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Residual effect of fertility levels, biofertilizers and organic manure on yield attributing parameters in fodder sorghum-barley cropping sequence in southern plain and Aravalli hills of Rajasthan

Amit Kumar, PC Chaplot, HS Purohit and Urmila

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. The results showed that single cut sorghum fertilized with 100% RDF (80 kg N+40 kg P2O5 + 40 kg K2O) gave higher crop productivity in terms of green (36.02 t ha^{-1}) and dry (11.34 t ha^{-1}) fodder yield representing increases of 6.0, 12.4 and 7.3, 15.7 per cent over application of 75 and 50% RDF, respectively. Dual inoculation of sorghum seed with *Azotobacter* + PSB significantly improved green and dry fodder yield by 6.3, 8.3 and 8.8, 9.4 per cent over single inoculation of PSB and Azotobacter, respectively. Consequently manuring with vermicompost produced highest green and dry fodder yield by 35.6 and 11.1 t ha-1 over no manure, respectively. The results of residual effect of fertility level revealed that application of 100% RDF to fodder sorghum crop had residual effect on barley resulted highest green and dry fodder yield representing increase of 13.5 and 2.4 q ha^{-1} over 50% RDF, respectively. The barley crop under residual effect of vermicompost significantly improved growth and productivity in terms of green & dry fodder yield as compared to no manure. The magnitude of increase was 9.2 & 5.2 per cent, respectively.

Keywords: fodder yield, sorghum, barley, residual effect, fertility levels, biofertilizer, organic manure

Introduction
India is basically an agriculture country and about 70 per cent of its people live in villages and their livelihood is dependent mainly on agriculture and livestock. Though, India has a huge livestock population of 529.62 million (Agriculture Statistics, 2012) [2] yet the production of milk and other livestock products are about the lowest in the world because of huge gap between demand and supply of all kind of feed and fodders. In India, only 4.4 per cent of the cultivated area is under fodder crops with annual total forage production of 866 million tones (Technology Bulletin, IGFRI, 2012) [42]. Whereas, the annual green forage requirement is 1097 million tonnes and dry fodder are 609 million tonnes, which contributes 63.5 per cent and 23.6 per cent deficit of forage production, respectively (Handbook of Agriculture, 2012). Country faces regional and national deficit of green fodder, dry crop residues and feeds and the projections show a further demand increase by 2030 due to changing food habits and more dietary reliance on livestock and its products (Kumar *et al.*, 2017) [18]. Sorghum (*Sorghum bicolor* (L.) Moench) is most widely grown as a non-leguminous fodder crop in North India because it has potential of high dry matter production and can tolerant to biotic and abiotic stresses. In Rajasthan because of its high tolerance to high temperature, great adaptability to environments from wet to drought, resistance to lodging and a very remarkable ability to recover from short interval of drought. The favorable climatic and soil conditions of our state encourage the farmers to grow different forage crops throughout the year. Although various agronomic factors determining crop productivity, adequate and balanced use of fertilizer is considered as one of the most important factor to achieve potential crop production. But, higher doses of inorganic fertilizers are applied which is uneconomical for fodder production and indiscriminate and continuous use of high amount of chemical fertilizers had deleterious effect leading to decline in productivity due to limitation of one or more micronutrients. On the other hand bio-fertilizers are cheaper, pollution free and renewable source of nutrients

supply, besides providing nutrients, these also add biomass into the soil and prevent it from deterioration. In plant nutrition, organic matter level of a soil is the key property that decides the availability status of essential nutrients. The role of organic materials in maintaining and increasing soil fertility is well established. Among these, vermicompost is now becoming very popular and has become an important input in the integrated nutrient management.

To meet out the fodder demand, integrated nutrient management is flexible approach to minimize the use of chemical fertilizers but maximise their use efficiency and farmers' profit. INM involving a combination of fertilizers, organic manures and bio- fertilizers not only to sustain crop production, preserve soil health and biodiversity it also help in minimizing the cost of chemical fertilizers; and improving crop performance and soil fertility. The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai, 2007) [24]. The nutrient requirement of sorghum grown for fodder is quite high which is mainly supplemented through inorganic fertilizers and partially through organic sources. Judicious use of FYM with chemical fertilizers improved soil physical, chemical and biological properties and improved the sorghum productivity (Sharma *et al.*, 2007). Barley is a dual purpose cereal, which can permit forage production in early season in addition to the grain yield later on (Singh *et al.*, 2012) [34, 40]. These necessitate judicious combination of inorganic, organic and biofertilizers to maintain soil health and productivity of sorghum in rotation with barley at sustained level. Keeping the above facts in view, this investigation was taken to assess the residual effect of fertility levels, biofertilizers and organic manure under fodder sorghum- barley cropping sequence in Sub- humid Southern Plain and Aravalli Hills of Rajasthan.

Materials and Methods

Experimental site: The experiment was conducted at the Instructional Farm, Rajasthan College of Agriculture, Udaipur to study the residual effect of fertility levels, biofertilizers and organic manure on growth, yield and yield attributes in fodder sorghum-barley cropping sequence. The experimental site situated at Southern part of Rajasthan at an altitude of 579.5 metre above mean sea level and at 24º35′ N latitude and 74º42′ E longitude. The region falls under agro-climatic zone IVa (Sub- humid Southern Plain and Aravalli Hills) of Rajasthan.Total amount of rainfall received during sorghum crop growth period in 2014 and 2015 was 649 and 508.2 mm, respectively. The barley crop received 39.2 mm rainfall during *rabi* 2014-15 (Depicted in Fig. 1).

Experimental design, treatments, agronomic practices and soil characteristics: A field experiment was conducted during consecutive two *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), three biofertilizer combinations (*Azotobacter* + PSB, *Azotobacter* and PSB) and two organic manure level (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. Initial status of soil was taken before experimentation to execute actual effect of INM on fodder sorghum & their residual effect on succeeding barley crop. It was subjected to mechanical, physical and chemical analysis to ascertain the physico-chemical properties (Table-1) of experimental site. The soil of experimental site was clay loam in texture, slightly alkaline in reaction, low in available nitrogen, medium in available phosphorus and higher in available potassium status.

Table 1: Physico-chemical properties of soil at experimental site

	Soil properties	Contents		Methods adopted
A.	**Physico-chemical**	**2014**	**2015**	
	(i) Electrical conductivity (dS m^{-1} at 25°C)	0.87	0.82	Conductivity bridge (Richards, 1968) [32]
	(ii) pH (1:2.5 soil : water)	8.15	7.07	Blackman's pH meter (Piper, 1950) [30]
B.	**Chemical properties**			
	(i) Organic carbon (%)	0.65	0.68	Walkley and Black (1965) [42]
	(ii) Available nitrogen (kg ha^{-1})	271.40	275.70	Alkaline $KMnO_4$ method, (Subbiah and Asija,1956) [41]
	(iii) Available phosphorus (kg ha^{-1})	19.60	20.20	Olsen's method (Olsen *et al.*, 1954) [23]
	(iv) Available potassium (kg ha^{-1})	286.61	292.80	Flame photometer method (Jackson, 1973) [14]

Statistical analysis

The significance of treatment effects was analyzed using Factorial RBD. The data recorded and pooled for evaluation of treatments were subjected to statistical analysis by applying techniques of analysis of variance as advocated by Fisher (1950). The pooled analysis of data was also carried out to estimate the trend of treatments applied. The critical difference for the comparison of treatment was worked out, to wherever, the F test was found significant at 5 per cent level of significance. Correlation studies were carried out with a view to determine interrelationship between various characters as ascribed by Panse and Sukhatme (1985). Regression equation for the characters indicating significant correlation were also worked out and presented at appropriate places.

Result and Discussion

Fertility Levels

Different increasing levels of fertilizers significantly increased the plant height, number of leaves and DMA plant^{-1} at various growth stages and at harvest (Table 2). On mean basis, the corresponding increases in plant height with the application of 100% RDF were of the order of 5.26, 13.31 cm at 30 DAS 7.52, 14.25 cm at 45 DAS and 12.72, 24.71 cm at harvest, respectively. In case, number of leaves it were significantly enhanced by 4.42, 10.14 per cent at 30 DAS, 11.02, 21.11 per cent at 45 DAS and 8.30, 16.92 per cent at harvest whereas, the pooled results also indicated that DMA plant^{-1} significantly improved in application of 100% RDF by 11.05, 18.75 per cent at 30 DAS 6.34, 12.15 per cent at 45 DAS and 5.80, 11.47 per cent at harvest over application of 75 and 50% RDF, respectively. Weight of green leaves plant^{-1} (6.61 and 13.38 per cent), weight of green stem plant^{-1} (4.80 and 9.86 per cent) and stem girth (4.16 and 9.68 per cent) were recorded significantly highest at harvest with the application of 100% RDF in compare to 75 and 50% RDF, respectively. Higher available major nutrients (NPK) result in more photosynthate production which led to progressive increase in plant height, number of leaves, DMA, weight of green leaves, weight of green stem and stem girth. These results were in line with the findings of Singh *et al.* (2010) [36], Rana *et al.* (2013) [31], Nirmal *et al.* (2016) [22], Yadav *et al.* (2016) [44], Buldak *et al.* (2016) [4] and Singh *et al.* (2016) [38].

The green and dry both fodder yields were influenced significantly due to increase in fertility levels from 50 to 100% RDF (Table 2). The sorghum crop fertilized with 100% RDF produced highest green and dry fodder yield (36.02 and 11.34 t ha^{-1}) with compare to 75 (33.98 and 10.57 t ha^{-1}) and 50% (32.06 and 9.80 t ha^{-1}) RDF. The extents of increases were to the tune of 12.35 and 15.71 per cent green and dry fodder yield, respectively in lower to higher fertility levels. The significant increase in fodder yield with increase in fertility levels is due to the fact that all these nutrients are involved in increasing protoplasmic constituents, root, shoot growth and accelerating the process of cell division and elongation which in turn show luxuriant vegetative growth thus resulted higher green and dry fodder yield. The positive response of forage sorghum crop to 100% RDF is in close agreement with the findings of Singh *et al.* (2008) [39], Agarwal (2009) [1], Kumar and Chaplot (2015) [17] and Singh (2016) [38].

Biofertilizers

Seed inoculation with biofertilizers failed to exhibit significant influence on all growth characteristics recorded at various growth stages and at harvest. Combined inoculation of *Azotobacter* + PSB brought about significant improvement in green as well as dry fodder yield in compared to single inoculation of PSB and *Azotobacter* during experimentation. *Azotobacter* + PSB enhanced these yields by 6.32, 8.30 per cent (green fodder) and 8.75, 9.38 per cent (dry fodder) over single inoculation of PSB and *Azotobacter*, respectively. *Azotobacter* + PSB produces phytohormones, antibacterial and antifungal compound, which can stimulate root system and induce changes in root morphology which in turns could affect the assimilation of nutrients and thus higher fodder yield. The results of present investigation are also confirmed by the findings of Patel *et al.* (2010) [26], Naserirad *et al.* (2011) [20], Jat *et al.* (2013) [15] and Devi *et al.* (2014) [6].

Organic Manure

Application of vermicompost at 5 t ha^{-1} significantly improved all growth & yield attributing characters *viz*., plant height, number of leaves plant^{-1} , DMA, weight of green leaves plant^{-1} weight of green stem plant^{-1} leaf stem ratio and stem girth at all growth stages till harvest less or more. The enrichment of soil with organic manure (vermicompost @ 5 t ha^{-1}) significantly increased green and dry fodder yield over no manure with the magnitude of improvement was 3.18 and 1.16 t ha^{-1}. The effect of vermicompost on plant growth and productivity may be ascribed to its direct as well as indirect involvement in the availability of nutrients to the crop plants. The direct effect relates to the uptake of humic substance or its decomposition products affecting favorably the growth and metabolism of plants (Yawalkar *et al.,* 1992) [45]. The Vermicompost has indirect effect in augmentation of beneficial microbial population and their activities, biological nitrogen fixation, solubilization of insoluble phosphates alongwith greater availability of primary nutrients nitrogen, phosphorus and potassium (Brady, 2006) [3]. Significant improvement in growth and development of sorghum forage crop under the influence of vermicompost was also noticed by several researchers (Sharma *et al.,* 2010, Elbasri *et al.,* 2011, Patel *et al.,* 2018) [33, 11, 25].

Interaction effect of fertility levels and organic manure on green and dry fodder yield

It is explicates from the data that interaction effect of fertility levels and organic manure significantly influenced green fodder yield. Green fodder yield was significantly enhanced up to 75% RDF under no manure. Significantly the highest green fodder yield was recorded under combined application of 100% RDF with vermicompost 5 t ha^{-1} throughout the study. This clearly shows that beneficial effect of vermicompost with different fertilizer doses. It also indicates that concomitant effect of fertility levels and manuring brought perceptible variation in dry fodder yield of sorghum during both the years. The maximum dry fodder yield was achieved by 100% RDF in combination with vermicompost. Higher yield might be due to cumulative effect of elevated growth stature as well as yield structure. Moreover, increase in uptake of nutrients due to optimum release of nutrients besides mobilizing unavailable plant nutrients into available form by bio fertilizers that in turn gave higher green forage production. These results are supported by findings of Gopalan *et al.* (2007) [12] and Singh *et al.* (2012) [34, 40].

Residual Effect of Fertility Levels, Biofertilizers And Organic Manure On Dual Purpose Barley

Residual effect of Fertility levels

The carry over effect of fertility levels applied to sorghum crop reveal that application of 100% RDF significantly increased plant height, number of tillers 0.5 m^{-1} row length, , DMA 0.5 m^{-1} row length at 55 DAS of succeeding barley crop over application of 75 and 50% RDF. Application of 100% RDF to sorghum accumulated significantly higher quantum of bio mass 0.5 m^{-1} row length of barley compared to 50% RDF during both years. The barley crop under residual effect of 100% RDF accumulated significantly higher biomass at green fodder harvest by 4.99 per cent over 50% RDF. It is explicit from data (Table 3) that among fertility levels, 100% RDF applied to sorghum crop registered highest green fodder yield at 55 DAS which was significantly higher over 50% RDF. The significant increase in green fodder yield of barley (55 DAS) due to residual 100% RDF was 7.68 per cent over 50% RDF. An appraisal of data (Table 3) reveals that application of 100% RDF to preceding crop brought about significant increase in dry fodder yield of barley also over 50% RDF. The tune of increase in dry fodder yield (55 DAS) of barley due to residual effect of 100% RDF was 5.79 per cent over 50% RDF.

The marked improvement in concentration of nitrogen, phosphorus and potassium in the barley fodder with residual effect of fertility levels seems to be on account of its pivotal role in formation of roots, their proliferation and improvement in their functional activities. This might have induced higher extraction of nutrients from soil environment for longer duration and their efficient translocation in the plant system. This might have enhanced meristematic activities, thereby increased division, enlargement and elongation of cells resulting in higher plant height at green fodder harvest. Likewise, significant improvement in tiller production at green fodder harvest could be attributed to enhanced growth of lateral buds due to higher availability of nutrients and assimilates with residual 100% NPK fertilization. The improvement in plant height and number of tillers seems to have increased photosynthetic efficiency resulting in higher production of dry matter. The significant positive correlation between DMA and plant height (r=0.821**) and tillers 0.5 m^{-1} row (r=0.836**) also validated above findings. Further regression analysis also indicated strong dependence of DMA on plant height and tillers 0.5 m^{-1} row as a unit increase in above said parameters increased DMA by 0.52 and 0.76 g $plant^{-1}$, respectively. The positive correlation between green fodder yield and number of tillers 0.5 m-1 row length (r=0.873**), plant height (r=0.914**), and DMA (r=0.910**) at green fodder cutting also substantiate dependence of green fodder yield on these components. The beneficial residual effect of increasing fertility levels on succeeding barley crop was also observed by several researchers (Patil, 2013 and Devi *et al*., 2015) [31, 7].

Residual effect of fertility levels showed significant variation in grain yield of barley during experimental years (Table 4). Application of 100% RDF to preceding sorghum crop registered significantly higher grain yield of barley compared to 50% RDF but remained at par with 75% RDF. Further residual 75% RDF also had no clear edge over 50% RDF. Data indicate that compared to 27.37 q ha^{-1} grain yield of barley realized under residual 50% RDF it was significantly increased by 7.64 per cent due to residual effect of 100% RDF. The carry over effect of fertility levels on straw yield of barley was also found significant during both years. Application of 100% RDF to preceding sorghum crop brought about significant increase in straw yield of succeeding barley over 50% RDF but remained at par with 75% . The magnitude of increase in straw yield of barley under residual 100% RDF was 6.23 per cent over 50% RDF. The significant increase in grain yield of barley with residual effect of 100% RDF could be ascribed to their positive influence on maintaining source – sink relationship. The regression studies also substantiated dependence of grain yield on nutrient content and a unit increase in nitrogen, phosphorus and potassium content increased grain yield by 68.73, 129.95 and 80.87 t ha^{-1}, respectively. The significant increase in straw yield due to residual effect of 100% RDF is ascribed to its direct influence on DMA by virtue of increased photosynthetic efficiency. While indirect influence seems to be due to increase in growth. The higher nutrient uptake with residual 100% RDF seems to be another reason for observed improvement in straw yield. The regression studies also indicated that unit increase in nitrogen, phosphorus and potassium by the crop increased straw yield by 1.07, 3.99 and 0.48 kg ha^{-1}, respectively. The results of present investigation corroborates findings of several researchers (Gawai and Pawar, 2007; Nawale *et al.*, 2009; Singh *et al.*, 2011; Kaushik *et al.*, 2013; Choudhary *et al.*, 2014; Devi *et al.*, 2015; Kumar, 2017) [9, 21, 35, 16, 7, 18].

Residual Effect of Biofertilizer

Residual effect of biofertilizers failed to exert significant variation on plant height at 55 DAS, DMA 0.5 m^{-1} row length, days to 50% heading and number of tillers 0.5 m^{-1} row length of barley. Biofertilizer inoculation to preceding crop failed to bring about perceptible variation on green fodder yield at 55 DAS of succeeding barley crop. The dry fodder yield of barley at 55 DAS due to residual effect of microbial inoculation was unaffected during experimentation.

Residual Effect of Organic Manure

An examination of data indicate that the extent of improvement in mean plant height was to tune of 3.51 cm of barley at green fodder harvest due to vermicompost application in preceding season over no manure during both years. Data further reveals that significantly higher numbers of tillers 0.5 m^{-1} row length and DMA 0.5 m^{-1} row length at green fodder harvest were obtained due to residual effect of vermicompost. There was found 9.23 and 5.16 per cent significant increase in green and dry fodder yield, respectively at 55 DAS of barley crop due to residual effect of vermicompost applied to sorghum over no manure. Vermicompost application in preceding sorghum crop had significant residual effect on grain yield of barley with magnitude of increase 8.62 per cent in comparison to no manure. The extent of mean increase in straw yield of barley due to residual vermicompost was 4.23 per cent.

The sustained availability of nutrients may be attributed to the reason that vermicompost act as nutrient reservoir and release major and minor nutrients slowly. Brady (2006) [3] generalized that about 50% of nitrogen and 20% of phosphorus becomes available to the immediate crop and rest to the subsequent crop. Besides this, vermicompost also solubilize native as well as fertilizer phosphorus through production of organic acids. Thus, it might have balanced N/P ratio for barley crop by supplying phosphorus in addition to that contained in vermicompost and compensated phosphorus removed by sorghum. The superiority of organic manures is also because of its beneficial effect on soil physical condition apart from acting as nutrient source. Experimental evidence suggests that soluble humic acid effects biochemical mechanism and processes within plant cell such as membrane permeability and transport, ATP production, photosynthesis and nucleic acid synthesis, thereby, improved overall growth and development of plants (Ladd *et al.*, 1993) [19], Patil and Varde (1998) [28] also observed that vermicompost application to *kharif* crop significantly increased availability of nitrogen, phosphorus and potassium in soil after harvest of *kharif* sorghum. The significant increase in green fodder yield due to residual vermicompost could be ascribed to the fact that green fodder yield of crop is a function of several growth components. The positive correlation between plant height (r=0.914**), tillers 0.5 m^{-1} row (r=0.873**) and DMA (r=0.910**) at fodder cutting also substantiated dependence of green fodder yield on these components. Further, a unit increase in aforesaid components increased green fodder yield to the magnitude of 3.488, 4.809 and 8.76 q ha^{-1}, respectively. Significant improvement in growth and development of barley crop under the influence of residual vermicompost was also noticed by several researchers (Ghosh *et al.*, 2013, Kumar, 2017) [10, 18].

The marked improvement in yield due to residual effect of vermicompost seems to be on account of consistent and regular release of nutrients during the process of decomposition of vermicompost. It is well documented that vermicompost have long residual effect and its positive impact on soil physico-chemical and biological properties remains for 2-3 years. Thus, it is considered as slow release fertilizer. The significant increase in grain yield with the residual effect of vermicompost could be ascribed to their positive influence on maintaining balanced source-sink relationship which is clearly evident from improvement in dry matter production alongwith its efficiency and sink components. The higher nutrient uptake with residual vermicompost could be another reason for observed improvement in grain yield. The results of present investigation corroborated findings of several researchers (Patidar and Mali, 2002, Devi *et al.*, 2014) [6].

Based on results emanated from the present experimentation, it is inferred that sorghum crop fertilized with 100% RDF, combined inoculation of *Azotobacter* + PSB and vermicompost is sufficient for sustain the productivity as well as soil health and fertility of the fodder sorghum-barley cropping sequence. The residual effect of RDF, biofertilizers and organic manure has been proved superior to improve growth, yield, yield attributes in succeeding barley crop.

Table 2: Effect of integrated nutrient management on growth characters of fodder sorghum

Treatments	Mean								
	30 DAS			45 DAS			At harvest		
	Plant height (cm)	Leaves plant^{-1}	DMA (g plant^{-1})	Plant height (cm)	Leaves plant^{-1}	DMA (g plant^{-1})	Plant height (cm)	Leaves plant^{-1}	DMA (g plant^{-1})
Fertility levels									
50% RDF	53.96	4.93	7.36	126.64	6.82	52.93	247.93	9.04	89.37
75% RDF	62.01	5.20	7.87	133.37	7.44	55.82	259.92	9.76	94.16
100% RDF	67.27	5.43	8.74	140.89	8.26	59.36	272.64	10.57	99.62
S.Em.±	0.689	0.046	0.097	1.626	0.136	0.580	2.869	0.162	1.079
C.D. (P=0.05)	1.945	0.130	0.274	4.588	0.385	1.636	8.097	0.456	3.044
Biofertilizers									
Azotobacter	60.44	5.11	7.88	131.43	7.38	55.52	257.99	9.61	92.64
PSB	60.78	5.19	7.93	133.76	7.57	55.81	258.78	9.76	94.48
Azotobacter + PSB	62.03	5.27	8.16	135.71	7.58	56.78	263.71	10.01	96.04
S.Em.±	0.689	0.046	0.097	1.626	0.136	0.580	2.869	0.162	1.079
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Organic manure									
No manure	61.05	4.98	7.39	130.62	7.11	54.34	254.90	9.20	92.46
Vermi-compost 5 t ha^{-1}	61.12	5.39	8.59	136.64	7.90	57.74	265.43	10.38	96.31
S.Em.±	0.563	0.038	0.079	1.327	0.111	0.473	2.343	0.132	0.881
C.D. (P=0.05)	NS	0.106	0.224	3.746	0.314	1.336	6.611	0.372	2.485

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

Table 3: Effect of integrated nutrient management on plant growth characters and fodder yield of sorghum

Treatments	Mean					
	Weight of leaves (g plant^{-1})	Weight of stem (g plant^{-1})	Leaf /stem ratio	Stem girth (mm)	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})
Fertility levels						
50% RDF	18.49	90.58	20.60	14.16	32.06	9.80
75% RDF	19.67	94.96	20.86	14.91	33.98	10.57
100% RDF	20.97	99.52	21.60	15.53	36.02	11.34
S.Em.±	0.283	1.014	0.374	0.145	0.353	0.132
C.D. (P=0.05)	0.799	2.862	NS	0.411	0.995	0.373
Biofertilizers						
Azotobacter	19.41	93.57	20.98	14.72	32.91	10.23
PSB	19.67	94.55	21.19	14.77	33.52	10.29
Azotobacter + PSB	20.05	96.95	20.90	15.12	35.64	11.19
S.Em.±	0.283	1.014	0.374	0.145	0.353	0.132
C.D. (P=0.05)	NS	NS	NS	NS	0.995	0.373
Organic manure						
No manure	18.92	92.44	20.70	14.55	32.43	9.99
Vermi-compost 5 t ha^{-1}	20.50	97.60	21.34	15.19	35.61	11.15
S.Em.±	0.231	0.828	0.306	0.119	0.288	0.108
C.D. (P=0.05)	0.652	2.337	NS	0.335	0.812	0.305

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

Table 4: Residual effect of integrated nutrient management on growth characters at harvest and yield of green fodder of barley

Treatments	Mean of Growth Characters at 55 DAS				Mean of green fodder yield at 55 DAS and Grain and straw yield at Harvest		
	Plant height (cm)	Tillers (0.5 m^{-1} row length)	DMA (g 0.5 m^{-1} row length)	Green fodder yield (q ha^{-1})	Dry fodder yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Fertility levels							
50% RDF	63.07	49.42	38.67	175.73	40.78	27.37	40.29
75% RDF	65.31	50.62	39.77	182.55	41.95	28.44	41.56
100% RDF	67.67	51.83	40.60	189.23	43.14	29.46	42.80
S.Em.±	0.854	0.432	0.388	2.529	0.422	0.367	0.477
C.D. (P=0.05)	2.410	1.219	1.095	7.137	1.190	1.036	1.347
Biofertilizers							
Azotobacter	64.80	49.93	39.69	179.58	41.50	27.86	41.30
PSB	65.12	50.61	39.52	181.21	41.83	28.42	41.33
Azotobacter + PSB	66.13	51.34	39.83	186.71	42.55	28.99	42.02
S.Em.±	0.854	0.432	0.388	2.529	0.422	0.367	0.477
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS
Organic manure							
No manure	63.59	49.32	38.24	174.45	40.90	27.25	40.69
Vermi-compost 5 t ha^{-1}	67.10	51.93	41.12	190.55	43.01	29.60	42.41
S.Em.±	0.697	0.353	0.317	2.065	0.344	0.300	0.390
C.D. (P=0.05)	1.968	0.995	0.894	5.827	0.972	0.846	1.100

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

References

1. Agarwal D. Forage yield of multicut forage sorghum (*Sorghum bicolor* (L.) Moench) varieties under varying nitrogen levels. M.Sc. (Ag.) Thesis, Department of Agronomy, RCA, Maharana Pratap University of Agriculture and Technology, Udaipur, 2009.
2. Agriculture Statistics. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India, 2012, 14.
3. Brady NC. The nature and properties of soil. Mac Millan Publishing Co., New York and Collier Mac Millan Publisher, London, 2006.
4. Buldak LR, Kaushik MK, Sumeriya HK, Devra NS. Effect of various sowing dates and seed rates on yield and nutrient realization by sorghum genotypes under Southern Rajasthan conditions. Annals of Biology. 2016;32:164-168.
5. Chaudhary SK, Singh SP, Singh Y, Dharminder. Influence of integrated use of fertilizers and manures on SRI grown rice (*Oryza sativa*) and their residual effect on succeeding wheat (*Triticum aestivum*) in calcareous soil. Indian Journal of Agronomy. 2014;59:527-533.
6. Devi U, Singh KP, Kumar S, Sewhag M. Effect of nitrogen levels, organic manures and *Azotobacter* inoculation on yield and economics of multi-cut oats. Forage Research. 2014;40:36-43.
7. Devi U, Singh KP, Kumar S, Sewhag M, Kumar P. Residual effect of nitrogen levels, organic manures and *Azotobacter* inoculation in multi-cut oats on succeeding sorghum crop. Forage Research. 2015;40:254-256.
8. Elbasri A, Ahmed M, Naim ME, Bashir E, Ebeadallah Khalid AI. Influence of tillage and farm yard manure on vegetative growth indices of grain sorghum (*Sorghum bicolor* L. Monech) in gardoud soil of Sudan in rain-fed. International Journal of Current Research. 2011;3:393-397.
9. Gawai PP, Pawar VS. Nutrient balance under INMS in sorghum-chickpea cropping sequence. Indian Journal of Agricultural Research. 2007;41:137-141.
10. Ghosh AK, Duary B, Ghosh DC. Nutrient management in summer sesame (*Sesamum indicum* L.) and its residual effect on black gram (*Vigna mungo* L.). International Journal of Bio-resource and Stress Management. 2013;4:541-546.
11. Gilchrist DG, Luechen WE, Hittle CN. Revised method for preparation of standards in the sodium picrate assay of HCN. Crop Science. 1967;7:267-268.
12. Gopalan C, Sastri SBV, Balasubramanian S. Nutritive value of Indian foods, National Institute of Nutrition (NIN), ICMR, Ind, 2007.
13. Handbook of Agriculture, Forage Crops and Grasses. 1353-1417. (https://icar.org.in/files/forage-and-grasses.pdf) 2010.
14. Jackson ML. Soil chemical analysis. Prentice Hall of India, New Delhi, 1967.
15. Jat MK, Purohit HS, Singh B, Garhwal RS, Choudhary M. Effect of integrated nutrient management on yield and nutrient uptake in sorghum (*Sorghum bicolor*). Indian Journal of Agronomy. 2013;58:543-547.
16. Kaushik MK, Bishnoi NR, Sumariya HK, Singh P. Yield, nutrient uptake and quality of wheat (*Triticum aestivum* L.) as affected by fertility levels and biofertilizers and their residual effect on fodder maize (*Zea mays* L.) under Southern Rajasthan condition. International Journal of Agricultural Sciences. 2013;9:32-38.
17. Kumar D, Chaplot PC. Effect of fertility levels on quality of multi-cut forage sorghum genotypes. Forage Research 2015;40:251-253.
18. Kumar R. Integrated nitrogen management in sorghum [*Sorghum bicolor* (L.) Moench] and its residual effect on chickpea. Ph.D Thesis, Department of Agronomy, RCA, Maharana Pratap University of Agriculture and Technology, Udaipur, 2017.
19. Ladd JN, Amato M, Zhou Li-Kai, Schultz JE. Differential effects of rotation, plant residues and nitrogen fertilizer on microbial biomass and organic matter in an Australian Alfisol. Soil Biology and Biochemistry. 1993;26:821-831.

20. Naserirad H, Soleymanifard A, Naseri R. Effect of integrated application of bio-fertilizer on grain yield, yield components and associated traits of maize cultivars. American-Eurasian Journal of Agriculture and Environment Science. 2011;10:271-277.
21. Nawale SS, Pawar AD, Lambade BM, Ugale NS. Yield maximization of chick pea through INM applied to sorghum-chickpea cropping sequence under irrigated condition. Legume Research-An International Journal. 2009;32:282-285.
22. Nirmal SS, Dudhade DD, Solanke AV, Gadakh SR, Bhakare BD, Hasure RR *et al*. Effect of nitrogen levels on growth and yield of forage sorghum [*Sorghum bicolor* (L.) Moench] varieties. International Journal of Science, Environment and Technology 2016;5:2999-3004.
23. Olsen CR, Cole CV, Dean LA. Estimation of available phosphorus in soil by extraction with sodium carbonate. USDA for Circular No. 939, Washington, 1954, 13.
24. Palaniappan SP, Annadurai K. Organic farming: theory and practices, Scientific Publishers, Jodhpur, Rajasthan. 2007.
25. Patel KM, Patel DM, Gehlot DG, Patel IM. Effect of integrated nutrient management on green forage yield, quality and nutrient uptake of fodder sorghum (*Sorghum bicolor* L.). International Journal of Chemical Studies. 2018;6:173-176.
26. Patel MR, Meisheri TG, Sadhu AC. Effect of irrigation, nitrogen and bio-fertilizer on forage yield and quality of oat (*Avena sativa* L.). Forage Research. 2010;35:231-235.
27. Patidar M, Mali AL. Integrated nutrient management in sorghum (*Sorghum biocolor*) and its residual effect on wheat (*Triticum aestivum*). Indian Journal of Agricultural Sciences. 2001;71:587-591.
28. Patil RB, Varde PA. Microbial poulations in rhizosphere as influenced by high input rates of application to sorghum on a Vertisol. Journal of Indian Society of Soil Science. 1998;46:223-227.
29. Patil SL. Productivity of winter sorghum and chickpea as influenced by integrated nutrient management in deep black soils of Bellary region, India. Indian Journal of Soil Conservation. 2013;41:52-60.
30. Piper CS. Soil and Plant Analysis. Interscience Publisher Inc., New Delhi. Pvt. Ltd., New Delhi. 1950, 501-502.
31. Rana DS, Singh B, Gupta K, Dhaka AK. Performance of single-cut forage sorghum genotypes to different fertility levels. Forage Research. 2013;39:96-98.
32. Richards LA. Diagnosis and improvement of saline and alkaline soils. U.S.D.A. Hand book No. 60, Oxford and IBH Publishing Co., New Delhi. 1968.
33. Sharma PK, Gallani R, Goutam VS. Evaluation of different integrated nutrient management practices on growth development and productivity of sorghum at Vertisols. Environment and Ecology 2010;28:1835-1838.
34. Singh G, Sharma GL, Golada SL, Choudhary R. Effect of integrated nutrient management on quality protein maize (*Zea mays* L.). Crop Research. 2012;44:26-29.
35. Singh G, Singh S, Prasad K, Singh RK. Effect of manures and inorganic fertilizers on productivity of rice-wheat cropping system in lowlands. Annals of Plant and Soil Research. 2011;13:92-97.
36. Singh I, Singh G, Singh I, Singh G. Evaluate appropriate fertility levels and N sources for baby corn. International Journal of Tropical Agriculture. 2010;9:33-57.
37. Singh KP. Response of single-cut forage sorghum genotypes to fertility levels. M.Sc. (Ag.) Thesis, Department of Agronomy, RCA, Maharana Pratap University of Agriculture and Technology, Udaipur. 2016.
38. Singh KP, Chaplot PC, Sumeriya HK, Choudhary GL. Performance of single cut forage sorghum genotypes to fertility levels. Forage Research. 2016;42:140-142.
39. Singh P, Sumeriya HK, Sharma V, Chhipa KG. Study on effect of integrated nutrient management on promising sorghum genotype SU 1080. International Journal of Tropical Agriculture. 2008;26:409-411.
40. Singh P, Sumeriya HK, Solanki NS, Upadhyay B. Yield and economics of sorghum genotypes as affected by fertility levels. Annals of Plants and Soil Research. 2012;14:65-67.
41. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soil. Current Science. 1956;25:259-260.
42. Technology Bulletin, IGFRI. 2012.
43. Walkley A, Black CA. An examination of different methods for determining soil organic matter and proposed modifications of the chromic acid titration method. Soil Science. 1965;37:29-38.
44. Yadav A, Singh P, Sumeriya HK, Ranwah BR, Devra NS, Verma A *et al*. Yield and economics of single cut fodder sorghum genotypes as influenced by different fertility levels. Annals of Biology. 2016;32:146-149.
45. Yawalkar KS, Agrawal JP, Bokde S. Bulky organic manures. In: Manures and Fertilizers Eds. 1992;7:49.