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RS Bochalya
Ph.D., Scholar, Division of Agronomy, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

AK Gupta
Chief Scientist, Department of Agronomy, FSR, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

BC Sharma
Professor and Head, Division of Agronomy, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

R Puniya
Chief Scientist, Department of Soil Science, FSR, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

NP Thakur
Scientist, Department of Agronomy, AICRP-Weed Management, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

Manish Sharma
Professor and Head, Division of Statistics and Computer Science, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

Praveen Singh
Assistant Professor, Division of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

Corresponding Author:
RS Bochalya
Ph.D., Scholar, Division of Agronomy, Sher-e-Kashmir University of Agricultural Science and Technology, Chatha, Jammu and Kashmir, India

Residual effect of biofertilizer consortium and foliar nutrition on soil chemical properties after harvest of black gram crop as affected by different fertility levels under subtropical condition of Jammu

RS Bochalya, AK Gupta, BC Sharma, R Puniya, NP Thakur, Manish Sharma and Praveen Singh

Abstract
Field experiments were conducted during summer season of 2018-19 and 2019-20 at the Research Farm, Division of Agronomy, SKUAST- J, Chatha. The soil of the experimental site was sand clay loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen but medium in phosphorus and potassium. The experiment was laid out in split -split plot design with three factors replicated thrice. Eighteen treatment combinations comprising of three fertility levels, *viz.* Control, RDF and 75% of RDF were taken as main plot treatments, two subplot treatment comprising of biofertilizer consortium *viz.*, seed treatment (1.25kg/ha) and soil application (1.25kg/ha) and three foliar application of 2% NPK (19:19:19) *viz.*, at tillering, flowering and tillering+ flowering stage as sub-sub- plot treatments. Wheat crop was sown at spacing of 20 cm with seed rate of 100 kg/ha. Half dose of nitrogen as per the treatment combination and uniform basal application of 50 kg P_2O_5 and 25 kg K_2O per hectare was applied to all the treatments through urea, DAP and MOP and the remaining nitrogen was top dressed in two equal splits at CRI and before booting stages. However, blackgram was sown after wheat to study the residual effect of treatment applied to wheat crop at spacing 30 cm with seed rate of 20 kg/ha. Application of 100% RDF along with bio-fertilizer consortium at the rate 1.25 kg/ha in soil and foliar spray of 2% solution of NPK at flowering stage to wheat showed better residual effect on soil properties in terms of organic carbon N, P and K to considerable levels from their initial value.

Keywords: Soil chemical properties, residual effect, Blackgram

Introduction
Blackgram is one of the most ancient crops among cultivated pulses. It is a multipurpose crop grown for pulse and forage purposes (Thiagarajan and Somasundaram 2019) [8]. Among the pulses, blackgram (*Vigna mungo* L.) is one of the important pulse crops grown in India which belong to the family Fabaceae sub family Papilionaceae and genus *Vigna*. Blackgram is a rich protein food. It contains about 24 percent protein, 1.74 percent fat, 3.5 percent fiber and 67 percent carbohydrates and it is rich source of calcium and iron (Kachave *et al*.2018) [4].
The importance of highly intensive crop sequence is well recognized to meet out the growing demands of ever-increasing population. To fulfil the demand of food, oil and vegetable with increasing human population, intensification of cropping sequences is essential depending on the need of the area. Oilseeds and pulses including vegetables are receiving more attention owing to higher prices due to increasing demand. Inclusion of these crops in sequence was found beneficial than cereals alone. An intensive cropping system which is not only highly productive and profitable but also stable over time and maintains soil fertility is of great importance in present conditions. It is well established that the basic requirement for stabilizing the crop productivity lies in the betterment of soil fertility. Adoption of intensive cropping system will meet the food demands of increasing population, requires high input energy, which are not only responsible for environment degradation but also increased the cost of cultivation. After the green revolution, production of crops has increased to a great extent due to the use of chemical fertilizers, but their indiscriminate use has led to soil sickness, ecological hazards and depletion of other sources of energy (Bisen *et al.* 2011) [1].

Materials and Methods
Field experiments were carried out during two consecutive *Summer* seasons of 2018-19and

2019-20 to study residual effect of biofertilizer consortium and foliar nutrition on physio-chemical properties of soil after harvest of black gram crop of summer blackgram (*Vigna Mungo*) under different fertility levels subtropical condition of Jammu at the Research Farm, Division of Agronomy, SKUAST- J, Chatha. The experimental site is situated at 32.6529° N latitude and 74.8071° E longitude at an elevation of 332 meters above mean sea level. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen but medium in phosphorus and potassium. During the crop growth period of blackgram about 137.8 mm of rainfall was received during the first year of cropping (2018-19), whereas 147.8 mm of rainfall was received during the second-year wheat crop growth period (2019-20). The experiment was laid out in split-split plot design with three factors replicated thrice. Eighteen treatment combinations comprising of three fertility levels, *viz.* Control, RDF and 75% of RDF were taken as main plot treatments, two subplot treatment comprising of biofertilizer consortium *viz.*, seed treatment (1.25kg/ha) and soil application (1.25kg/ha) and three foliar application of 2% NPK (19:19:19) *viz.*, at tillering, flowering and tillering+ flowering stage as sub-sub- plot treatments. Wheat crop was sown at spacing of 20 cm with seed rate of 100 kg/ha. Half dose of nitrogen as per the treatment combination and uniform basal application of 50 kg P_2O_5 and 25 kg K_2O per hectare was applied to all the treatments through urea, DAP and MOP and the remaining nitrogen was top dressed in two equal splits at CRI and before booting stages. However, blackgram was sown after wheat to study the residual effect of treatment applied to wheat crop at spacing 30 cm with seed rate of 20 kg/ha. The recommended dose of NPK was 100:50:25 kg/ha for wheat crop and the sources of nitrogen, phosphorus and potassium were urea, diammonium phosphate and muriate of potash, respectively. Half of the nitrogen along with full dose of phosphorus and potassium was applied at the time of sowing as basal dose. The remaining half of nitrogen was top dressed in two equal splits i.e at crown root initiation (CRI) stage and before booting of wheat crop. The experiment was conducted on same site without changing the randomization of the treatment for the successive year to assess the residual effects.

Wheat cv. HD-3086 was sown with spacing 20cm x 5cm in the third week of November and harvested in fourth week of April during both the years. The blackgram cv pant u 31 was sown with spacing 30cm x10cm.

Collection and preparation of soil samples

After land preparation, soil samples from top 15 cm depth were taken by following the two step procedure of random sampling using core sampler. The soil samples were drawn randomly from five different spots in the field before imposition of the experimental treatments. The soil samples obtained from all the spots were mixed together to form initial composite sample. The collected composite soil sample was air dried, grinded and then passed through 2 mm sieve and used for analysis of different chemical properties of experimental field. Similarly, treatment wise soil sampling was also done after harvest of the Blackgram crop.

The analysis of an initial soil samples of the experimental field for ascertaining chemical properties indicated that soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen but medium in available phosphorus and potassium.

Nutrient status of soil

After harvesting of black gram crop, treatment wise soil samples from all the plots were taken from the surface (0-15cm) for determination of pH, OC, available nitrogen, phosphorus and potassium. The samples were dried under shade, grinded and passed through 2 mm sieve and were analyzed.

Available nitrogen (kg/ha)

The available nitrogen (N) was determined by the modified alkaline permanganate method given by Subbiah and Asija (1956) [8] and was expressed in N kg per ha.

Available phosphorus (kg/ha)

The available phosphorus was determined using method defined by Olsen *et al*. (1954) [5]. The intensity of colour developed by stannous chloride was measured at 660 nm on spectrophotometer and was expressed as P_2O_5 kg/ha

Available Potassium (kg/ha)

Available Potassium was extracted with neutral normal ammonium acetate solution as described by Jackson (1973) [3] and potassium was determined by flame photometer and expressed as K_2O kg/ha.

All the observations are statistically analyzed by using the analysis of variance. The results were tested for the treatments mean by applying F-test of significance on the basis of null hypothesis (Cochran and Cox, 1957) [2]. Wherever necessary, standard errors along with critical difference at 5 per cent of significance were computed for discriminating the treatment effects for chance effects. The key for degrees of freedom used in analysis of variance (ANOVA).

Results

Chemical properties of soil after black gram crop harvest

The data presented in Table 1 indicated that different treatments and their interaction showed a non-significant influence on soil chemical properties such as pH and organic carbon in black gram after harvest stage. Among fertility levels, the higher value of pH was recorded with the treatment of 75% RDF, while the lowest pH was recorded under control. Among bio-fertilizer consortium, the highest value of pH was recorded in the soil application of bio-fertilizer consortium as compared to the seed treatment with bio-fertilizer. However, 2% NPK recorded highest value of pH at tillering + flowering stage, while the lowest pH was recorded at tillering stage under control during both the years of cultivation. Among fertility levels, numerically higher value of organic carbon was recorded under 100% RDF, while the lowest organic carbon was recorded under control. Among bio-fertilizer consortium, the highest value of organic carbon was recorded in seed treatment with bio-fertilizer consortium as compared to the soil application of bio-fertilizer consortium. Foliar application of 2% NPK recorded highest value of organic carbon at tillering + flowering stage, while the lowest organic carbon was recorded at tillering stage under control during both the years.

Available nitrogen

The data with respect to the available nitrogen in the soil is presented in Table 1 which revealed that, 100% RDF received numerically highest nitrogen content in the soil followed by 75% RDF and control. Among bio-fertilizer consortium, soil application of bio-fertilizer consortium recorded highest

nitrogen content as compared to the seed treatment with bio-fertilizer. Foliar application of 2% NPK (grade of 19:19:19) recorded highest available nitrogen at tillering + flowering stage as compared to the tillering and flowering stage

Table 1: Soil fertility with respect to pH, O.C, N, P and K as affected by fertility levels, bio-fertilizer consortium and foliar nutrition after harvest of black gram

Treatment	Soil studies									
Fertility level	pH (1:2.5)		O.C (g/kg)		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
N1 = Control	7.89	7.84	4.3	4.6	238.68	240.43	15.13	14.79	143.77	150.32
N2 = RDF (100:50:25 kg/ha)	7.86	7.82	4.5	4.9	254.36	256.80	16.58	15.35	147.58	154.10
N3 = 75% RDF	7.94	7.89	4.4	4.7	243.56	248.79	15.98	15.04	145.18	151.53
S.Em+	0.04	0.03	0.003	0.006	5.61	5.606	0.31	0.16	0.74	0.77
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plots: Bio-fertilizer Consortium										
C1 = Seed treatment (1.25 kg/ha)	7.89	7.84	4.4	4.8	242.05	246.47	15.53	14.89	145.37	151.63
C2 = Soil application (1.25 kg/ha)	7.90	7.86	4.3	4.7	249.02	250.88	16.26	15.23	145.65	152.34
S.Em+	0.04	0.04	0.004	0.01	2.29	1.86	0.30	0.11	0.43	0.54
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub Sub plots: Foliar application (2% NPK)										
F1 = Tillering stage	7.90	7.85	4.3	4.7	243.21	247.74	15.89	15.07	145.50	152.20
F2 = Flowering stage	7.87	7.82	4.4	4.8	244.96	248.44	15.98	15.12	145.46	151.39
F3 = Tillering stage and Flowering stage	7.91	7.87	4.4	4.8	248.44	249.83	15.81	15.00	145.56	152.36
S.Em+	0.03	0.04	0.004	0.004	2.81	2.58	0.12	0.07	0.31	0.43
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C × F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × C × F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Available Phosphorus

The data presented in Table 1 showed that the available phosphorus content in the soil was found to be non-significant with fertility levels, bio-fertilizer consortium and foliar application after harvest stage in black gram. Treatment of 100% RDF recorded highest phosphorus content in the soil followed by 75% RDF and control. Among bio-fertilizer consortium, soil application of bio-fertilizer consortium recorded highest available phosphorous as compared to the seed treatment with bio-fertilizer.

Foliar application of 2% NPK (grade of 19:19:19) at flowering stage recorded numerically highest available phosphorus in the soil as compared at tillering stage and tillering + flowering stage.

Available Potassium

The data with respect to the available potassium content is presented in Table 1 which showed that different fertility levels, bio-fertilizer consortium and foliar application does not showed a significant impact on the available potassium content in the soil after the harvest stage of black gram. Treatment of 100% RDF received numerically highest available potassium content in soil followed by 75% RDF and control. Among bio-fertilizer consortium, soil application of bio-fertilizer consortium recorded highest potassium content in the soil as compared to the seed treatment with bio-fertilizer. Foliar application of 2% NPK (grade of 19:19:19) at tillering recorded numerically highest available soil potassium than at flowering stage and tillering + flowering stage.

Discussion

Chemical properties of soil after harvest of black gram crop

The data presented in Table 1 indicated that different treatments and their interaction showed a non-significant contribution on soil chemical properties *viz.* pH and organic carbon of soil after harvest of black gram. Among fertility levels, pH ranged from 7.86 to 7.94 and 7.82 to 7.89 and OC ranged from 4.3 to 4.5 and 4.6 to 4.9 during 2018-19 and 2019-20, respectively, i. e. 6.85% to 6.93%, 6.81 to 6.88% and 3.3 to 3.5, 3.6 to 3.77 which was lower from initial level. Among bio fertilizer consortium, value of pH and soil organic carbon obtained ranged from 7.89 to 7.90 and 7.84 to 7.86 and OC 4.3 to 4.4 and 4.7 to 4.8 during 2018-19 and 2019-20, respectively which was 6.88 to 6.89, 6.83 to 6.85% and 3.27 to 3.4, 3.7 to 3.7 to 3.82% and was lower from the initial value. However, with 2% NPK, pH and soil organic carbon obtained ranged from 7.87 to 7.91 and 7.82 to 7.87 and OC 4.3 to 4.4 and 4.7 to 4.8 during 2018-19 and 2019-20, respectively which was 6.86 to 6.90%, 6.81 to 6.86% and 3.27 to 3.37, 3.7 to 3.8 and was found to be lower than the initial level during both the years. While during the second year, organic carbon increased from its initial value.

Available nitrogen, Phosphorus and Potassium after harvest of black gram crop

The data with respect to the available nitrogen, Phosphorus and Potassium in the soil is presented in Table 1 which revealed that, 100% RDF received numerically highest nitrogen, Phosphorus and Potassium content in the soil followed by 75% RDF and control. Varalakshmi *et al.* (2005) [9] reported that the legume cropping helped to increase the available N, P_2O_5 and K_2O content in soil. These results are in agreement with those of Sharma and Dayal (2005) [6] and Prasad who observed an increase in the residual NPK by the rice based cropping systems. These results also in line with the observations of Weijabhandara *et al.* (2011) [10] reported an increased level of residual NPK in soil and its availability to the succeeding crops. Over all the residual effects observed in the experiments were lower with control for the preceding wheat crop. This could be due to lesser nutrient availability in the plots due to nutrient losses and or mining of soil nutrient pool by the preceding crop caused much poorer effect on the

residual crop. Among bio fertilizer consortium, soil application of bio fertilizer consortium recorded highest nitrogen, Phosphorus and Potassium content as compared to the seed treatment with bio fertilizer it might be due to more mineralization and increase microbial activity in soil. Foliar application of 2% NPK (grade of 19:19:19) recorded highest available nitrogen, Phosphorus and Potassium at tillering + flowering stage as compared to the tillering and flowering stage due to more availability of nitrogen, phosphorus and potassium.

Conclusion

Application of 100% RDF along with bio-fertilizer consortium at the rate 1.25 kg/ha in soil and foliar spray of 2% solution of NPK at flowering stage to wheat showed better residual effect on soil properties in terms of organic carbon N, P and K to considerable levels from their initial value.

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