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Effect of fertility levels, biofertilizers and organic manure on nutrient uptake by sorghum fodder and its residual effect on barley

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Abstract
A field experiment was conducted on clay loam soil at Instructional Farm, Rajasthan College of Agriculture, Udaipur during two consecutive *kharif* season of 2014 & 2015 and *rabi* seasons of 2014-15 & 2015-16. The objectives were to assess effect of fertility levels, biofertilizer and organic manure on yield of fodder sorghum and to evaluate the residual effect of these on succeeding barley crop. Application of 100 % RDF to fodder sorghum registered highest N, P, K uptake by dry fodder which was significantly higher over lower fertility levels. The magnitude of increases in N, P and K uptake was to the tune of 11.1, 13.5, 8.3 per cent over 75 % RDF and 27.7, 29.3, 18.8 per cent over 50 % RDF, respectively. The crop inoculated with *Azotobacter* + PSB accumulated higher quantum of N, P and K by dry fodder as compared to inoculation of PSB and *Azotobacter* alone. Application of vermicompost to sorghum registered highest N,P,K and its uptake by dry fodder over no manure. Crop under residual effect of 100% RDF also accumulated highest quantum N, P and K in dry fodder. The barley crop accumulated highest quantum of N, P and K in dry fodder.

Keywords: Nutrient uptake, sorghum, barley, residual effect, fertility levels, biofertilizer, organic manure

Introduction
In Indian agriculture, livestock plays vital role in the development and progress of mankind with crop production programmers as a complementary enterprise, India is basically an agriculture country and about 70 per cent of its people live in villages. Limited supply with poor quality of fodder is considered as major limiting factor for the livestock industry in India. Importance of increasing the milk yield per animal through better health care and balanced feed and fodder supply has been relished by the farmers who have so far been growing fodder crops with traditional systems resulting in low productivity of fodder. The availability of green and dry fodder is in deficit on an average to the extent of 40 per cent, which may further increase to the extent to 45.0 per cent in 2025. There is an urgent need to narrow down the gap between demand and supply of good quality fodder to improve health and productivity of vast livestock population in India by enhancing production and productivity of forage crops especially forage sorghum. Forage sorghum being the major fodder crop in *kharif*, which meets 60% demand of livestock in India. Amongst the nutrients, nitrogen plays an important role in the growth and development of crop plants. Nitrogen is essential constituent of protein and chlorophyll, it imparts dark green colour to the plants, promotes shoot elongation tillering and regeneration after defoliation. Nitrogen fertilization lowers the fibre, lignin and NDF content of forage, thereby improves succulence and palatability of fodder crops. Nitrogen is removed by plants in comparatively larger amounts coupled with greater volatilization and leaching losses. Several studies showed that application of nitrogen fertilizer increased the green and dry fodder yields of sorghum (Meena, 2012) [8]. After nitrogen, phosphorus has key role to the play in plant metabolism. It is most essential for all living creatures for their growth and development. The effectiveness of phosphorus nutrition is depends on various factors namely soil type, agro climatic condition, crop and its growth habit, *etc*. Though sorghum has extensive root system and explores a large volume of soil, it shows greater response to applied phosphorus. Likewise a potassium acts as a chemical traffic police man, root booster, stalk strengthener, food former, sugar and starch transport, protein builder, breathing regulator, water stretcher and as a disease retarder (Brady and Well, 2007) [1] thus improve quality of fodder.

The optimum does of NPK is dependent for several factors like soils, crop, environment and crop growing situations, it is therefore, imperative to work out economically viable dose for the fodder sorghum for agro climatic zone IVa.

Materials and methods

A field experiment was conducted during consecutive *kharif* and *rabi* seasons of 2014-15 and 2015-16. The details of experimental procedure, techniques followed and materials used for both the sorghum and barley crops. The experiment consisted of 18 treatments combinations comprising three fertility levels (50, 75 and 100% RDF), biofertilizer (*Azotobacter* + PSB, *Azotobacter* and PSB) and organic manure (no manure and vermicompost 5 t ha^{-1}). These treatments were evaluated in factorial randomized block design with three replications. The sorghum crop was fertilized with recommended dose of fertilizer *i.e.* 80 kg N+ 40 kg P_2O_5+ 40 kg K_2O ha^{-1} (100% RDF). The sorghum seeds were inoculated with biofertilizer before sowing. The vermicompost was incorporated in soil one month before sowing. Fodder sorghum cv. "PC-1080" and barley cv. "RD-2715" was sown as per recommended package of practices.

Result and Discussion

Nitrogen

Irrespective of years as well as on pooled basis, nitrogen, phosphorus and potassium uptake by dry fodder was significantly influenced due to fertility levels (Table 1). The maximum nitrogen, phosphorus and potassium uptake by dry fodder was estimated under the influence of 100 % RDF which was significantly higher over application of 75 and 50 % RDF during both years. Thus when compared to mean nitrogen, phosphorus and potassium uptake realized under application of 75 and 50% RDF, sorghum crop fertilized with 100 % RDF significantly improved it by 11.08, 13.47, 8.27 and 27.72, 29.26, 18.83 per cent, respectively. It is well established fact that uptake of nutrients by the crop is primarily governed by total biomass production and secondarily on account of nutrient status at cellular level. Thus, improvement in both these under 100% RDF application resulted in higher uptake of added nutrients. The result confirms the findings of Yadav (2014) [11], Kumar and Chaplot (2015) [5], Yadav and Singh (2016) [12], Meena *et al.* (2017) [7].

The fodder produced under the influence of *Azotobacter* + PSB co-inoculation accumulated maximum nitrogen, phosphorus and potassium which was significantly higher over inoculation of PSB and *Azotobacter* alone during both years as well as in pooled analysis (Table 1). Thus when compared to mean nitrogen, phosphorus and potassium accumulation by dry fodder under the influence of PSB and *Azotobacter* inoculation alone, dual inoculation of *Azotobacter* + PSB significantly increased nitrogen, phosphorus and potassium uptake by 11.66, 11.46, 20.22 and 12.92, 9.10, 9.57 per cent, respectively. The positive influence of biofertilizer inoculation seems to be due to increase in growth of above ground plant parts due to secretion of growth promoting substances which might have maintained adequate supply of metabolotes for enhancing root growth and their functional activities, thereby, greater extraction of nutrients from soils and their efficient translocation in the plant system. These findings are in close conformity with the findings of Dadarwal *et al.,* (2009) [3], Suke *et al.,* (2011) [10] and Singh *et al.* (2012) [9].

Further, sorghum fodder produced under the application of 5 t vermicompost ha^{-1} accumulated significantly higher nitrogen, phosphorus and potassium compared to no manure during both years as well as in pooled analysis. On the mean basis, vermicompost application significantly enhanced nitrogen, phosphorus and potassium uptake by dry fodder to the tune of 13.90, 15.10 and 13.02 per cent over no manure. Significant increase in uptake of nutrients (N, P and K) with the application of vermicompost seems to be due to fact that uptake of nutrients is product of biomass accumulated by crop and its nutrient content. Thus, positive impact of vermicompost on both these aspects ultimately led to higher accumulation of nutrients. The results indicating better nutritional status of plant with vermicompost fertilization are in close conformity with the findings of Singh *et al.* (2012) [9] and Kumar and Chaplot (2015) [5].

Nutrient uptake by residual barley

During each year, fertilizer applied to sorghum crop had significant residual effect on nitrogen, phosphorus and potassium uptake by barley fodder (Table 2). Barley crop raised under residual fertility level 100 % RDF significantly improved nitrogen, phosphorus and potassium uptake by dry fodder over 50 % RDF during both years. Further difference in nitrogen, phosphorus and potassium uptake by fodder due to residual effect of fertility levels between 100 & 75 and 75 & 50 % RDF was not significant. The pooled results indicate that residual effect of 100 % RDF significantly improved nitrogen, phosphorus and potassium uptake by dry fodder to the tune of 8.08, 8.38 and 7.72 per cent over 50 % RDF, respectively. The positive influence of residual fertility levels of 100% RDF on nutrient status of plant parts seems to be due to their increased availability in the root zone. Moreover, increase in shoot growth as evident from higher accumulation of dry matter under the influence of residual 100% RDF, further reveals that there was adequate supply of photosynthates from shoot to root. This might have promoted growth of roots as well as their functional activity leading to higher extraction of nutrients to soil to plant parts. The results are in close agreements with the findings of several researchers (Choudhary *et al.,* 2014, Devi *et al.,* 2015 and Kumar, 2017) [2, 4, 6]. Further residual effect of biofertilizer did not registered significant increase in nitrogen, phosphorus and potassium uptake by dry fodder of barley crop during both the years of study and pooled analysis (Table 2).

The barley fodder produced under the residual effect of vermicompost accumulated significantly higher nitrogen, phosphorus and potassium over no manure treatment during both years as well as in pooled analysis. On pooled basis, vermicompost applied to preceding crop significantly increased nitrogen, phosphorus and potassium uptake by barley fodder to the tune of 6.42, 6.91 and 6.38 per cent over no manure. Barley crop raised under residual vermicompost accumulated the highest quantum of nutrients in dry fodder, grain and straw (Table 4.2.8 and 4.2.11). These improvement primarily seems to be on account of enrichment of these nutrients in soil ecosystem, secondly it can be attributed to their efficient extraction/ translocation due to increase in root ramification/activities as vermicompost play vital role in maintaining physic-chemical and biological properties of soil because organic manure has long residual effect of 2-3 years.

Table 1: Effect of integrated nutrient management on nutrient uptake by dry fodder of sorghum

Treatments	Nutrient uptake (kg ha^{-1})								
	Nitrogen			Phosphorus			Potassium		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Fertility levels									
50% RDF	79.48	83.38	81.43	17.74	18.77	18.25	153.77	159.63	156.70
75% RDF	90.99	96.26	93.63	20.19	21.38	20.79	168.71	175.27	171.99
100% RDF	101.70	106.32	104.01	22.97	24.21	23.59	183.65	188.77	186.21
S.Em.±	1.572	2.154	1.333	0.372	0.459	0.295	2.512	3.572	2.183
C.D. (P=0.05)	4.517	6.190	3.762	1.068	1.318	0.833	7.219	10.266	6.161
Biofertilizers									
Azotobacter	86.92	90.81	88.86	18.60	19.58	19.09	163.94	168.24	166.09
PSB	87.92	91.80	89.86	20.03	21.14	20.59	164.63	169.00	166.81
Azotobacter + PSB	97.33	103.35	100.34	22.26	23.64	22.95	177.55	186.43	181.99
S.Em.±	1.572	2.154	1.333	0.372	0.459	0.295	2.512	3.572	2.183
C.D. (P=0.05)	4.517	6.190	3.762	1.068	1.318	0.833	7.219	10.266	6.161
Organic manure									
No manure	84.55	89.41	86.98	18.69	20.12	19.41	158.10	164.19	161.14
Vermi-compost 5 t ha^{-1}	96.90	101.23	99.07	21.91	22.78	22.34	179.32	184.92	182.12
S.Em.±	1.283	1.759	1.089	0.303	0.374	0.241	2.051	2.916	1.783
C.D. (P=0.05)	3.688	5.054	3.072	0.872	1.076	0.680	5.894	8.382	5.031

Recommended dose of fertilizers (RDF) 80 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}.

Table 2: Residual effect of integrated nutrient management on nutrient uptake by barley fodder

Treatments	Nutrient uptake (kg ha^{-1})								
	Nitrogen			Phosphorus			Potassium		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Fertility levels									
50% RDF	37.40	39.61	38.51	13.78	14.37	14.08	25.74	26.89	26.31
75% RDF	38.97	41.10	40.04	14.32	15.02	14.67	26.81	27.88	27.35
100% RDF	40.93	42.31	41.62	15.10	15.42	15.26	28.05	28.63	28.34
S.Em.±	0.770	0.620	0.494	0.249	0.222	0.167	0.467	0.368	0.297
C.D. (P=0.05)	2.214	1.783	1.395	0.715	0.638	0.471	1.343	1.056	0.839
Biofertilizers									
Azotobacter	38.69	40.43	39.56	14.29	14.74	14.51	26.68	27.44	27.06
PSB	39.03	40.70	39.87	14.34	14.81	14.57	26.75	27.57	27.16
Azotobacter + PSB	39.58	41.89	40.74	14.58	15.26	14.92	27.17	28.39	27.78
S.Em.±	0.770	0.620	0.494	0.249	0.222	0.167	0.467	0.368	0.297
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Organic manure									
No manure	37.40	40.22	38.81	13.73	14.64	14.18	25.69	27.28	26.49
Vermi-compost 5 t ha^{-1}	40.80	41.80	41.30	15.07	15.24	15.16	28.05	28.32	28.18
S.Em.±	0.629	0.506	0.404	0.203	0.181	0.136	0.381	0.300	0.243
C.D. (P=0.05)	1.808	1.455	1.139	0.584	0.521	0.384	1.096	0.863	0.685

Recommended dose of fertilizers (RDF) 80 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}.

Conclusion

Based on results emanated from the present investigation, it is inferred that sorghum crop fertilized with 100% RDF, 5 t vermicompost ha^{-1} and *Azotobacter* + PSB inoculation improve the soil status and ultimately increase the productivity of fodder sorghum as well as barley crop.

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