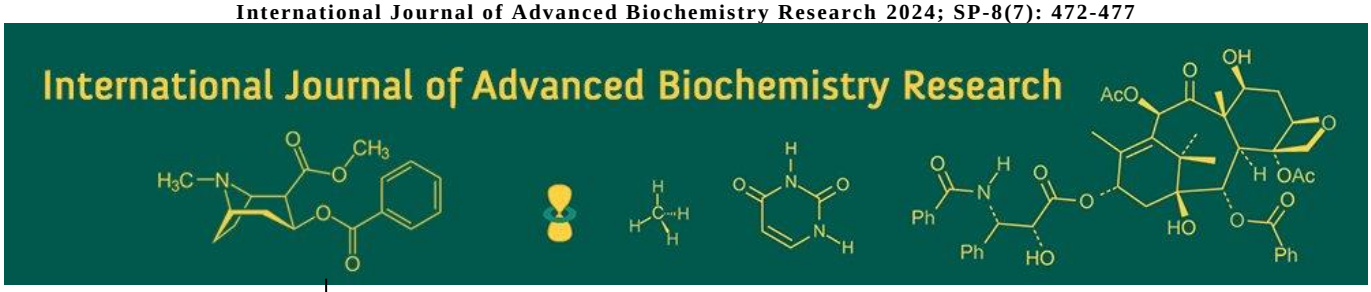

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Impact of integrated nutrient management on nutrient content and their uptake by black gram crop (*Vigna mungo* L.)

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Abstract
To study the effect of integrated nutrient management practices on nutrient content and their uptake by black gram crop, a field experiment was carried out during the *kharif* of 2023 at Research Farm of the School of Agriculture, Abhilashi University, Chail Chowk, Mandi (H.P.). The experiment was laid out in randomized block design with nine treatments and three replications. The different treatment combinations used in experiment were- T_1= Absolute control, T_2=100% RDF, T_3=100% RDF + *Rhizobium*, T_4= *Rhizobium* + 75% RDF + 25% N by FYM, T_5= *Rhizobium* + 75% RDF + 25% N by Vermicompost, T_6= *Rhizobium* + 50% RDF + 50% N by FYM, T_7= *Rhizobium* + 50% RDF + 50% N by Vermicompost, T_8= *Rhizobium* + 50% N by FYM + 50% N by Vermicompost and T_9= 50% N by FYM + 50% N by Vermicompost.
The study of data of results revealed that the application of various integrated nutrient management treatments showed non-significant effect on content of nitrogen, phosphorus and potassium, however, treatment T_3 noted highest content of these nutrients in grains and straw of black gram crop. Whereas, the application of treatment T_3 recorded the maximum uptake of nitrogen, phosphorus and potassium by grains, straw as well as total uptake by black gram crop. While, the minimum content of nitrogen, phosphorus and potassium in grains and straw of black gram along with their uptake by grains, straw and total uptake by black gram crop was found under treatment T_1 during the field experiment.

Keywords: Black gram, integrated nutrient management, biofertilizers, nutrient content and uptake

Introduction
Black gram is one of the most important legume crop and being drought tolerant and warm weather crop, it is well adopted to the drier regions of the tropics. It is grown throughout the country during both in summer and rainy seasons and contributes about 13% of total area in pulses and 10% of their total production in our country (Shashidhar *et al*., 2020) [19]. It has ability to fix the atmospheric nitrogen in the soils through its root nodules as it is a legume crop. Integrated nutrient management practices supply all the macro and micro nutrients which are required by crop for balanced nutrition (Patil *et al*., 2010) [18].
Black gram is one of the major pulse crops cultivated in India. Being a crop with a short growing season, it fits very well with the cropping system since it clears the field quickly, allowing numerous winter crops- like mustard, lentils, and others-to be cultivated in areas with minimal rainfall. In India, produces approximately 2.7 million tonnes from an approximately 4.4 m ha^{-1} area with an average yield of 598 kg ha^{-1} (Directorate of Economics and Statistics, 2021) [6]. It is mostly grown in southern and eastern states of India. In India black gram predominantly grown in Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh, Punjab, Orisa, Bihar, Uttar Pradesh and West Bengal (Nair *et al*. 2023) [17]. India is the biggest producer and user of black grams worldwide. With an average output of 501 kg per hectare in 2020–21, it produces roughly 23.4 lakh tons of black gram yearly from 46.7 lakh hectares of area (agricoop.in). Andhra Pradesh produced 3.65 lakh tons of black gram on 3.93 lakh ha^{-1} of land (des.ap.gov.in). The second advance estimate for 2021-2022 states that black gram was cultivated on 3.93 lakh ha^{-1}, producing 3.65 lakh tons and 929 kg ha^{-1} of productivity (2-BLACKGRA_January to December 2021, n.d.)

Lower productivity of black gram is due to use of sub-optimal rate of fertilizers, poor management and cultivation in marginal and sub-marginal lands. Moreover, the use of chemical fertilizers resulted in deterioration of soil fertility (Masu *et al*., 2019 [13]. The existing blanket recommendation for crops does not ensure efficient and economic use of fertilizers, as it does not take into account of the fertility variations resulting in imbalanced use of fertilizer nutrients (Singh, 2018) [20]. The nutrient management and legume-based cropping system also tremendously benefit the sustenance of soil health (Sreedevi *et al*., 2018) [22]. The alternate source of nutrients other than the conventional inorganic sources in an integrated manner, is highly needed for sustained pulses productivity (Chaudhary *et al*., 2019 [2]. There is immense scope for improving the production potential of black gram by use of organic manures, inorganic manures and biofertilizers (Verma *et al*., 2017) [24]. Integrating mineral fertilizers with organic manures offer an environmentally safe, economically sound, socially reasonable and ecologically sustainable production system (Midya *et al*., 2021) [15]. Applications of integrated nutrient management practices involving organic manures like FYM, biofertilizers and inorganic chemical fertilizers is a better way to achieve higher seed yield and yield attributes and to improve physico-chemical and biological properties of the soils (Chhaya and Jain, 2014) [3]. Application of different organic-cum-inorganic sources of nutrients is effective for higher yield, better economy and improved soil fertility status (Nagar *et al*., 2016) [16]. Among the various methods of fertilizer recommendations, the soil test-based fertilizer recommendations are also appropriate practices to improve yield as well as soil nutrient status (Gayathri *et al*., 2009) [7]. Thus, there is a scope for improving the production potential of the crops by using inorganic fertilizers and bio-fertilizers. Application of *Rhizobium* with seed priming significantly increased nodulation (Basumatary *et al.*, 2018) [1] which resulted in significant atmospheric nitrogen fixation in soils.

Organic manures provide a good substrate for the growth of micro-organisms and maintain a favorable nutrient supply environment and improve soil physical properties. Biofertilizer is the products containing one or more carrier-based living species of microorganism. The living micro-organism is capable to augment plant nutrient supplies in one way or other way. Integration of manures and Biofertilizer with inorganic fertilizer proved to be better for higher crop yield as well as maintain the soil health (Singh *et al*. 2011) [21]. Keeping in view such things this field experiment was laid out with an objective to study the effect of integrated nutrient management practices on nutrient content and their uptake by the black gram.

Materials and Methods

The experiment was carried out at Research farm of the School of Agriculture, Abhilashi University, Chail Chowk, Mandi (H.P) during the *kharif* of 2023. The experimental farm is situated at 30^0 32' N latitude and 74^0 53'E longitude, with an elevation of 1391 m above mean sea level. The pH of the experimental field was slightly acidic in reaction (5.6) with electrical conductivity of 0.010 dS m^{-1}, high in organic carbon (0.76%), medium in nitrogen (242.83 kg ha^{-1}), medium in phosphorus (21.38 kg ha^{-1}) and medium in potassium (280.61 kg ha^{-1}). The experiment was laid out in randomized block design (RBD) with nine treatments and three replications. The treatments used in the experiment were- T_1 = Absolute control, T_2 = 100% RDF, T_3 = 100% RDF + *Rhizobium*, T_4 = *Rhizobium* + 75% RDF + 25% N by FYM, T_5 = *Rhizobium* + 75% RDF + 25% N by Vermicompost, T_6 = *Rhizobium* + 50% RDF + 50% N by FYM, T_7 = *Rhizobium* + 50% RDF + 50% N by Vermicompost, T_8 = *Rhizobium* + 50% N by FYM + 50% N by Vermicompost and T_9= 50% N by FYM + 50% N by Vermicompost. The recommended doses of nitrogen, phosphorous and potassium was 20:40:20 kg ha^{-1} which was applied through Urea, DAP and MOP. The various fertilizers applications and organic manures was done according to the treatments. The application of chemical fertilizers was given as basal application; however, organic manures was applied about two weeks earlier before of sowing of crop. After the harvest of the crop, the samples of the crop plant were collected from every net plot and were cleaned and dried under the shade. After the drying of the samples under shade, the samples were oven-dried at 60 ± 2 °C for 24 to 48 hours until their weight was constant and then samples were finely powdered with a mixer grinder. After the grinding process, the samples were used for the analysis of nitrogen, phosphorous and potassium content in grains and straw of black gram crop. The Kjeldahl digestion and distillation method was used to determine the nitrogen content described by Jackson, 1973 [9]. The vanadomolybdate phosphoric yellow color method was used for determining the phosphorus content given by Jackson, 1973 [9]. The flame photometer method was used for determining the potassium content given by Jackson, 1973 [9]. The nitrogen, phosphorous and potassium uptake (kg ha^{-1}) by grains and straw of black gram crop in each treatment was calculated by multiplying the nitrogen, phosphorous and potassium content (%) with yields of grains and straw (q ha^{-1}). The total uptake of different nutrients was calculated after summing their uptake by grain and straw of black gram crop.

Results and Discussion

Nitrogen content (%) and uptake (kg ha^{-1})

The nitrogen content in grains, straw and their uptake by black gram crop is presented in Table - 1 and depicted in Fig.-1. The study of data showed the content of nitrogen in grains and straw was found to be non-significant with applications of the different integrated nutrient management practices. Whereas, the nitrogen uptake of grains and straws and total uptake by black gram crop was significantly affected by the application of different integrated nutrient management treatments.

The impact of different integrated nutrient management practices showed nonsignificant differences for the content of nitrogen in grains and straw of black gram crop, however, maximum nitrogen content in grains and straw of black gram crop were found under the treatment T_3 (100% RDF + *Rhizobium*), whereas, the minimum content of the nitrogen in grains and straw of black gram crop were noted with the applications of treatment T_1 (Absolute control) during the field experiment.

The uptake of nitrogen by grains and straw along with their total uptake by black gram crop was recorded maximum under treatment T_3= (100% RDF + Biofertilizers) and it was statistically at par with treatment T_2 (100% RDF) and T_5 (*Rhizobium* + 75% RDF + 25% N by Vermicompost). However, the minimum nitrogen uptake by grains and straw as well as total uptake by black gram crop was recorded

under treatment T_1= (Absolute control) during the field experiment.

The nitrogen uptake by grains and straw of black gram increased significantly with the application of integrated nutrient management. The reason for the increase uptake of nitrogen is balanced supply of nutrients, improving soil health, limiting nutrient losses and microbial activity. Integrated use of fertilizer with organic manures improves soil structure, water holding capacity and reduce nitrogen losses through leaching which promote better root growth, more available nitrogen in the root zone and improve efficiency of nitrogen uptake. Whereas, biofertilizer build synergistic relationship with black gram plants that enable the plant to directly absorb nitrogen from the atmosphere or from soil organic matter resulting in improving nitrogen uptake. Similar results also reported by Makwana *et al*. (2020) [12], Kalaiyarasi *et al*. (2019) [10] and Masu *et al*. (2019) [13].

Phosphorus content (%) and uptake (kg ha^{-1})

The data regarding phosphorus content, uptake and their total uptake is described in Table- 2 and illustrated in Fig.- 2. The analysis of the data revealed that the phosphorus content of black gram crop was didn't affect significantly with the various application of treatments. However, phosphorus uptake by grains and straw along with their total uptake was varied significantly under various treatment conditions.

The integration of integrated nutrient management on phosphorus content in grains and straw of black gram crop was found non-significant. The treatment T_3= (100% RDF + *Rhizobium*) was noted the highest phosphorus content in grains and straw. While, the treatment T_1= (Absolute control) was noted lowest phosphorus content during the field experiment.

The 100% RDF and biofertilizers were considerably increase the phosphorus uptake of black gram crop. The highest phosphorus uptake by grains and straw as well as their total uptake was recorded under treatment under T_3= (100% RDF + *Rhizobium*) which was statistically on par with treatment T_2= (100% RDF) and T_5= (*Rhizobium* + 75% RDF + 25% N by Vermicompost). Whereas, the lowest phosphorus uptake by grains and straw and their total uptake was recorded under treatment T_1= (Absolute control).

The integrated nutrient management found the maximum content and uptake of phosphorus and was more effective than control treatment in promoting phosphorus uptake in black gram. Integrated nutrient management improves phosphorus uptake in black gram by enhancing soil health, raising phosphorus availability through microbial activity balancing nutrient supply and decreasing phosphorus fixation. Organic material improves soil structure and microbial activity, as a result they create a favourable environment for root growth which increase the process of scouring the soil for phosphorus. Use of combination of chemical fertilizer, biofertilizer and organic sources provide balanced supply of nutrients, including phosphorus. By providing sufficient amounts of phosphorus throughout the black gram growth stages resulting in increasing phosphorus uptake by grains and straw. Danga *et al*. (2022) [4], Meera *et al*. (2022) [14] and Gosh *et al*. (2011) [8] also noted the similar finding related to this study.

Potassium content (%) and uptake (kg ha^{-1})

The perusal of data regarding potassium content, uptake and their total uptake are given in Table- 3 and displayed in Fig.- 3. The application of different treatments doesn't vary the potassium content in grains and straw of black gram crop. While, the application of 100% RDF and biofertilizers were considerably varied the potassium uptake of black gram crop.

The effect of integrated nutrient management on potassium content was found nonsignificant. However, among the various treatment applications, the treatment T_3= (100% RDF + *Rhizobium*) was observed the maximum potassium content in grains and straw and minimum potassium content was recorded under treatment T_1= (Absolute control) during the field trail.

The integrated nutrient management practices were substantially increasing the uptake of potassium by grains and straw of black gram crop. The treatment T_3= (100% RDF + *rhizobium*) was observed the maximum potassium uptake by grains and straw along with their total uptake. The treatment T_3 was statistically at par with treatment T_2= (100% RDF) and T_5= (*Rhizobium* + 75% RDF + 25% N by Vermicompost). While, the treatment T_1= (Absolute control) was noted the minimum potassium uptake by grains and straw as well as their total uptake of black gram crop.

The use of chemical fertilizer and organic manures may have improved the soil's physical chemical and biological characteristics and improved in the absorption and uptake of potassium. The integration of both organic and inorganic fertilizers might be resulted in more uptake of potassium as compared to sole use of organic or inorganic fertilizers and control. This may be due to the fact that the balanced and combined use of various plant nutrient sources results in proper absorption, translocation and assimilation of those nutrients, ultimately increasing the dry matter accumulation and nutrient contents of plant and thus showing more uptake of potassium by black gram crop. These results are in conformity with the findings of Yuganthra *et al*. (2023) [25], Desai *et al*. (2020) [5] and Tyagi *et al*. (2019) [23].

Table 1: Effect of integrated nutrient management practices on nitrogen content (%) and their uptake (kg ha^{-1}) by black gram crop

S. N.	Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		
		Grain	Straw	Grain	Straw	Total
T_1	Absolute control	3.27	1.02	13.93	10.56	24.49
T_2	100% RDF	3.81	1.23	50.25	34.72	84.97
T_3	100% RDF + *Rhizobium*	3.84	1.25	52.92	36.31	89.23
T_4	*Rhizobium* + 75% RDF + 25% N by FYM	3.75	1.17	44.89	29.76	74.65
T_5	*Rhizobium* + 75% RDF + 25% N by Vermicompost	3.77	1.19	47.87	31.96	79.83
T_6	*Rhizobium* + 50% RDF + 50% N by FYM	3.68	1.11	36.25	22.94	59.19
T_7	*Rhizobium* + 50% RDF + 50% N by Vermicompost	3.71	1.13	38.51	23.79	62.3
T_8	*Rhizobium* + 50% N by FYM + 50% N by Vermicompost	3.66	1.08	31.51	18.48	49.99
T_9	50% N by FYM + 50% N by Vermicompost	3.63	1.07	29.29	17.75	47.04
	SEm±	*0.25*	*0.27*	*2.53*	*2.21*	*5.39*
	CD (P=0.05)	*NS*	*NS*	*5.37*	*4.69*	*11.43*

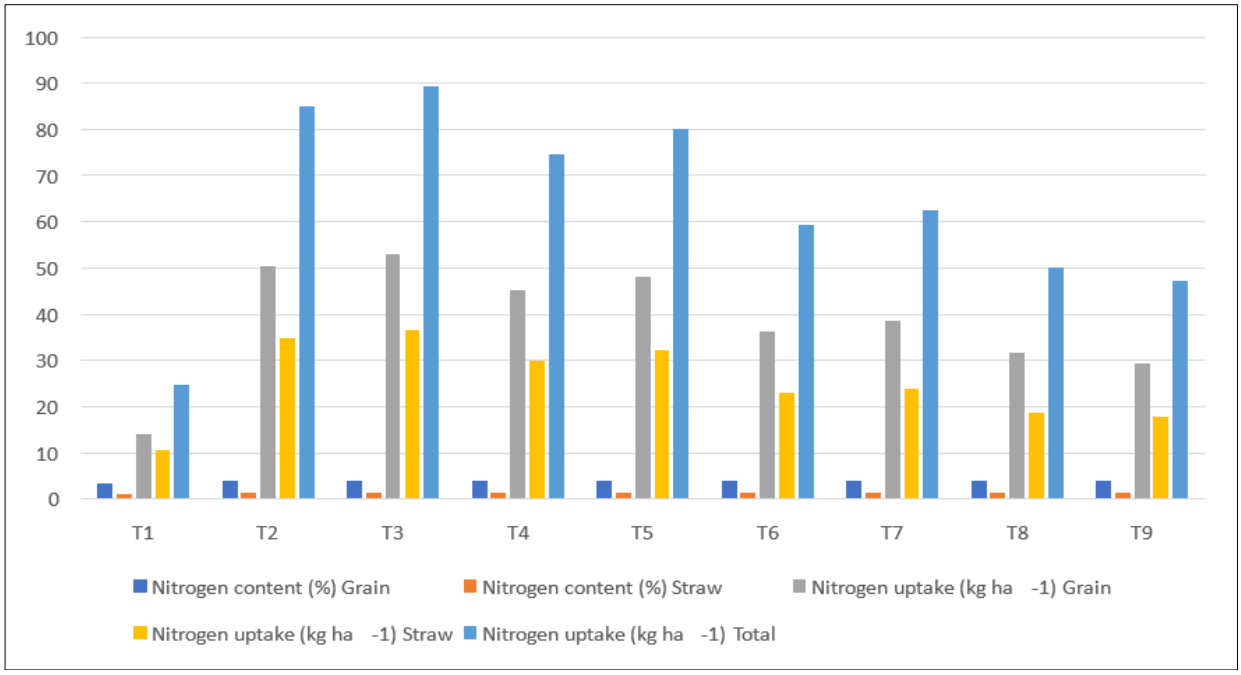

Fig 1: Effect of integrated nutrient management practices on nitrogen content (%) and their uptake (kg ha^{-1}) by black gram crop

Table 2: Effect of integrated nutrient management practices on phosphorus content (%) and their uptake (kg ha^{-1}) by black gram crop

S.N.	Treatments		Phosphorus content (%)		Phosphorus uptake (kg ha^{-1})	
		Grain	Straw	Grain	Straw	Total
T_1	Absolute control	0.37	0.13	1.58	1.31	2.89
T_2	100% RDF	0.50	0.30	6.60	8.47	15.07
T_3	100% RDF + *Rhizobium*	0.52	0.31	7.17	9.01	16.18
T_4	*Rhizobium* + 75% RDF + 25% N by FYM	0.43	0.26	5.15	6.61	11.76
T_5	*Rhizobium* + 75% RDF + 25% N by Vermicompost	0.46	0.28	5.84	7.52	13.36
T_6	*Rhizobium* + 50% RDF + 50% N by FYM	0.40	0.23	3.94	4.72	8.66
T_7	Rhizobium + 50% RDF + 50% N by Vermicompost	0.42	0.23	4.36	4.84	9.20
T_8	Rhizobium + 50% N by FYM + 50% N by Vermicompost	0.39	0.20	3.36	3.42	6.78
T_9	50% N by FYM + 50% N by Vermicompost	0.39	0.18	3.15	2.99	6.14
	SEm±	0.05	0.04	0.65	0.74	1.44
	CD (P=0.05)	NS	NS	1.39	1.56	3.05

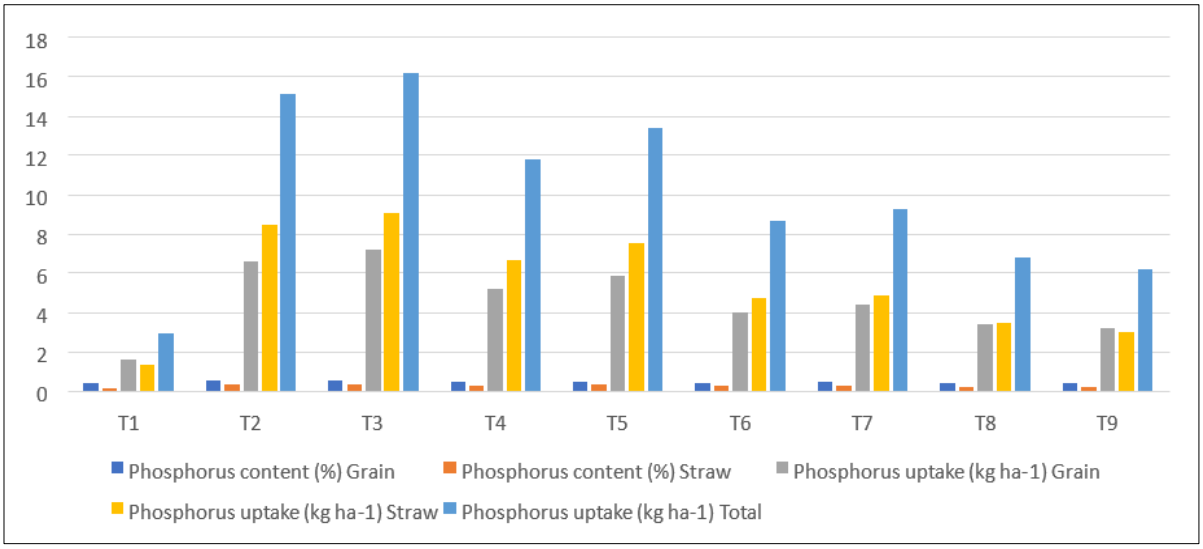

Fig 2: Effect of integrated nutrient management practices on phosphorus content (%) and their uptake (kg ha^{-1}) by black gram crop

Table 3: Effect of integrated nutrient management practices on potassium content (%) and their uptake (kg ha^{-1}) by black gram crop

S.N.	Treatment		Potassium content (%)		Potassium uptake (kg ha^{-1})		
		Grain	Straw	Grain	Straw	Total
T_1	Absolute control	1.09	2.20	4.64	22.77	27.41
T_2	100% RDF	1.30	2.46	17.15	69.45	86.60
T_3	100% RDF + *Rhizobium*	1.34	2.49	18.47	72.33	90.80
T_4	*Rhizobium* + 75% RDF + 25% N by FYM	1.25	2.40	14.96	61.06	76.02
T_5	*Rhizobium* + 75% RDF + 25% N by Vermicompost	1.28	2.42	16.25	65.00	81.25
T_6	*Rhizobium* + 50% RDF + 50% N by FYM	1.19	2.34	11.72	48.37	60.09
T_7	*Rhizobium* + 50% RDF + 50% N by Vermicompost	1.21	2.37	12.56	49.89	62.45
T_8	*Rhizobium* + 50% N by FYM + 50% N by Vermicompost	1.15	2.32	9.90	39.70	49.60
T_9	50% N by FYM + 50% N by Vermicompost	1.11	2.29	8.96	37.99	46.95
	SEm±	0.07	0.29	1.22	3.78	5.04
	CD (P=0.05)	NS	NS	2.59	8.01	10.68

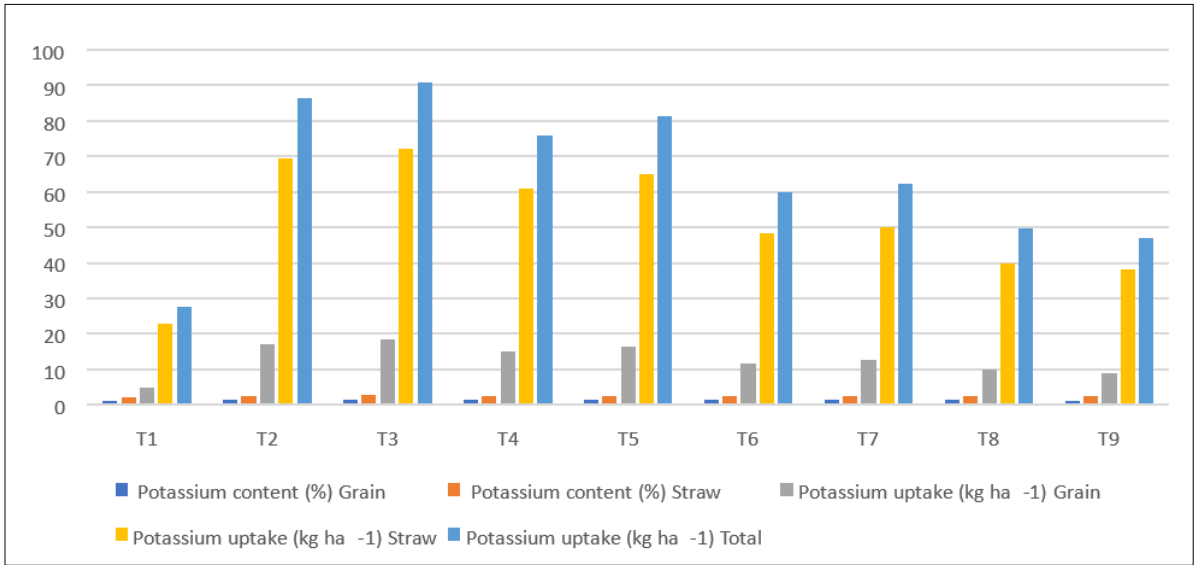

Fig 3: Effect of integrated nutrient management practices on potassium content (%) and their uptake (kg ha^{-1}) by black gram crop

Conclusion

The content of nitrogen, phosphorus and potassium in the grains and straw of the black gram crop was found to be non-significant with the different integrated nutrient management practices during the field experiment. But, the nitrogen, phosphorus and potassium uptake by grains and straw as well as the total uptake was found to be significant during various nutrient management practices in black gram crop in field experiment. The maximum nutrient uptake of nitrogen, phosphorus and potassium in the grains and straw along with their total uptake by black gram crop was found under treatment T_3= (100% RDF + *Rhizobium*). The treatment T_3 was at par with treatment T_2 and T_5 for nitrogen, phosphorus and potassium nutrient uptake in grains and straw as well as, their total uptake by black gram crop under different integrated nutrient management practices. In conclusions, the integrated nutrient management practices highlight its promising role in promoting enhanced nutrient utilization by the black gram crop. These findings provide valuable insights for future research and agricultural strategies, emphasizing the importance of considering micronutrient interventions for nutrient content and their uptake by transplanted rice crop.

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