK, Rhizobium, inorganic fertilizer,growth and yield.

INTRODUCTION

Soil is a natural body consisting of layers (soil horizon) of mineral constituents of variable thickness which different from the parent material in their morphological, physical, chemical and mineralogical characteristics. (bradyet al., 2016) The annual production of black gram is about 24.5 lakh tones from about 4.6 million hectares of area, with an average productivity of 533 kg ha-1 in 2021-22. It is a drought resistant crop grown both as a summer and Kharif crop. (directorate of pulses development, 2022).

After cereals and oilseeds, pulses occupy an important place in Indian agriculture. The total world acreage under pulses is about 85.40 M ha with production of 87.40 Mt at productivity 1023kg ha-1 production with 34 and 26% respectively with average productivity of 835 kg ha-1(Agricultural Statistics Division, Directorate of Economics and Statistics, 2019). 70% of the total world's black gram and green gram production comes from India, of which black gram constitutes 1.65 Mt with the share of 12.4 % (Elzebroek and Wind, 2008). Pulses are excellent source of high quality protein, essential amino acids, fatty acids, fibers, minerals and vitamins. The protein level of black gram is quite high *i.e* about 24 % with nutritional value of 10.9 % moisture, 1.4 % fats, 60.3 % carbohydrates and 3.4 % ash (Shroti *et al.,* 2018). It improves soil health by enriching nitrogen status and also maintains sustain ability of the cropping systems.

Black gram (*Vigna mungo* L.) is one of the important pulse crops grown throughout India. Proper fertilization is essential to improve the productivity of black gram. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur. Black gram is very much responsive to sulphur application. Both phosphorus and sulphur can improve the quality and quantity of the crop. Hence, the present investigation was undertaken to find out the response of black gram to different levels of phosphorus, sulphur and PSB application.

Nitrogen is vitally important for plant nutrient. Nitrogen is essential constituent of protein and is present in many other compound of great physiological importance in plant metabolism. Nitrogen is called a basic constituent of life. Phosphorus plays key roles in many plant processes such as energy metabolism, nitrogen fixation, synthesis of nucleic acids and membranes, photosynthesis, respiration and enzyme regulation. Phosphorus is critical to black gram yield because it is reported to stimulate growth, initiate nodule formation as well as influence the efficiency of the *Rhizobium* legume symbiosis (Ndakidemi and Dakora, 2007) .

According to Oti *et al.* (2004), phosphorus decrease zinc concentration in the black gram grain, thereby affecting its nutritional quality. It is required for the physiological processes of protein synthesis and energy transfer in plants. Application of phosphorus has been reported by several authors to improve yield of black gram. Seed yield is, therefore, governed by number of factors which have a direct or indirect impact. Among these factors are yield components such as number of pods per plant, number of seeds per pod and100 seed weight over a given land area.

Potassium play important role information of protein and chlorophyll and it provide much of osmotic "pull" that draw water into plant roots. Potassium produces strong stiff straw in maize and reduce lodging in maize. Potassium imparts increase vigor and disease resistance to plant (Cobbinah *et al.*,2011).

Rhizobia are symbiotic diazotrophs (prokaryotic organisms that carryout di-nitrogen fixation) that form a symbiotic association with legumes. This association is symbiotic in that both the plant and rhizobia benefit. The plant supplies the rhizobia with energy in the form of amino acids and the rhizobia fix nitrogen from the atmosphere for plant uptake. The reduction of atmospheric dinitrogen into ammonia is the second most important biological process on earth after photosynthesis

(Singh,2008).

The main aim of the whole research is to increase the soil physic-chemical property and hence will increase the productivity of black gram as well. Black gram is leguminous which automatically fix atmospheric nitrogen and if it combines with Rhizobium increase the nitrogen content in soil which will increase growth and yield of black gram, as well as increase the soil fertility

MATERIALS AND METHODS

A field experiment to study the "Effect of different level of NPK and Rhizobium on soil physico-chemical properties of black gram (*Vigna mungo* L. var. Shekhar-2)" was conducted at central research farm department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj. This area normally falls under the sub-tropical belt in the south east of Uttar Pradesh, where the summers are quite hot and the winters are moderately chilly. The location's highest temperature occasionally drops below4^{0}Cor 5^{0}C and can reach up to 46^{0}C to 48^{0}C. Between 20 to 94% the relative humidity was present. Around 1100 mm of rain precipitation occurs yearly on average in this region. The experimental site is located 98 meters above sea level at 25^{0}57'N latitude and 81^{0}59' E longitude. The soil in the experimental region is classified as Inceptisol, and its texture is sandy loam (sand content: 62.71%; silt content: 23.10%; clay content: 14.1%).The experiment was setup using a randomized block design (RBD), which included nine treatments and three doses of NPK (0, 50,and 100%) and Rhizobium (0, 50, and 100%). Three replicates of the treatment have been made. There were 27 plots in total. Black gram sowing in 2 x 2 m plots during the *Zaid* season, with a spacing of30 x10cm. Soil samples were taken from each plot both before and after the experiment at a depth of 0-15 to 15–30 cm by using a soil auger. The soil samples were air dried, put through a 2 mm screen, and then had their different soil qualities examined. M.L. Jackson (1958) assessed the soil pH with a pH meter, and Wilcox (1950) measured the electrical conductivity (EC) with a conductivity meter. The available nitrogen (N) was calculated using the Subbiah and Asija method (1956), the phosphorus (P) was calculated using the Olsen et al. method (1954), the potassium (K) was calculated using the Toth and Prince method (1949).The soil organic carbon (SOC) was estimated using the Walkley and Black method.

RESULT AND DISCUSSION

Bulk density (Mg m^{-3})

The response bulk density of soil was found to be non-significant in levels of NPK and

Rhizobium. The maximum bulk density of soil was recorded 1.293 Mg m^{-3} at 0-15 cm and 1.294 Mg m^{-3} at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 1.291 Mg m^{-3} at 0-15 cm and 1.289 Mg m^{-3}at 15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum bulk density of soil was recorded 1.241 Mg m^{-3} at 0-15 cm and 1.251 Mgm^{-3} at 15-30 cm in treatment T_1 [control (NPK @ 0 % + Rhizobium @ 0 %)] respectively. It was also observed the bulk density of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Kumar *et al.,* 2008; Reddyn *et al.,* 2005 and Bhattacharya *et al.,* 2004.

Particle density (Mg m^{-3})

The response particle density of soil was found to be non-significant in levels of NPK and Rhizobium. The maximum particle density of soil was recorded 2.515 Mg m^{-3} at 0-15 cm and 2.525Mg m^{-3}at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %)followed by 2.509 Mg m^{-3} at 0-15 cm and 2.521 Mg m^{-3} at 15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum particle density of soil was recorded 2.473Mgm^{-3} at 0-15 cm and 2.481 Mg m^{-3} at 15-30 cm in treatment T_1 [control (NPK @ 0 % + Rhizobium @ 0 %)] respectively. It was also observed the particle density of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Hussain *et al*., 2022; Chintha *et al*., 2021 and Dangi *et al*.,2020.

Percent Pore space (%)

The response pore space of soil was found to be significant in levels of NPK and Rhizobium. The maximum pore space of soil was recorded 48.65 % at 0-15 cm and 47.75 % at15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 48.11 % at 0-15cm and 47.20 % at 15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum pore space of soil was recorded 44.12 % at 0-15 cm and 40.75 % at 15-30 cm in treatment T_1[control (NPK @ 0 % + Rhizobium @ 0 %)] respectively. It was also observed the pore space of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Kumawat *et al*., 2013; Azadi *et al*.,2013 and Amurta *et al*., 2017.

Water holding capacity (%)

The response water holding capacity of soil was found to be significant in levels of NPK and Rhizobium. The maximum water holding capacity of soil was recorded 46.31 % at 0-15 cm and 44.72% at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 45.09% at

0-15 cm and 43.07% at 15-30 cm in treatment T_8 (NPK @ 100% + Rhizobium @ 50%) and minimum water holding capacity of soil was recorded 40.47 % at 0-15cm and 37.08 % at 15-30 cm in treatment T_1 [control (NPK @ 0 % + Rhizobium @ 0 %)] respectively. It was also observed the water holding capacity (%) of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Kumawat *et al.*, 2013;Azadi *et al.*,2013 and Amurta *et al.*, 2017.

pH of soil w/v (1:2.5)

The response pH of soil was found to be non-significant in levels of NPK and Rhizobium. The maximum pH of soil was recorded 7.20 at 0-15 cm and 7.21 at 15- 30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 7.21 at 0-15 cm and 7.22 at15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum pore space of soil was recorded 7.29 at 0-15 cm and 7.31 at 15-30 cm in treatment T_1 [control (NPK @ 0 % +Rhizobium @ 0 %)] respectively. It was also observed the pH of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Sohel *et al.*, 2017; Chandrakar, 2018 and Jha *et al.*, 2015.

Electrical Conductivity (dS m^{-1})

The response Electrical Conductivity of soil was found to be non-significant in levels of NPK and Rhizobium. The maximum Electrical Conductivity of soil was recorded 0.475 dSm^{-1} at 0-15 cm and 0.480 dS m^{-1} at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 0.471 dSm^{-1}at 0-15 cm and 0.475 dSm^{-1} at 15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum EC of soil was recorded 0.443 dSm^{-1} at 0-15 cm and 0.446 dSm^{-1} at 15-30 cm in treatment T_1 [control (NPK @ 0 % + Rhizobium @ 0 %)] respectively. It was also observed the pH of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Sohel*etal*.,2017; Chandrakar, 2018and Jha *et al*.,2015.

Organic Carbon (%)

The response organic carbon of soil was found to be non-significant in levels of NPK and Rhizobium. The maximum organic carbon of soil was recorded 0.407% at 0-15cm and 0.409% at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 0.406 %at 0-15 cm and 0.403 % at 15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum organic carbon of soil was recorded 0.385 % at 0-15 cm and 0.378 % at 15-30 cm in treatment T_1 [control (NPK @ 0 % + Rhizobium@ 0 %)] respectively. It was also observed the pH of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Sohel *et al*., 2017; Chandrakar, 2018 and Jha *et al*., 2015.

Available Nitrogen (kg ha^{-1})

The response Available Nitrogen of soil was found to be significant in levels of NPK and Rhizobium. The maximum Available Nitrogen of soil was recorded 331.45 kg ha^{-1}at 0-15 cm and 327.18 kg ha^{-1} at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 325.17 kg ha^{-1} at 0-15 cm and 320.62 kg ha^{-1} at 15-30 cm in treatment T_8 (NPK @ 100 % +Rhizobium @ 50 %) and minimum available nitrogen of soil was recorded 297.15 kg ha^{-1} at 0-15cm and 291.32 kg ha^{-1} at 15-30 cm in treatment T_1 [control (NPK @ 0 % + Rhizobium @ 0 %)] respectively. It was also observed the pH of soil was gradually increased with an increase in dose of different levels of NPK and Rhizobium. Similar result has been recorded by Sohel*etal*.,2017; Chandrakar, 2018 and Jha *et al*., 2015.

Available Phosphorus (kg ha^{-1})

The response available phosphorus of soil was found to be significant in levels of NPK and Rhizobium. The maximum available phosphorus of soil was recorded 29.14 kg ha^{-1}at0-15 cm and 24.31 kg ha^{-1} at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 27.82 kg ha^{-1}at 0-15 cm and 22.57 kg ha^{-1} at 15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum available phosphorus of soil was recorded 18.42 kg ha^{-1} at 0-15 cm and 14.15 kg ha^{-1} at 15-30 cm in treatment T_1 [control (NPK @ 0% + Rhizobium @ 0 %)] respectively. Similar result has been recorded by Sharma *et al*., 2009; Javeed *et al*., 2017 and Sammauria, 2007.

Available Potassium (kg ha^{-1})

The response available potassium of soil was found to be significant in levels of NPK and Rhizobium. The maximum available potassium of soil was recorded 221.29 kg ha^{-1}at 0-15 cm and 217.62 kg ha^{-1} at 15-30 cm in treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by 216.38 kg ha^{-1} at 0-15 cm and 212.74 kg ha^{-1} at 15-30 cm in treatment T_8 (NPK @ 100 % + Rhizobium @ 50 %) and minimum available potassium of soil was recorded 192.32 kg ha^{-1} at 0-15 cm and 188.25 kg ha^{-1} at 15-30 cm in treatment T_1 [control (NPK @ 0 % + Rhizobium @ 0 %)] respectively. Similar result has been recorded by Sharma *et al*., 2009; Javeed et al., 2017 and Sammauria, 2007.

Fig.1. Effect of different levels of NPK and Rhizobium on BD (Mg m^{-3}), PD (Mg m^{-3}), PS (%), and WHC (%) of soil depth (0-15 cm).

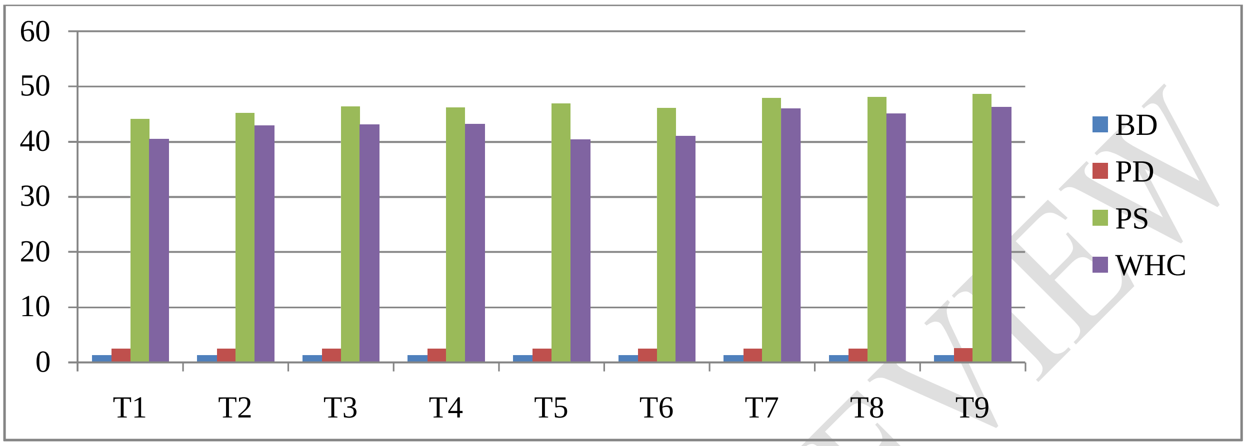

Table1.EffectofNPKandRhizobiumonsoilphysicalproper

Treatment	BD(Mgm^{-3})		PD(Mgm^{-3})		Pore space(%)		WHC(%)	
	0-15 cm	15-30 cm	0-15 Cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
NPK@0%+Rhizobium@0%	37.08	37.08	37.08	37.08	44.12	40.75	40.47	37.08
NPK@0%+Rhizobium@50%	37.21	37.21	37.21	37.21	45.22	44.19	42.94	37.21
NPK@0%+Rhizobium@100%	39.29	39.29	39.29	39.29	46.39	44.89	43.16	39.29
NPK@50%+Rhizobium@0%	39.62	39.62	39.62	39.62	46.19	45.09	43.21	39.62
NPK@50%+Rhizobium@50%	40.38	40.38	40.38	40.38	46.90	45.54	40.42	40.38
NPK@50%+Rhizobium@100%	40.63	40.63	40.63	40.63	46.10	45.55	41.03	40.63
NPK@100%+Rhizobium@0%	42.97	42.97	42.97	42.97	47.90	45.54	46.07	42.97
NPK@100%+Rhizobium@50%	43.07	43.07	43.07	43.07	48.11	47.2	45.09	43.07
NPK@100%+Rhizobium@100%	44.72	44.7	44.7	44.7	48.6	47.75	46.31	44.72

		2	2	2	5			
F-Test	NS	NS	NS	NS	S	S	S	S
S.Ed.(±)	-	-	-	-	0.60	0.70	0.65	0.50
C.D.at0.5%	-	-	-	-	1.81	2.71	1.97	1.51

Fig.2.EffectofdifferentlevelsofNPKandRhizobiumonBD(Mgm^{-3}),PD(Mgm^{3}),PS (%), andWHC(%)ofsoildepth(15-30cm).

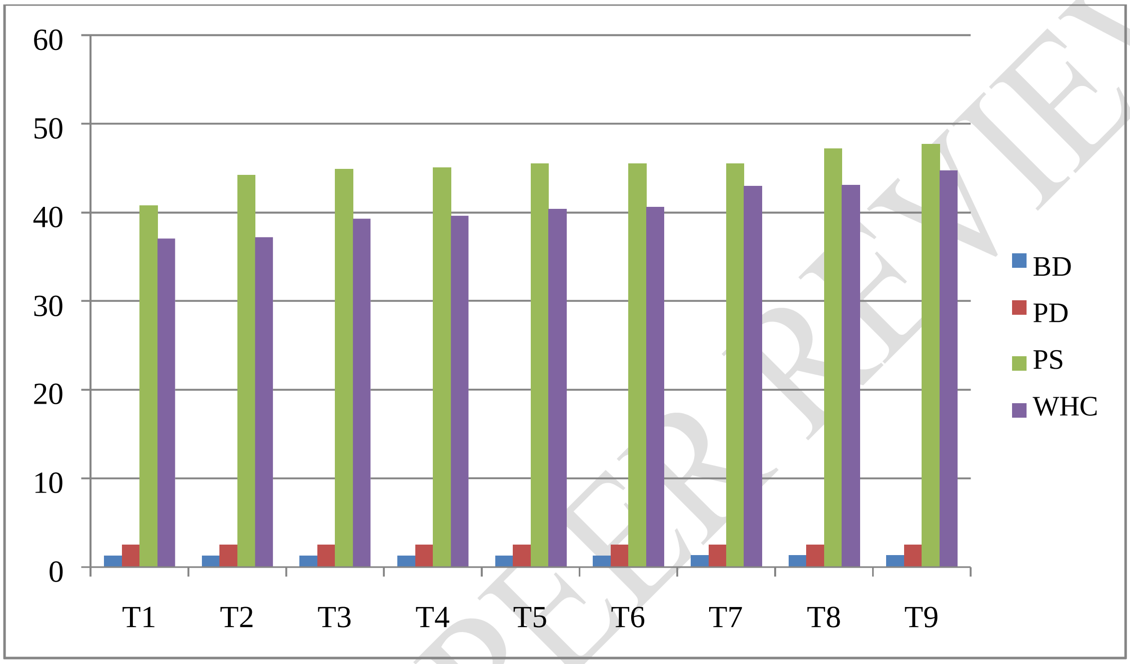

Table2.EffectofNPKandRhizobiumonsoilchemicalproperties

Treatm nt	pH		EC(dSm^{-1})		Organic carbon(%)	
	0-15 cm	15-30 cm	0–15 cm	15–30 cm	0-15 Cm	15–30 cm
NPK@0%+Rhizobium@0%	7.29	7.31	0.443	0.446	0.385	0.378
NPK@0%+Rhizobium@50%	7.26	7.27	0.448	0.449	0.39	0.382
NPK@0%+Rhizobium@100%	7.25	7.26	0.452	0.453	0.394	0.386
NPK@50%+Rhizobium@0%	7.24	7.26	0.455	0.456	0.399	0.389
NPK@50%+Rhizobium@50%	7.25	7.25	0.459	0.463	0.402	0.391
NPK@50%+Rhizobium@100%	7.23	7.24	0.463	0.467	0.405	0.396
NPK@100 %+Rhizobium@0%	7.22	7.23	0.461	0.471	0.405	0.403

NPK@100%+Rhizobium@50%	7.21	7.22	0.471	0.475	0.406	0.403
NPK@100%+Rhizobium@100%	7.20	7.21	0.475	0.480	0.407	0.409
F-Test	NS	NS	NS	NS	NS	NS
S.Ed.(±)	-	-	-	-	-	-
C.D.at0.5%	-	-	-	-	-	-

Fig.3.EffectofdifferentlevelsofNPKandRhizobiumonAvailableN(kgh^{-1}),P(kgh^{-1}),andK (kgh^{-1}),ofsoildepth(0-15 cm).

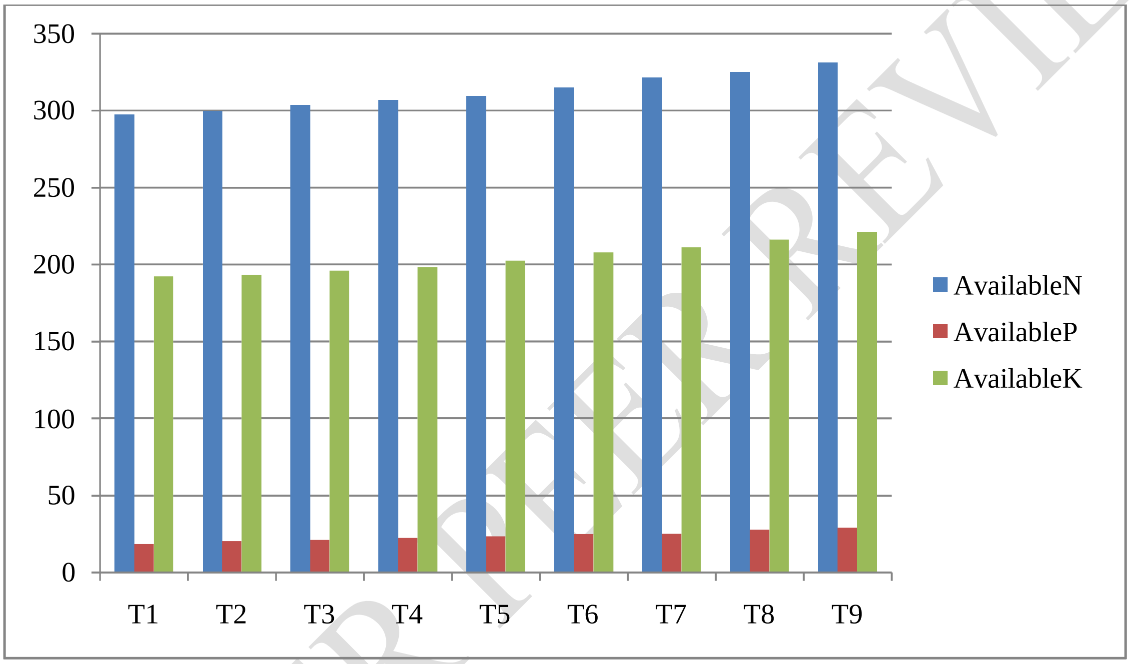

Table3.EffectofNPKandRhizobiumonsoilchemicalpropertie

Treatment	AvailableNitrogen(kgha^{-1})		AvailablePhosphorus(kgha^{-1})		AvailablePotassium(kgha^{-1})	
	0–15 cm	15-30 Cm	0–15 cm	15–30 cm	15–30 Cm	15–30 cm
NPK@0%+Rhizobium@0%	297.15	291.32	18.42	14.15	192.32	188.25
NPK@0%+Rhizobium@50%	299.68	294.54	20.36	15.27	193.54	189.42
NPK@0%+Rhizobium@100%	303.42	297.35	21.27	16.46	196.05	191.46
NPK@50%+Rhizobium@0%	306.72	302.28	22.52	18.33	198.38	194.02
NPK@50%+Rhizobium@50%	309.46	304.6	23.48	18.24	202.65	197.8
NPK@50%+Rhizobium@100%	315.08	309.32	24.96	20.97	207.82	201.56
NPK@100%+Rhizobium@0%	321.36	315.45	25.05	20.13	211.25	206.25
NPK@100%+Rhizobium@50%	325.17	320.62	27.82	22.57	216.38	212.74
NPK@100%+Rhizobium@100%	331.45	327.18	29.14	24.31	221.29	217.62

F-Test	S	S	S	S	S	S
S.Ed.(±)	4.42	5.05	0.40	0.222	2.92	3.43
C.D.at0.5%	13.31	15.21	1.23	0.67	8.79	10.35

Fig..4.EffectofdifferentlevelsofNPKandRhizobiumonAvailableN(kgh^{-1}),P(kgh^{-1}),andK (kgh^{-1}),ofsoil depth(15-30 cm).

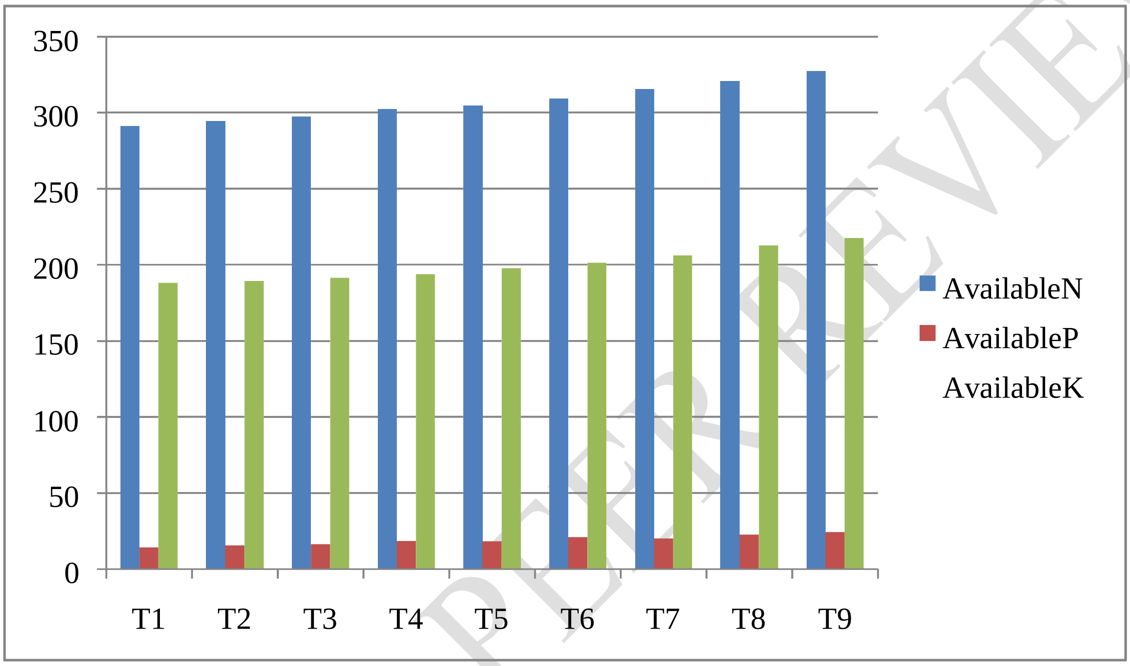

Table 4. Effect of different cost benefit ratio (C:B) of different treatment combination of black gram.

Treatment	Yield (q ha^{-1})	Selling Price (₹ q^{-1})	Gross return (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Net profit (₹ ha^{-1})	Benefit Cost ratio (B: C)
T_1	7.90	9600	75840	42250.00	33590	1:1.79
T_2	9.17	9600	88032	44716.00	43316	1:1.96
T_3	9.46	9600	90816	47182.00	43634	1:1.92
T_4	9.85	9600	94560	44759.00	49801	1:2.11
T_5	10.33	9600	99168	47225.00	51943	1:2.09
T_6	10.67	9600	102432	49691.00	52741	1:2.06
T_7	11.18	9600	107328	47268.00	60060	1:2.27
T_8	11.55	9600	110880	49734.00	61146	1:2.22
T_9	12.5	9600	120000	52200.00	67800	1:2.30

Conclusion

From trial it was concluded that the various level of NPK and Rhizobium used from different sources fertilizers [*i.e.* Urea (46 % N), + SSP (16 % P_2O_5) + MOP (60 % K_2O) + Rhizobium] in the experiment gave the best result in the treatment T_9 (NPK @ 100 % + Rhizobium @ 100 %) followed by treatment T_8, in T_9 the soil health parameters retained the suitable soil properties, yield attributes and yield of black gram and gave highest net profit of68080.00 ₹ ha^{-1} with highest cost benefit ratio is 1:2.30. Therefore, it can be recommended for farmers to obtain best combination Treatment (T_9) for higher farm income and sustainable agriculture.

References

Amruta N, Devaraju PJ, Mangalagowri Kiran SP, Ranjitha HP, Kalavati P. (2017). Effect of integrated nutrient management and spacing on seed quality parameters of black gram cv. Lbg-625 (rashmi). Journal of Applied and Natural Science.;**8(1):**340-345.

Azadi E, Rafiee M, Hadis N. (2013.) The effect of different nitrogen levels on seed yield and morphological characteristic of mungbean in the climate condition of Khorramabad. Annals of Biological Research. **4(2)**:51-5.

Bhattacharya VP, Mani AK, Thilagvathi T. (2004). Effect of sources and levels of phosphorus and P solubilizers on yield and nutrient uptake in rainfed green gram. Annals of Arid Zone.**40**:43-8.

Bethlenfalvay, G. J., Pacovsky, R. S., Bayne, H. G. and Stafford, A. E. (1992). Interactions between nitrogen fixation, mycorrhizal colonization, and host-plant growth in the Phaseolus rhizobium-glomus symbiosis. *Plant Physiology*. **70(2)**: 446–450.

Black, C. A., (1965). Methods of soil analysis part – ii. Chemical and microbiological properties. Agronomy monograph no. 9. *American society of agronomy,* inc. Madison, wisconsin, usa, **18**-25.

Chandrakar K, Verma SK, Dubey S, Kesari R. (2018). Yield gap analysis of black gram through front line demonstration under rainfed condition. Int J Chem Stud. **6(4)**:3173-6.

Chintha, P., Alka, Y., Choudhary, B. L. and Puniya, M.M. (2021). Response of integrated phosphorus management on nodulation and productivity of mungbean on typic ustipsamment. *Green farming*, **5**: 222-225.

Dangi A, Kumar S, Singh S, Omkar, Singh BP. (2020). Effect of phosphorus and sulphur fertilization on productivity and nutrient uptake of black gram. Ann Agric Res New S. **35(1)**:54-7.

Elzebroek, T. and Wind, K. (2008). Guide to Cultivated Plants.*CAB International, United Kingdom.* 262.

Fisher RA. (1960). Statistical methods and scientific induction. J R Stat Soc S.**17**:69-78.

Hussain M, Tahir M, Majeed MA. (2022). Effect of zinc sulphate as soil application and seed treatment on black gram (*Vignamungo* L.). Pakistan Journal Life Society Science.**12(2):**87-91.

Jackson ML.(1958). Soil chemical analysis Prentice Hall of India Ltd. New Delhi. 219-21.

Jha DP, Sharma SK, Amarawat T. (2015). Effect of organic and inorganic sources of nutrients on yield and economics of black gram (*Vignamungo*) grown during Kharif. Agric Sci. **35(3):**224-8.

Kumar J, Sharma P, Meena S. (2008). Physicochemical properties of the soil, under thetwo forest plantation stands around Varanasi (U.P.), India.

Kumawat, N., Sharma, O. P. and Kumar, R. (2013). Effect of organic manures, psb and phosphorus fertilization on yield and economics of mungbean (*vigna radiata* l.) *Environment & ecology*.**27(1):** 5-7.

Kachroo, P. (1970). Pulse crops of india. Icar, new delhi. 148.

Muthuvel P, Udayasoorian C, Natesan R, Ramaswamy PP. (1992). Introduction to soil analysis. Coimbatore: Tamil Nadu Agricultural University-641002.

Ndakidemi PA, Dakora FD. (2007). Yield components of nodulated black gram (*Vigna unguiculata*) and maize plants grown with exogenous phosphorus in different cropping systems. Aust. J Exp. Agric.**47**:583-589.

Olsen SR, Cole CV, Watanabe FS, Dean LA. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate ($NaHCO_3$). Dairy Australia [Circular].

939:1-19.

Oti NN, Uzoho BU, Opara CC. (2004). Determination of phosphorus requirement of black gram using P-sorption isotherm. Int. J Agric. Rural Dev. **5**:77-85.

Rautaray, S. R. and Guldekar, D. D. (2003). Studies on synergistic effect of dual inoculation of Rhizobium, PSB and antagonistic bacteria on nodulation and grain yield of cowpea [*Vigna unguiculata* (L.) Walp]. *Annals of Plant Physiology*.**17(1)**:78-80.

Reddy, S., Jitendra, K. M., Thenua, O.V.S. and Jat, H.S. (2005). Effect of phosphorus and bio fertilizer on productivity nutrient uptake and economics of black gram. *Legume Res*., **36(1)**: 41-48.

Sammauria, R. and Yadav, R.S. (2008). Effect of phosphorus and zinc application ofgrowth and yield of Black gram and their residual effect on succeeding pearl millet (*Pennisetum graucum*) under irrigated conditions of North West Rajasthan. *Indian Journal of Agricultural Sciences*, **78**: 61-64.

Sharma SN, Prasad R, Shivay YS, Dwivedi MK, Kumar S, Kumar D. (2009). Effect ofrates and sources of phosphorus on productivity and economics of black gram as influenced by crop-residue incorporation. Indian Journal of Agronomy.;**54(1)**:42-6.

Shroti, S.K., Pathak, A., Tiwari, A., Gupta, A. and Chauhan, S.K. (2018). Morphological, physiological and yield analysis of black gram under different levels ofFYM, PSB and phosphorus. International Journal of Chemical Studies 6(3): 403-411.

Sohel, M. H., Miah, M. R., Mohiuddin, S. J., Islam, A. K. M. S., Rahman, M. M. andHaque, M. A. (2017). Correlation and path coefficient analysis of black gram (*vigna mungo* l.). *Journal of bioscience and agriculture research*. **07(02):** 621-629.

Subbiah BV, Asiija EC. (1956). A rapid procedure for estimation of available nitrogen in soil. Current Science.**25(8)**:259-60.

Toth SJ, Prince AL. (1949). Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. Soil Sci.**67 (6)**:439-46.

Walkley A, Black IA. (1947). Estimation of soil organic carbon by the chromic acid titration method. Soil Sci.**47**:29-38.

Wilcox LV. (1950). Electrical conductivity. Water Works Assoc.**42(8)**:775-6.