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Effect of nutrient management approaches on seed yield and nutrient uptake of soybean-sorghum based cropping system

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Abstract
The improvement in seed yield characters was the manifestation of improved growth characters as a result of higher uptake of nutrients caused by balanced supply of nutrients in this regard soil test based nutrient management approaches aims provide a scientific basis for balanced fertilization to obtain more yield per unit of fertilizer investment. An experiment was conducted during *kharif* and *rabi* seasons of 2017-18 and 2018-19 at Agricultural Research Station, Janwada, Bidar district, which comes under the jurisdiction of University of Agricultural Sciences, Raichur, to study the soil test based nutrient management approaches on seed yield and nutrient uptake of soybean-sorghum cropping sequence. Pooled results indicate that maximum seed yield (27.82q ha^{-1}) was recorded with application of nutrients as per SSNM approach for targeted yield of 30q ha^{-1}+25kg $FeSO_4$ $5H_2O$ ha^{-1} in soybean. Similarly maximum sorghum grain yield (1210kg ha^{-1}) was recorded with the residual effect of nutrients through SSNM approach for targeted yield of 30q ha^{-1} +25kg $FeSO_4$ $5H_2O$ ha^{-1} and higher uptake of nutrients (seed +haulm) *viz*., nitrogen (231.99kg ha^{-1}), phosphorus (17.17kg ha^{-1}), potassium (90.04kg ha^{-1}) sulphur (55.82kg ha^{-1}), zinc (159.36g ha^{-1}), iron (3035.2g ha^{-1}), and), boron (75.88g ha^{-1}) by soybean. Similarly higher uptake of nutrients (grain +stover) *viz*., nitrogen (22.83kg ha^{-1}), phosphorus (9.64kg ha^{-1}), potassium (29.43kg ha^{-1}), sulphur (2.68kg ha^{-1}), zinc (49.70g ha^{-1}),), iron (121.04g ha^{-1}), and), boron (20.98g ha^{-1}) by sorghum was recorded with residual effect of nutrients through SSNM approach targeted yield of 30q ha^{-1} +25kg $FeSO_4$ $5H_2O$ ha^{-1} as compared to absolute control, RDF, and other soil test methods.

Keywords: Soybean, sorghum, nutrient uptake, targeted yield approach, soil test and yield

Introduction

Soybean (*Glycine max* L.) is considered as a natural fertilizer factory because of its high nitrogen fixing property with rhizobium. Being a leguminous crop, it is expected to improve soil fertility and productivity of succeeding crop. The crop in fact has revolutionized the agricultural economy with its immense potential for food, seed and industrial products. Soybean like most legumes performs nitrogen fixation by establishing symbiotic relationship with bacteria, *Rhizobium japonicum*. In India, the annual soybean production was 10.98 million tonnes with its area under cultivation was 10.47 million hectares and average productivity is 1049kg ha^{-1} (2017-18) Fourth advance estimates, Directorate of Economics and Statistics,(New Delhi). Madhya Pradesh is known as the soybean bowl of India, contributing 59 percent of the national soybean production, followed by Maharashtra (29 per cent and Rajasthan (6 percent) contribution. Andhra Pradesh, Karnataka, Chhattisgarh and other parts of India also produce the soybean in small quantities (Anon, 2013) [2]. In Karnataka, soybean is grown over an area of 0.32 million hectares with production of 2.91 million tonnes and productivity of 991kg ha^{-1} in 2018-19 according to Soybean Processors Associations of India. The actual yield potentiality of soybean had not been achieved because of existing fertilizer recommendation, as it consist of fixed rates and timing of N, P and K for vast areas of production in soybean growing areas including Bidar. Such recommendations are in practice over the years in large areas. But crop growth and crop need for supplemental nutrients are strongly influenced by genotype, soil type and climate which can vary greatly among fields, seasons and years. A judicious use of fertilizers is essential since the cost of fertilizers has gone up very high in recent years. At present, the state or regional recommendations are very general and does not consider site-specific crop nutrient requirements. Most of the existing fertilizer blanket recommendations for soybean are not so scientific and resulted in imbalanced and inefficient fertilizer uses leading to poor economic returns.

Sorghum (*Sorghum bicolor* L.) crop cultivated as winter *rabi* crop with available residual soil nutrients of Soybean. Sorghum is the staple food crop in the drier parts of the tropical Africa, India and China. It ranks fourth among the cereals after wheat, rice and maize in the world while, in India sorghum ranks third in importance after rice and wheat. It is being grown over an area of about 5.14 million hectares with a production of 4.57 million tonnes and productivity is 889kg ha^{-1} in India. In Karnataka, sorghum is grown over an area of 0.95 million hectares with production of 0.84 million tonnes and productivity of 889kg ha^{-1} in 2016-17 according to Directorate of economics and statistics, (New Delhi). Nutrient uptake also plays an important role in the determination of yield potential in soybean-mustard cropping system. Application of inorganic fertilizer through different nutrient management approaches based on targeted yield along with FYM improved the uptake of NPKS and micronutrients (Zn, Fe and B) over other treatments. The increased N, P K S uptake and micronutrients might be due to the higher nutrient supply as compared to RDF and other soil test methods. The nutrient retained in the soil after harvest of the crop mainly depends on both supply of nutrients through various sources and uptake by the crop.

Material and Methods

The field experiment was conducted during *kharif* and *rabi* seasons of 2017-18 and 2018-19 at Agricultural Research Station, Janwada, Bidar district, which comes under the jurisdiction of University of Agricultural Sciences, Raichur. It is situated between 17.91^0 North latitude and 77.51^0 East longitudes at an altitude of 615 m above the Mean Sea Level and is located in the North Eastern transitional zone of Karnataka. The soil of the experimental site is clay in texture (Sand 18.90%, silt 23.43% and clay 56.67%), with a bulk density of 1.16Mg m^{-3}, particle density of 2.92Mg m^{-3} and having maximum water holding capacity 58.25 percent. The soil pH is 7.69 with electrical conductivity of 0.31 dS m^{-1}. The soil is low in organic carbon content (0.43g kg^{-1}), available nitrogen (210.0kg ha^{-1}) and medium in available phosphorus (24.0kg ha^{-1}) and high in available potassium (340kg ha^{-1}). While other parameters *viz.*, sulphur (10.70Mg kg^{-1}), exchangeable calcium and magnesium (35.40 and 24.7 C mol (p^+) kg^{-1}) are within the normal ranges that are comparable to any normal soils of this region. However, this experimental soil is low in available boron (0.47Mg kg^{-1}), zinc (0.56Mg kg^{-1}), iron (2.70Mg kg^{-1}) and high in copper and manganese were 1.18 and 30.5Mg kg^{-1} respectively. Soybean JS 335 and sorghum M 35-1 used as a crop variety. The experiment was laid out in RCBD included thirteen treatments consisted of T_1: Absolute control (00: 00: 00 NPKkg ha^{-1}), T_2: RDF- (40:80:25kg ha^{-1}. NPK +30kg ha^{-1} S +12.5kg ha^{-1} $ZnSO_47H_2O$ +1.0kg ha^{-1} boron), T_3: STL-(Soil testing laboratory method), T_4: STCR approach (Targeted yield 25q ha^{-1}), T_5: STCR approach (Targeted yield 30q ha^{-1}), T_6: SSNM approach (Targeted yield 25q ha^{-1}), T_7: SSNM approach (Targeted yield 30q ha^{-1}), T_8: RDF- Recommended Dose Fertilizer +25kg ha^{-1} $FeSO_4$ $5H_2O$, T_9: STL-Soil Testing Laboratory method +25kg ha^{-1} $FeSO_4$ $5H_2O$, T_{10}: STCR approach (Targeted yield 25q ha^{-1}) +25kg ha^{-1} $FeSO_4$ $5H_2O$, T_{11}: STCR approach (Targeted yield 30q ha^{-1}) +25kg ha^{-1} $FeSO_4$ $5H_2O$, T_{12}: SSNM approach (Targeted yield 25q ha^{-1}) +25kg ha^{-1} $FeSO_4$ $5H_2O$, T_{13}: SSNM approach (Targeted yield 30q ha^{-1}) +25kg ha^{-1} $FeSO_4$ $5H_2O$ and FYM @2.4t ha^{-1} was applied for all treatments except absolute control. The recommended dose of fertilizer for soybean in the North-Eastern transitional zone of Karnataka (Zone-1) is 40: 80: 25kg N: P_2O_5: K_2O ha^{-1} +30kg ha^{-1} S +12.5kg ha^{-1} $ZnSO_47H_2O$ +1.0kg ha^{-1} boron (Package of practice, UAS Raichur, 2016). Nitrogen, phosphorus, potassium, zinc and boron in the form of Urea, Diammonium phosphate (DAP), Muriate of potash (MOP), gypsum, zinc sulphate and borax, respectively were applied. As per RDF, full dose of N, P, K, Zn and boron were applied at basal. Sulphur applied as source of gypsum 20 days before sowing. Seed /grain yield and haulm/stover yield per hectare were recorded. Five plants were harvested from each treatment at harvest stage, oven dried. Haulm/stover and Seed/grain were ground in a Wiley mill and digested in diacid mixture (9:4) for P, K, S, Zn, Fe and for Nitrogen digested with concentrated H_2SO_4 in presence of digestion mixture (K_2SO_4:$CuSO_4$.$5H_2O$: Se in the proportion of 100:20:1) and distilled under alkaline medium (Kjeldahl's method). Zinc and iron contents in the extracts were measured by atomic absorption spectrometry (AAS).

Results and Discussion

Effect of different nutrient management approaches on seed/grain yield of soybean-sorghum

Application of nutrients through targeted yield approach exerted significant influence on the seed and haulm yield of soybean. Significantly higher seed (27.82q ha^{-1}) and haulm (5197kg ha^{-1}) (Table 1) yield of soybean was recorded with treatment receiving SSNM approach for targeted yield of 30q ha^{-1} +25kg $FeSO_4$ $5H_2O$ ha^{-1} as compared to absolute control (951q ha^{-1} and 3298kg ha^{-1}). RDF (2015q ha^{-1} and 4183kg ha^{-1}) and other soil test methods.The increase in yield might be due to improvement in yield components for better partitioning of carbohydrates from leaf to reproductive parts and use efficiency of applied nutrients in the soil has resulted increased yield in soybean.The increased haulm yield in SSNM approach was due to application of graded levels of nutrients along with iron supply and subsequently enhanced uptake of nutrients by crop which was responsible for better growth, dry matter accumulation, seed and haulm yield. The higher yield can be attributed to the ability of targeted yield approaches to satisfy the nutrient demand of crop more efficiently (Saraswathi *et al.*, 2018). The maximum seed and haulm yields of soybean was also due to better translocation of photosynthate from source to sink and higher growth attributing characters like more number of leaves and greater dry matter production and its accumulation in different parts of the plant and yield attributing characters like, number of pods per plant, pod weight, individual seed weight. The studies are also agreement with the findings of Anand *et al.* (2017) [1] who reported that the SSNM for soybean genotypes, the treatment, JS 335 with target yield of 3.0t ha^{-1} recorded significantly higher seed yield due to higher yield parameters such as number of pods $plant^{-1}$, pod weight, seed yield and hundred seed weight and growth parameters *viz*., plant height, number of branches and leaf area duration at harvest as compared to JS 335 with farmers practice. Similar findings also reported by Shreenivas *et al*. (2017) [17] that pooled results registered significantly higher grain yield of maize with treatment receiving SSNM approach targeted yield of 8.0t ha^{-1}. These results are also coroborated with the findings of Doberman *et al.* (2002) [7], Biradar *et al.* (2006) [4], Umesh *et al*. (2014) [20] and Singh *et al.* (2014) [19]. However, it was found on par with treatments of T_7:SSNM approach targeted yield of 30q ha^{-1} (2534 and 4868kg ha^{-1}), T_{11}: STCR approach targeted yield of 30q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$ (2397 and 5083kg ha^{-1}) and T_{12}: SSNM approach targeted yield of 25q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$ (2382 and 4968kg ha^{-1}) and significantly superior over T_2:RDF (2015 and 4183kg ha^{-1}), T_3: STL method (2144 and 4430kg ha^{-1}), T_4: STCR approach targeted yield of 25q ha^{-1} (2150 and 4592kg ha^{-1}), T_5: STCR approach targeted yield of 30q ha^{-1}(2300 and 4697kg ha^{-1}), T_6:SSNM approach targeted yield of 25q ha^{-1}(2278 and 4635kg ha^{-1}), T_8:RDF +25kg ha^{-1} $FeSO_4$ $5H_2O$ (2168 and 4462kg ha^{-1}), T_9:STL +25kg ha^{-1} $FeSO_4$ $5H_2O$ (2244 and 4567kg ha^{-1}) T_{10}: STCR approach targeted yield of 25q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$(2295 and 4787kg ha^{-1}), The lowest seed and haulm yield was recorded in absolute control (1024q ha^{-1} and 3298kg ha^{-1}).

Similarly highest sorghum grain yield was obtained with the residual effect of $FeSO_45H_2O$ @25kg ha^{-1} along with SSNM approach targeted yield of 30q ha^{-1} recorded significantly higher grain yield (1210kg ha^{-1}) and stover yield (2128kg ha^{-1}) over T_1:absolute control (570 and 1253kg ha^{-1}), T_2:RDF (807 and 1513kg ha^{-1}), T_3: STL method (847 and 1619kg ha^{-1}), T_4:STCR approach targeted yield of 25q ha^{-1} (928 and 1682kg ha^{-1}), T_5:STCR approach targeted yield of 30q ha^{-1}(1013 and1777kg ha^{-1}), T_6:SSNM approach targeted yield of 25q ha^{-1}(995 and 1727kg ha^{-1}), T_8:RDF +25kg ha^{-1} $FeSO_4$ $5H_2O$(865 and 1631kg ha^{-1}) T_9:STL +25kg ha^{-1} $FeSO_4$ $5H_2O$ (910 and 1718kg ha^{-1}) T_{10}: STCR approach targeted yield of 25q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$(1023 and 1828kg ha^{-1}), and it was found noticed on par with T_7:SSNM approach targeted yield of 30q ha^{-1} (1080 and 1870kg ha^{-1}), T_{11}: STCR approach targeted yield of 30q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$ (1149 and 2049kg ha^{-1}) and T_{12}: SSNM approach targeted yield of 25q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$ (1098 and 1970kg ha^{-1}), respectively. It might be due to the residual effect of nutrients applied through targeted yield approaches in combination with iron plus recommended dose of FYM exerted significant influence on the earhead length, earhead girth, and grain weight, and grain yield, stover yield of sorghum during both the years of experimentation and also on pooled basis. The better performance of succeeding sorghum could be due to higher amount of available nitrogen, phosphorous, potassium, sulphur, zinc, iron and boron after harvest of soybean. Soybean is considered as a natural fertilizer factory because of its high nitrogen fixing property with *rhizobium*. Being a leguminous crop, it is expected to improve soil fertility and productivity of succeeding crop. The crop in fact has revolutionized the agricultural economy with its immense potential for food, seed and industrial products. Soybean like most legumes performs nitrogen fixation by establishing symbiotic relationship with bacteria, *Rhizobium japonicum* and made substantial build up in soil as reflected higher soil nutrient status after harvest of soybean. Meena *et al*. (2018) [12] studied that the residual effect of combined application of 5kg Zn +10kg Fe +10t FYM to proceeding crop pearl millet resulted in significantly higher grain and straw yield of mustard. Similar results were obtained by Gawai *et al*. (2005) [9] studied that the residual effect of application of 100 per cent RDF and 5t FYM ha^{-1} to proceeding crop sorghum resulted in significantly higher grain and haulm yield of chickpea. These findings are also in line with those reported by Kuldeep *et al*. (2018) [10] and Patil *et al.* (2018) [14], respectively. The similar interpretation was also reported by Ashoka *et al.* (2008) [3] results revealed that residual effect of RDF (150:75:40kg N, P_2O_5, K_2O ha^{-1}) +25kg $ZnSO_4$ +10kg $FeSO_4$ +35kg Vermicompost to chickpea also increased pods per plant (100.33), test weight (24.80g) and seed yield (15.4q ha^{-1}) over RDF alone and all other treatments. Shreenivas *et al*. (2017) [17] that the better performance of succeeding chickpea could be due to higher amount of available nitrogen, phosphorus and potassium after harvest of maize. These findings are also in line with those reported by Chavan *et al*. (2014) [6], Shankar *et al*. (2014) [15], Brij *et al*. (2018) [5] and Meena *et al*. (2018) [12].

Effect of different nutrient management approaches on nutrient uptake by soybean-sorghum

Further, seed/grain yield is governed by the factors which have direct or indirect impact. The factors which have direct influence on the seed/grain yield are the yield components have an indirect influence on grain yield through the yield components, which intern depends on different growth components. All these growth components could have been promoted by more quantity of nutrients made available by the treatment received in SSNM approach for targeted yield of 30q ha^{-1}+25kg ha^{-1} $FeSO_4$ $5H_2O$ and evidenced through higher uptake of nutrients *viz.*, nitrogen, phosphorous, potassium, sulphur, zinc, iron and boron as compared absolute control, RDF and other soil test based approach. (Table 2 and 3)

It has been proved that, application of nutrients through different nutrient management approaches along with recommended FYM improves the absorption and utilization of major nutrients. Total uptake (seed +haulm) of nutrients was significantly higher with treatment receiving SSNM for targeted yield of 30q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$ (231.99, 17.17, 90.04, 55.82kg N, P, K, S ha^{-1}, 159.36, 3035.2, 75.88g Zn, Fe and B ha^{-1} respectively) as compared to absolute control and other treatments (Table 2). It might be due to application of balanced fertilization based on target yield resulting in higher total NPK & S uptake. The higher nutrient uptake is well reflected in terms of higher seed and haulm yield of soybean. Obviously this could be due to application of nitrogen, potash, phosphorus and along with required micronutrients fertilizers; this might be the reason for higher uptake of nutrients by the soybean. This might be due to higher biomass production coupled with higher availability of nitrogen after harvest of soybean crop. The better performance of growth and yield of sorghum further traced back to the improvement in nitrogen uptake. Chaudhary *et al.* (1998) [8] observed that higher dry matter in chickpea resulted in higher uptake of nutrients in SSNM approach. Meena *et al*. (2018) [12] came to the same conclusion in pearl millet-mustard cropping system. All available NPK, Zn and Fe after harvest of soybean has helped in higher acquisition of atmospheric nitrogen in nodule by symbiotic microbes making it available to the plant and resulting into its higher uptake by sorghum crop. The sufficient application of N on SSNM basis to preceding soybean crop improved in N content and uptake with increased availability of Zn, suggesting a synergistic effect of Zn on N uptake. Similar results have been reported by Kumar *et al*. (2009) [11] in french bean and Singh *et al*. (2015) [18] in pea crop. Ashoka *et al*. (2008) [3] in maize-chickpea sequence cropping system, Shankar *et al*. (2014) [20] green gram - finger millet cropping system. Shreenivas *et al*. (2017) [17] in maize-chickpea cropping system.

Table 1: Effect of different nutrient management approaches on seed/grain yield of soybean-sorghum cropping system (Pooled data of 2 years) 2017-18 and 2018-19

Treatments	Soybean		Sorghum	
	Seed yield ($q\ ha^{-1}$)	Haulm yield ($kg\ ha^{-1}$)	(Grain yield ($kg\ ha^{-1}$)	Stover yield ($kg\ ha^{-1}$)
T_1:Absolute control	951	3298	570	1253
T_2:RDF- (Recommended dose fertilizer)	2015	4183	807	1513
T_3:STL- (Soil test laboratory method)	2144	4430	847	1619
T_4:STCR approach (Targeted yield 25 q ha^{-1})	2150	4592	928	1682
T_5:STCR approach (Targeted yield 30 q ha^{-1})	2300	4697	1013	1777
T_6:SSNM approach (Targeted yield 25 q ha^{-1})	2278	4635	995	1727
T_7:SSNM approach (Targeted yield 30 q ha^{-1})	2534	4868	1080	1870
T_8:RDF- Recommended Dose Fertilizer + 25 kg ha^{-1} $FeSO_4\,5H_2O$	2168	4462	865	1631
T_9:STL- Soil Test Laboratory method + 25 kg ha^{-1} $FeSO_4\,5H_2O$	2244	4567	910	1718
T_{10}:STCR approach (Targeted yield 25 q ha^{-1}) + 25 kg ha^{-1} $FeSO_4\,5H_2O$	2295	4787	1023	1828
T_{11}:STCR approach (Targeted yield 30 q ha^{-1}) + 25 kg ha^{-1} $FeSO_4\,5H_2O$	2397	5083	1149	2049
T_{12}:SSNM approach (Targeted yield 25 q ha^{-1}) + 25 kg ha^{-1} $FeSO_4\,5H_2O$	2382	4968	1098	1970
T_{13}:SSNM approach (Targeted yield 30 q ha^{-1}) + 25 kg ha^{-1} $FeSO_4\,5H_2O$	2782	5197	1210	2128
S. Em.±	951	138	52	90
C.D. at 5%	2015	401	150	263

Note: 1) RDF (40:80:25kg ha^{-1}. NPK +30kg ha^{-1} S +12.5kg ha^{-1} $ZnSO_47H_2O$ + 1.0 kg ha^{-1} boron)
2) FYM @ 2.4 t ha^{-1} was applied for all treatments except absolute control

Table 2: Effect of different nutrient management approaches on NPK uptake in soybean (seed + haulm) and sorghum (grain +stover) under soybean-sorghum cropping systems nutrient (Pooled data of 2 years) 2017-18 and 2018-19

Treatments	Nitrogen uptake ($kg\ ha^{-1}$)			Phosphorus uptake ($kg\ ha^{-1}$)			Potassium uptake ($kg\ ha^{-1}$		
	Soybean	Sorghum	Total uptake	Soybean	Sorghum	Total uptake	Soybean	Sorghum	Total uptake
T_1	80.87	6.96	87.83	5.94	3.46	9.4	43.94	12.09	56.03
T_2	153.39	10.05	163.44	9.00	4.72	13.72	59.99	16.31	76.3
T_3	165.07	11.27	176.34	9.90	5.15	15.05	64.71	17.77	82.48
T_4	170.81	12.66	183.47	10.38	5.53	15.91	67.57	19.07	86.64
T_5	186.93	16.72	203.65	12.54	6.68	19.22	71.76	21.25	93.01
T_6	183.14	15.83	198.97	12.08	6.39	18.47	69.80	20.33	90.13
T_7	207.48	19.03	226.51	14.89	7.73	22.62	80.30	24.56	104.86
T_8	168.92	12.61	181.53	10.52	5.40	15.92	64.91	17.87	82.78
T_9	176.55	13.97	190.52	11.35	5.92	17.27	67.96	19.35	87.31
T_{10}	189.51	17.58	207.09	13.39	7.12	20.51	74.55	22.39	96.94
T_{11}	205.17	21.65	226.82	15.18	8.50	23.68	84.30	27.33	111.63
T_{12}	198.82	19.44	218.26	14.19	7.82	22.01	79.46	24.96	104.42
T_{13}	231.99	22.83	254.82	17.17	9.64	26.81	90.04	29.43	119.47
S. Em.±	13.12	1.33	14.45	0.98	0.65	1.63	3.68	1.76	5.44
C.D. at 5%	38.13	3.87	42.00	2.84	1.93	4.77	10.71	5.11	15.82

Note: 1) RDF (40:80:25kg ha^{-1}. NPK +30kg ha^{-1} S +12.5kg ha^{-1} $ZnSO_47H_2O$ +1.0kg ha^{-1} boron)
2) FYM @ 2.4 t ha^{-1} was applied for all treatments except absolute control

Table 3: Effect of different nutrient management approaches on sulphur, zinc, iron and boron uptake in soybean (seed + haulm) and sorghum (grain +stover) under soybean-sorghum cropping systems nutrient (Pooled data of 2 years)

Treatments	Sulphur uptake ($kg\ ha^{-1}$)			Zinc uptake ($g\ ha^{-1}$)			Iron uptake ($g\ ha^{-1}$			Boron uptake ($g\ ha^{-1}$)		
	Soybean	Sorghum	Total uptake	Soybean	Sorghum	Total uptake	Soybean	Sorghum	Total uptake	Soybean	Sorghum	Total uptake
T_1	22.25	0.57	22.82	56.53	9.95	66.48	1491.1	37.98	1529.08	24.52	8.03	32.55
T_2	32.39	1.14	33.53	99.35	19.38	118.73	2157.2	50.36	2207.56	35.71	10.72	46.43
T_3	35.70	1.29	36.99	107.45	22.58	130.03	2316.7	55.45	2372.15	39.31	11.51	50.82
T_4	37.76	1.66	39.42	112.85	24.16	137.01	2401.0	62.79	2463.79	42.54	12.45	54.99
T_5	40.98	1.85	42.83	129.84	29.91	159.75	2499.0	69.20	2568.2	54.24	14.95	69.19
T_6	39.34	1.77	41.11	124.57	28.76	153.33	2485.7	72.78	2558.48	50.51	13.96	64.47
T_7	48.30	2.07	50.37	150.33	38.68	189.01	2663.3	83.58	2746.88	65.74	16.90	82.64
T_8	35.68	1.52	37.2	114.15	23.67	137.82	2409.1	73.59	2482.69	44.52	12.18	56.7
T_9	38.03	1.67	39.7	120.32	26.53	146.85	2493.1	81.16	2574.26	48.07	13.13	61.2
T_{10}	43.17	1.92	45.09	136.38	33.55	169.93	2642.5	96.72	2739.22	59.38	16.60	75.98
T_{11}	51.05	2.32	53.37	150.51	43.11	193.62	2834.8	110.07	2944.87	69.18	18.09	87.27
T_{12}	46.60	2.09	48.69	144.37	38.67	183.04	2819.4	106.71	2926.11	64.12	17.80	81.92
T_{13}	55.82	2.68	58.5	159.36	49.70	209.06	3035.2	121.04	3156.24	75.88	20.98	96.86
S. Em.±	3.18	0.29	3.47	6.74	1.99	8.73	134.7	5.17	139.87	4.12	1.05	5.17
C.D. at 5%	9.31	0.63	9.94	19.59	5.79	25.38	1491.1	15.03	1506.13	11.98	3.04	15.02

Note: 1) RDF (40:80:25kg ha^{-1}. NPK +30kg ha^{-1} S +12.5kg ha^{-1} $ZnSO_47H_2O$ + 1.0kg ha^{-1} boron)
2) FYM @ 2.4 t ha^{-1} was applied for all treatments except absolute control.

Nutrient uptake by sorghum

Total uptake (grain +stover) of nutrients by sorghum were significantly highest with the residual effect of nutrients through SSNM approach for targeted yield of 30q ha^{-1} +25kg ha^{-1} $FeSO_4$ $5H_2O$ (22.83, 9.64, 29.43, 2.68kg N, P, K, S ha^{-1}, 49.70, 121.04, 20.98g Zn, Fe and B ha^{-1} respectively) over other treatments. The higher uptake of nitrogen, phosphorous, potassium, sulphur, zinc, iron and boron by sorghum might be due to higher biomass production coupled with higher availability of NPK after harvest of soybean. The higher availability of N, P and K in SSNM or STCR treated plot may be due to mineralization of organic manure applied for the previous crop and also root biomass which contributed for decomposition in soil itself. Pankaj *et al.,* (2013) [13] opinionated that conjunctive use of organic and inorganic source of fertilizer *kharif* rainfed rice induced significantly higher residual contribution of nutrients N, P, K and S in the soil available pool thereby increased uptake by lentil plant at harvest. Similar results reported by Shreenivas (2016) [16].

The results obtained in the present investigation which was carried out for two consecutive years (2017-18 and 2018-19) by following different nutrient management approaches on performance of soybean-sorghum cropping system based on the results following conclusions are made. Application of fertilizers through SSNM approach targeted yield of 30q ha^{-1} (57: 75: 111kg N, P_2O_5 and K_2O ha^{-1}, respectively) along with 25kg $FeSO_4$ $5H_2O$ ha^{-1} recorded higher yield and nutrient uptake as compared to absolute control, RDF and other soil test methods.

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