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Effect of Sardar Amin Granules and Bentonite Sulfur on the Productivity of Maize-based Cropping System in a Sandy-loam Soil

R. Sikka, B. S. Sekhon, Simranpreet Kaur, Tanvi Sahni, Radha Ahuja, Chaitra P.

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ABSTRACT

Maize among one of staple cereal accounting major proportion of human diet accounting 42% of worlds' food calorie and 37% of protein intake. However, there is a need to optimize its nutrient content due to deficiencies in soil. The application of nutrient additives helps in supplementing the soil with these essential nutrients and ensures crops' optimum growth. Purpose of this study is to evaluate the efficiency of Sardar amin granules (SAG) and bentonite sulfur in various proportions to improve nutrient uptake by sown crops. A three-year field experiment study (2018-21) was conducted on maize based cropping systems viz. Maize-wheat, Maize-potato-onion, and Maize-potato-summer moong at research farm, department of soil science, Punjab Agricultural University, Ludhiana. At the end of two-year field experiment, the results revealed numerical increase in yield of maize, wheat, onion and summer moong grown in rotation and products were recommended as additional fertilizers sources over the recommended dose of fertilizers considering the type of regional soil.

Keywords Sardar amin granules, Bentonite sulfur granules, Sandy-loomy soil, Maize.

INTRODUCTION

Maize (*Zea mays* L.) plays a crucial role in global food security and is one of the most widely cultivated cereal crops (Tiwari and Yadav 2019). Its versatility as a food, feed, and industrial raw material contributes significantly to human nutrition, livestock production, and various industrial applications (Murdia *et al.* 2016). With the increase in world's population, the demand for maize is expected to rise substantially. Maize (*Zea mays*) is the largest crop in terms of global annual production (about 1.2 billion metric tonnes in 2022-23) and the area under cultivation amounts to 197 M ha including Sub-Saharan Africa (SSA), Asia and Latin America (FAO Stat 2021). Consequently, maximizing the yield potential of maize-based cropping systems has become a priority to meet growing demand and ensure food security (Nicholson *et al.* 2021).

Additionally, deficiency of nutrients in soil

R. Sikka[1]*, B. S. Sekhon[2], Simranpreet Kaur[3], Tanvi Sahni[4], Radha Ahuja[5], Chaitra P.[6]

[1, 2] Principal Soil Chemist, [3]Graduate Assistant, [4, 5, 6]Senior Research Fellow

[1, 2, 4, 5, 6] Department of Soil Science, Punjab Agricultural University, Ludhiana 141001, India

[3]University of Florida, USA

Email : sikkar@pau.edu
*Corresponding author

clearly reflects in crop health and yield quantity. The other main impact was found on public health which down-grades due to lack of enough food nutrients. Therefore, it's extremely important to ensure that well-balanced and quality nutrients are provided throughout the entire crop life cycle (Roberto 2005). The secret to good nutrient management is to ensure that crops are receiving the right quantity of nutrients exactly when they need them most (Xiang *et al.* 2008). In agricultural practices, optimizing crop productivity often involves the strategic use of inputs such as chemical fertilizers, nutrient additives or bulky organic manures (Jat *et al.* 2015). Fertilizers can be applied either as granular in soil or as a foliar spray directly on plants (Kumar and Nagesh 2019). Granular soil application of fertilizers is the most common way of feeding the plants and best method for soil enrichment due to their slow-release potential (Rashid *et al*. 2021).

Apart from fertilizers the use of some other nutrient additives is becoming popular among maize growing farmers (Anonymous 2023 pp *kharif*). One such product is Sardar amin granules (SAG), has been developed by Gujrat state fertilizer and chemical limited contains amino acids derived from plant proteins and certain micronutrients which are said to facilitate seed germination, root and shoot development, impart tolerance to the plant, and increase flower and fruit setting. The granular form of SAG is applied in the soil as basal or as a top dressing in splits. Bentonite sulfur containing 90% pure elemental sulfur is highly feasible when applied to soil in granular form and helps to increase crop resistance against soil-borne fungal and bacterial diseases (Muscolo *et al.* 2020).

Therefore, research experiments were conducted for three years (2018-2021) to evaluate the effects of Sardar amin granules and Bentonite sulfur on the productivity of maize based cropping systems and on soil health.

MATERIALS AND METHODS

Site description and experimental plan

A three-year (2018-21) field experiment was conducted to study the effects of Sardar amin granules (SAG) and Bentonite sulfur (BS) with eight treatments (Table 1) on the productivity of maize-based cropping systems at the research farm, Department of soil science, PAU, Ludhiana (30◦ 56′ N and 75◦ 52′ E) India. A semi-arid subtropical climate characterizes the study area, which receives approximately 700-800 mm of rainfall annually. The physico-chemical characteristics of experimental fields are given in Table 2. The experiment was laid out in split plot design with three mize-based cropping systems viz Maize-wheat, Maize-potato-onion and Maize-potato-summer moong, which were kept in main plot and eight SAG and BS treatments which were kept in sub-plots. The detail of the package of practices of different crops is given in Table 3 (Anonymous 2023).

Table 1. The eight fertilizer treatments which encompass.

Sl. No.	Treatments	
1	T_1	Control
2	T_2	SAG @ 8 kg/acre
3	T_3	SAG @ 8 kg/acre with BS
4	T_4	100% recommended dose of fertilizers (RDF)
5	T_5	75% RDF with SAG @ 8 kg/acre
6	T_6	75% RDF with SAG @ 8 kg/acre and BS
7	T_7	100% RDF with SAG @ 8 kg/acre
8	T_8	100% RDF with SAG @ 8 kg/acre and BS

Table 2. Physico-chemical characteristics of experimental fields.

Cropping system	Soil texture	pH	EC (dS/m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Maize based	Sandy loamy	7.14	0.147	0.65	150.5	29.6	161.25

Table 3. Details of the package of practices of different crops.

Sl. No.	Crop	Variety	Spacing (cm×cm)	Fertilizer dose (kg/acre) N: P_2O_5: K_2O
1	Maize	PMH 11	60 × 20	50:24:12
2	Wheat	Unnat PBW 343	20	50:25
3	Potato	Kufri Pushkar	Rows (65×18.5), tubers (75×15)	75:25:25
4	Summer moong	SML 1827	22.5×7	5:16:0
5	Onion	Punjab Naroya	60 × 45	40:20:20

These were kept in subplots with a total of twenty-four treatments which were replicated thrice on a fixed layout.

Materials

Sardar amin granules (SAG) and Bentonite sulfur are the products of Gujrat State Fertilizer and Chemical Limited. SAG contains Nitrogen, Hydrolyzed Proteins (Amino Acids-Alanine, Glutamic acid, leucine, serine) derived from plant protein, Hydrolyzed carbohydrates, phosphorus, potassium, zinc, iron, manganese. Bentonite sulfur was used for soil application. Bentonite sulfur contains 90% sulfur bound or 10% bentonite clay.

Grain yield and system productivity

Average grain yield (q/ha) of different crops grown under maize-based cropping systems, was worked out for three years. The average grain yield of each cropping system (3 years) was converted into maize equivalent yield (q ha^{-1}) taking into account the minimum support price of the crops (Uddin *et al.* 2009). It was calculated using the following formula :

$$\text{Equivalent yield (main crop)} = \frac{(YMC*PMC+YSC*PSC)}{PMC}$$

YMC= Yield of the main crop (q ha^{-1})

YSC= Yield of the secondary crop (q ha^{-1})

PSC= Price of the secondary crop (Rs q^{-1})

PMC= Price of main crop (Rs q^{-1})

System productivity (kg ha^{-1} day^{-1}) was calculated by dividing the system equivalent yield (kg ha^{-1}) by the duration (no. of days) of the respective cropping system (Tomar and Tiwari 1990).

Soil analysis

The surface soil upper layer (0-15) was taken from farm located in Punjab region of India. The samples were sieved through 2 mm for various physico-chemical parameters. Soil $pH_{1:2}$ and $EC_{1:2}$ (1:2; soil: water suspension) were analyzed using a glass rod and conductivity meter, dS/m (Jackson 1967). Soil-available macronutrients nitrogen (N), phosphorus (P), potassium (K) and organic carbon (%) were analyzed as per reported procedures: Subbiah and Asija (1956), 0.5M $NaHCO_3$ (pH 8.5) extraction (Olsen 1954), neutral ammonium acetate method through flame photometer (Merwin and Peech 1950) and Walkley and Black method (1934) respectively.

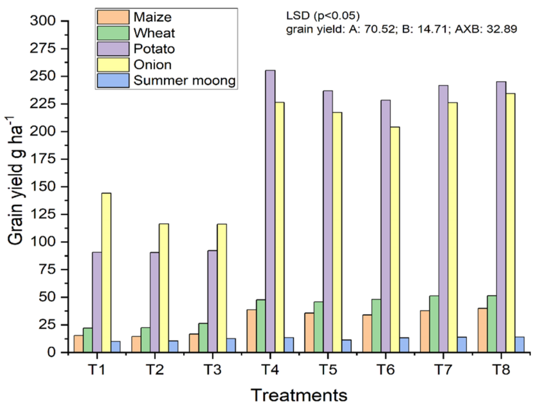

Fig. 1. The mean value of grain yield in five different crops across the tested treatments.

Statistical analysis

Data from various treatments were analyzed using ANOVA (Analysis of variance). Treatment means were analyzed for their significance through LSD (least significant difference) at $p \leq 0.05$ unless otherwise mentioned (Fig. 1).

RESULTS AND DISCUSSION

Grain yield

The treatment of different cropping systems with SAG and BS on the average grain yield of maize based cropping system across three years was found significant in the case of maize, wheat, and potato while non-significant in onion and summer moong (Table 4). Thus, pooled data for the three-year experiment are discussed, respectively.

Table 4. Effect of SAG and BS application on average grain yield (q ha^{-1}) of component crops grown in maize-based cropping system (2018-21).

Fertilizer treatments	Maize	Wheat	Potato	Onion	Summer moong
Control	15.28	22.10	90.47	144.10	10.10
SAG @ 8 kg/acre	14.44	22.50	90.73	116.37	10.43
SAG @ 8 kg/acre with BS	16.60	26.33	92.13	116.03	12.57
100% recommended dose of fertilizers (RDF)	38.67	47.50	255.20	226.23	13.43
75% RDF with SAG @ 8 kg/acre	35.60	45.73	236.77	217.23	11.20
75% RDF with SAG @ 8 kg/acre and BS	34.00	48.13	228.27	203.93	13.27
100% RDF with SAG @ 8 kg/acre	37.90	51.10	241.70	226.10	13.83
100% RDF with SAG @ 8 kg/acre and BS	39.83	51.27	245.03	234.13	13.93
Mean	**29.04**	**39.33**	**185.04**	**185.52**	**12.35**
LSD (5%)	13.70	13.96	79.75	NS	NS

Table 5. Effect of SAG-BS application on maize equivalent yield (2018-21).

Fertilizer treatments	Maize equivalent yield (q ha^{-1})			
	M-W	M-P-O	M-P-Sm	Mean
1 Control (No fertilizer)	36.88	72.10	81.73	60.89
2 Sardar amin granules @ 8 kg/acre	37.69	64.30	80.67	63.57
3 Sardar amin granules @ 8 kg/acre + bentonite sulfur	42.36	66.27	94.40	67.68
4 100% recommended dose of fertilizers (RDF)	91.09	150.20	148.77	130.02
5 75% RDF + Sardar amin granules @ 8 kg/acre	87.45	138.07	136.77	120.76
6 75% RDF + Sardar amin granules @ 8 kg/acre + bentonite sulfur	86.16	132.47	135.37	118.00
7 100% RDF + Sardar amin granules @ 8 kg/acre	94.72	151.00	138.13	127.95
8 100% RDF + Sardar amin granules @ 8 kg/acre + bentonite sulfur	95.32	145.67	149.00	130.00
Mean	71.46	115.01	120.60	
CD	CS	9.45		
*CS= Cropping system, NL= Nutrient levels	NL	12.80		
	CS X NL	NS		

Table 6. Effect of SAG-BS application on system productivity (kg $ha^{-1}day^{-1}$) (2018-21).

Fertilizer treatments	System productivity (kg $ha^{-1}day^{-1}$)			
	M-W	M-P-O	M-P-Sm	Mean
1 Control (No fertilizer)	12.00	21.40	22.10	18.50
2 Sardar amin granules @ 8 kg/acre	12.30	19.10	21.80	17.73
3 Sardar amin granules @ 8 kg/acre + bentonite sulfur	13.83	19.70	25.50	19.68
4 100% recommended dose of fertilizers (RDF)	29.83	44.67	40.20	38.23
5 75% RDF + Sardar amin granules @ 8 kg/acre	28.63	41.07	36.93	35.54
6 75% RDF + Sardar amin granules @ 8 kg/acre + bentonite sulfur	28.23	39.37	36.50	34.70
7 100% RDF + Sardar amin granules @ 8 kg/acre	31.03	44.97	37.33	37.78
8 100% RDF + Sardar amin granules @ 8 kg/acre + bentonite sulfur	31.27	43.40	40.27	38.31
Mean	23.39	34.21	32.58	
CD	CS	NS		
*CS= Cropping system, NL= Nutrient levels	NL	3.42		
	CS X NL	NS		

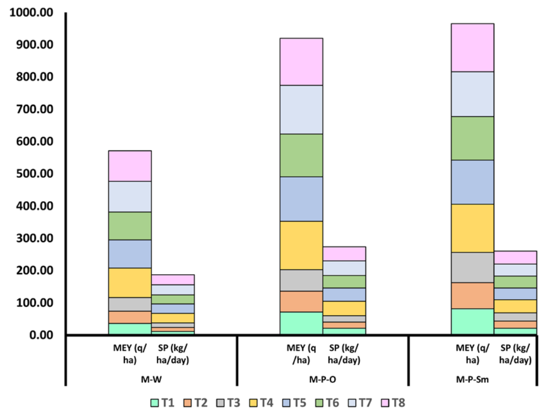

Fig. 2. Maize equivalent yield and system productivity (2018-21) of different crop sequences.

Maize

A significant variation in maize crop yield among different treatments was observed. Maize yield ranged from 14.44 (T_2) to 39.83 (T_8). This indicating there by that substantial effect of fertilizer treatments on maize yield. Lowest maize yield was obtained in T_2 (SAG @ 8 kg) and maximum was obtained under treatment T_8 where SAG and BS were applied along with recommended fertilizers. Significant increase in maize yield was obtained in T_4, T_5, T_6, T_7, T_8 treatments compared to T_1, T_2 and T_3. However, the variation was not significant among T_4, T_5, T_6, T_7, T_8 treatments. The increase in maize yield with the application of SAG and BS may be due to increased mobility and availability of nutrients (Meyer *et al.* 2023) also reported the same.

Wheat

Wheat also responded to the application of the SAG and BS. The highest wheat grain yield was obtained in T_8 treatment which was significantly higher than T_1, T_2 and T_3. Although, there was a numerical increase in the grain yield with the application of SAG and BS but over RDF the increase was statistically non-significant. A numerical increase in grain yield of wheat was also observed.

Potato

Minimum tuber yield of potato was obtained in control. A major increase in yield was obtained with application of SAG and SAG and BS without any other chemical fertilizer. Whereas, maximum tuber yield was obtained in the treatment 100% RDF treatment (T_4). Although a numerical decrease in potato tuber yield was obtained in the treatments involving 75% RDF along with SAG and BS. The yield among treatments T_4,T_5,T_6,T_7 remain at par indicating there by that potato did not respond to application of either SAG or SAG and BS.

Onion

Minimum onion yield (116.3) was obtained in control and maximum was observed in 100 % RDF + SAG +BS treatment (T_8). In the treatments, where 75% RDF was applied along with SAG and BS there was a reduction in the bulb yield.

Summer moong

Similarly, highest yield was obtained in treatment T_8 and minimum was obtained in T_1. The yield of summer moong was higher in all treatments over control.

Overall, treatment 7 was found to be most promising with highest grain yield in case of maize wheat, onion and summer moong. Thus, application of RDF with Sardar amin granules tends to result in higher grain yield (Ojo *et al.* 2011).

Equivalent yield and system productivity

The grain yield of component crop of different cropping systems was converted into maize equivalent yield and data are presented in Table 5, (Fig. 2). Maximum maize equivalent yield (MEY) was observed under Maize-potato-summer moong (120.6 q/ha) cropping system which may be due to which could be due to inclusion of third crop of summer moong in M-P-Sm cropping system (Singh and Sikka 2007). Minimum grain yield was obtained in maize-wheat (71.5 q/ha), which may be due to low yields and low returns of maize in this sequence. The MEY under both M-P-O and M-P-Sm were significantly higher as compared to M-W cropping system. Mean different fertilizer treatments also significantly influenced maize equivalent yield. A minimum was obtained

Table 7. Influence of SAG and BS on soil health after maize-based cropping systems.

Fertilizer treatments	pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	7.58	0.50	0.30	74.4	58.6	202.3
T_2	7.61	0.51	0.27	93.6	60.0	181.3
T_3	7.63	0.42	0.38	93.6	57.6	197.5
T_4	7.68	0.48	0.26	127.7	60.8	223.1
T_5	7.66	0.49	0.24	103.6	51.9	199.2
T_6	7.63	0.50	0.37	119.1	62.1	226.4
T_7	7.51	0.61	0.34	151.1	39.8	197.5
T_8	7.69	0.62	0.36	154.2	44.3	202.6
LSD (p= 0.05)	NS	NS	NS	11.47	6.41	15.8

in control whereas maximum MEY was obtained in 100% RDF treatment (T_4). The MEY observed under among T_4, T_5, T_6, T_7 and T_8 remained statistically at par.

System productivity

System productivity in the terms of kg/ha/day following similar trend as in case of maize equivalent yield (Table 6). The maximum system productivity 34.2 kg/ha/day was obtained in maize-potato-onion crop system followed by maize-potato-summer moong whereas minimum was obtained under maize-wheat. This may be because of higher level of production of component crop in different cropping system. Similar trend was also reported by (Singh and Sikka 2007).

Soil health

After two cycles of cropping system no significant effect was found pH, EC and OC% of soil. Treatments had significant effect on available N, P and K. Highest value of OC%, available P and K was found maximum in T_6 (75% RDF + SAG @ 8 kg/acre + BS). Available P of soil decreased under treatment T_7 (100% RDF with SAG @ 8 kg/acre) and T_8 (100% RDF with SAG @ 8 kg/acre and BS). This may be due to more P uptake by crops than applied to different crops (Sikka *et al.* 2022). Similar trend was observed in available K of soil. Soil available N content (Table 7) was significantly higher with the application of 100% recommended dose of fertilizers +SAG + Bentonite sulfur (154.2 kg ha^{-1}), followed by 100% recommended dose of fertilizers +SAG (151.1 kg ha^{-1}) as compared to that of 100% recommended dose fertilizers (127.7 kg ha^{-1}) applied alone. This could be due to nitrogen containing SAG (Sikka *et al*. 2018).

CONCLUSION

Maize is one of the most important crops of India. Optimum nutrition of the crop through application of fertilizers and nutrient additives ensures sustainable high yield of crops. In this study, Sardar amin granules and Bentonite sulfur was evaluated in different proportions in a three-year field experimentation involving different maize-based cropping systems. Maize-potato-summer moong proved to be the most productive cropping system whereas maize-wheat the predominant cropping system proved least productive. Addition of SAG and Bentonite sulfur alone or in combination significantly enhanced the yield of maize, wheat and potato. Not much variation in soil properties was observed.

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