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Effect of organic manures, phosphorus and sulphur on growth, yield attributes and yield of summer groundnut in loamy sand

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Abstract
A field experiment was conducted at Agronomy Instructional Farm, Department of Agronomy, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar to study the effect of organic manures, phosphorus and sulphur on growth, yield attributes and yield of summer groundnut in loamy sand during summer 2020 and 2021. There were eighteen treatment combinations comprising of three organic manures i.e., M_1: 5 t FYM/ha, M_2: 0.75 t castor cake/ha and M_3: 2.5 t vermicompost/ha as well as three levels of phosphorus i.e., P_1: 25 kg P_2O_5/ha, P_2: 50 kg P_2O_5/ha and P_3: 75 kg P_2O_5/ha and two levels of sulphur i.e., S_1: 20 kg S/ha and S_2: 40 kg S/ha were tested in a spilt-split plot design with four replications. The results revealed that an application of 2.5 t vermicompost/ha, 75 kg P_2O_5/ha and 40 kg S/ha either in combination or alone gave significantly higher growth, yield attributes and yield parameters *viz*., higher number of pods per plant, pods weight per plant, seed index, pod and haulm yield of summer groundnut.

Keywords: FYM, vermicompost, castor cake, phosphorus, sulphur, groundnut, yield

Introduction

Groundnut holds significant importance in India as a versatile crop used for food, fodder, and cash purposes. The seeds contain substantial oil (43-50%) and protein (21-26%). The crop is predominantly grown across 4.89 million hectares in India, yielding around 10.10 million tonnes. Gujarat, Rajasthan, Tamil Nadu, Andhra Pradesh, Karnataka, Madhya Pradesh, and Maharashtra accounting for the majority of production. Gujarat leads in both area and production, particularly in the Saurashtra region, often referred to as the 'bowl of groundnut'. Despite challenges like uncertain rainfall and pest infestations, the cultivation of groundnut remains profitable, especially in the summer season due to controlled moisture, sunlight, and fewer pest issues.

In the era following the green revolution, soil degradation and depletion have become significant concerns, primarily due to the excessive harvesting of nutrients compared to their application, particularly phosphorus and sulphur. This has led to reduced productivity and profitability in agriculture. Soil nutrient reserves are being rapidly exploited due to imbalanced and inadequate fertilizer use, insufficient organic manure application and lack of farmer awareness. The improper utilization of input led to detrimental effects on soil health, as revealed by an analysis of approximately 9.6 million soil tests, nearly half (49.3%) of India's soil area has low available phosphorus, 48.8% is medium, and only 1.9% is high in phosphorus content. Compared to previous data, the proportion of land with low phosphorus fertility has increased by 3.0%, while medium and high categories have decreased by 2.7% and 0.3% respectively. Additionally, around 70% of soil samples were found to be deficient or marginally adequate in plant-available sulphur (AICRPs NRM, 2002-07) [1].

To achieve sustainable high yields, supplementing deficient nutrients through organic manure in combination with fertilizers is crucial. The integration of organic manures with inorganic fertilizers under the Integrated Plant Nutrient System (IPNS) has been shown to reduce chemical fertilizer usage. The synergy of organic manure and chemical fertilizers is complementary and enhances each other's benefits. This integration leads to improved and sustainable crop production when applied to phosphorus and sulphur fertilizers (Bellakki and Badanur, 1997) [2].

Organic manures play a significant role in enhancing crop yield and improving soil properties. Among various organic manures, Farm Yard Manure (FYM) is providing a balanced mineral composition and improving nutrient availability through biological decomposition (Kumar *et al*., 2011) [12]. Additionally, vermicompost is a potential source of bulky organic manure due to the presence of readily available plant nutrients, growth enhancing substances and a number of beneficial microorganisms like nitrogen fixing, phosphorus solubilizing and cellulose decomposing organisms (Kumari and Ushakumari, 2002) [13] and castor cake, a residual product from oil extraction, contribute to soil health and plant nutrition. Phosphorus is vital for plant growth and yield, playing a key role in cell division, energy transfer, and root development. Sulphur, the fourth major nutrient, is crucial for oilseed crops due to its role in amino acid composition (Gangadhara *et al*., 1990) [8] and protein formation.

Material and Methods

A field experiment was conducted at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of organic manures, phosphorus and sulphur on summer groundnut and their residual effect on succeeding greengram in loamy sand during summer - *kharif*, 2020 and 2021. The soil of the experimental plot was loamy sand in texture, low in organic carbon, available N and DTPA-extractable Fe and Zn, medium in available P_2O_5, K_2O and S whereas high in DTPA-extractable Mn and Cu content. There were eighteen treatment combinations comprising of three organic manures *i.e.*, M_1: 5 t FYM/ha, M_2: 0.75 t castor cake/ha and M_3: 2.5 t vermicompost/ha as well as three levels of phosphorus *i.e.*, P_1: 25 kg P_2O_5/ha, P_2: 50 kg P_2O_5/ha and P_3: 75 kg P_2O_5/ha and two levels of sulphur *i.e.*, S_1: 20 kg S/ha and S_2: 40 kg S/ha were tested in a spilt-split plot design with four replications.

As per treatments, the summer groundnut crop cv. GG2 was fertilized with phosphorus in the form of DAP and sulphur in the form of elemental sulphur with organic manures i.e., farm yard manure, castor cake and vermicompost in respective treatments combinations. all agronomical practices and plant protection measure was followed for better and successful crop production. The observation on growth yield attributes and yield were recorded by randomly selected five plants from net plot area and tagged all plants for further observations. The data of various parameters were statistically analyzed using analysis of variance (ANOVA) technique and the treatments were compared at 5% levels of significance (Cochran and Cox, 1957) [5].

Results and Discussion

Effect of Organic manures

The data in respect of growth, yield attributes and yield of summer groundnut as influenced by different organic manures are resented in Table 1 and 2. An application of 2.5 t vermicompost/ha (M_3) recorded significantly higher number of pods per plant, pods weight per plant, seed index, pod and haulm yields of summer groundnut compared to 5 t FYM/ha (M_1), but it was remained at par with 0.75 t castor cake/ha (M_2). However, Plant height, shelling percentage and number of root nodules per plant did not affected significantly due to various organic manures. This result might be due to fact that each organic manure (Vermicompost, FYM, and castor cake) brings a unique nutrient profile and microbial community to the soil. This can lead to variable effects on different growth parameters. The disparity in effects might be due to variations in nutrient availability, such as nitrogen, phosphorus, and micronutrients, provided by each organic source. Different nutrients play distinct roles in plant growth and development, influencing different aspects of the plant's physiology. Vermicompost tends to have finer particle size and higher decomposition rates compared to FYM and some other organic amendments. This faster breakdown can result in quicker release of nutrients, making them more readily available to plants during critical growth stages. Vermicompost contains beneficial microorganisms introduced by earthworms during the decomposition process. These microorganisms can improve soil nutrient supply capacity, nutrient cycling, and overall microbial activity in the rhizosphere. The microbial activity in vermicompost can facilitate nutrient release and uptake by plants, potentially leading to better nutrient utilization and improved growth. The presence of plant growth-promoting substances like auxins, cytokinins, and gibberellins in vermicompost can stimulate plant growth, root development, and flowering. These compounds might have contributed to the observed improvements in pod formation, seed index, and yield-related parameters. These results are in confirmation with the findings of Dhakal *et al*. (2016) [7], Devi *et al.* (2013) [6], Moinuddin and Kaleem (2017) [15] and Choudhary *et al*. (2017) [4] in groundnut.

Effect of phosphorus

Significantly the higher plant height at harvest, number of root nodules per plant at flowering, number of pods per plant, pods weight per plant, seed index, shelling percentage, pod and haulm yields of summer groundnut were registered with the application of 75 kg P_2O_5/ha (P_3) over 25 kg P_2O_5/ha (P_1) but it was remained at par with 50 kg P_2O_5/ha (P_1). This might be due to fact that phosphorus is a crucial nutrient for plant growth and development. Its importance extends across a numerous critical physiological processes, involving not only the transfer of energy within the plant but also the complex process of root growth and seed formation. As the availability of phosphorus increases, its varied impacts become evident as root growth is stimulated, akin to the plant's extended hands reaching deeper into the soil to absorb vital nutrients. This heightened intake of nutrients enhances the plant's overall health, reflecting not only in its vitality but also in its stature, as shown by an increase in plant height reaching towards the sunlit canopy. Root nodules, the delicate homes of nitrogen-fixing bacteria, multiply in number, a testament to the harmonious partnership enabled by ample phosphorus. These results are in the lines of those reported by Kumar *et al.* (2008) [11] in groundnut, Meena *et al.* (2015) [14] in soybean, Jeetarwal *et al*. (2015) [9] in groundnut, Kalita *et al*. (2015) [10] in groundnut and Pandey and Pandey (2019) [17] in groundnut.

Effect of sulphur

Among different levels of sulphur, an application of 40 kg S/ha gave significantly higher plant height and number of root nodules per plant at flowering, number of pods per plant, pods weight per plant, seed index, shelling percentage, pod and haulm yields of summer groundnut compared to 20 kg S/ha (S_1). This might be due to fact that sulphur is an essential macronutrient required by plants for various metabolic processes, including protein synthesis and chlorophyll formation. It's a vital component of amino acids and certain vitamins. Adequate sulphur availability can lead to better plant growth, as it's involved in multiple physiological processes that contribute to overall plant development. These results are in agreement with those reported by Pandey and Pandey (2019) [17] in groundnut.

Interaction effects

The combined results of the study revealed notable findings with respect to various combinations of organic manures and phosphorus or sulphur applications. Among the various combinations of organic manures and phosphorus, the combination labelled as M_3P_3 (Involving 2.5 t vermicompost/ha + 75 kg P_2O_5/ha) demonstrated a markedly higher count of pods per plant, along with increased pod weight per plant and overall pod and haulm yields. Conversely, among the diverse combinations of organic manures and sulphur, the M_3S_2 combination (involving 2.5 t vermicompost/ha + 40 kg S/ha) exhibited a significant increase in the number of pods per plant, as well as enhanced pod and haulm yields. Furthermore, considering the different combinations of phosphorus and sulphur, the P_3S_2 combination (Involving 75 kg P_2O_5/ha+ 40 kg S/ha) demonstrated pronouncedly higher values for parameters such as pods per plant, pod weight per plant, seed index and yields of kernel, pod and haulm. In contrast, the integration of organic manures, phosphorus, and sulphur in the $M_3P_3S_2$ combination (2.5 t vermicompost/ha + 75 kg P_2O_5/ha + 40 kg S/ha) yielded particularly substantial results in terms of pods per plant, pod yield and haulm yield of summer groundnut.

These finding may be due to fact that, when these three components were combined in the 2.5 t vermicompost/ha + 75 kg P_2O_5/ha + 40 kg S/ha combination, the synergistic effects of organic matter, phosphorus, and sulphur likely created an ideal environment for the plants. The vermicompost provided a continuous release of nutrients and improved soil structure. Concurrently, the presence of phosphorus and sulphur played pivotal roles in supporting essential plant functions. This harmonious blend resulted in robust and thriving plants, ultimately leading to elevated yields. The specific combination of vermicompost, phosphorus, and sulphur in the $M_3P_3S_2$ treatment might have provided a balanced nutrient supply, addressed potential deficiencies and ensured that the plants had access to the necessary nutrients throughout their growth cycle. This balance could have led to improved plant growth, pod development, and ultimately higher yields. Similar findings were obtained by Murthy *et al.* (2009) [16] and Bhavya *et al.* (2018) [3].

Table 1: Plant height**,** number of root nodules per plant**,** number of pods per plant and pods weight per plant of summer groundnut as influenced by organic manures, phosphorus and sulphur

Treatments	Plant height (cm)			Number of root nodules per plant (at flowering)			Number of pods per plant			Pods weight per plant (g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Organic manures (M)												
M_1: 5 t FYM/ha	36.7	36.9	36.9	63.7	64.2	64.0	22.0	22.8	22.4	10.3	11.7	11.0
M_2: 0.75 t castor cake/ha	37.4	37.5	37.6	64.1	64.3	64.2	23.1	23.2	23.1	12.4	12.6	12.5
M_3: 2.5 t vermicompost/ha	37.5	37.8	37.7	65.0	65.9	65.5	23.9	24.4	24.2	13.1	13.5	13.3
S.Em.±	0.51	0.58	0.53	0.81	0.90	0.83	0.34	0.37	0.40	0.26	0.21	0.23
C.D. at 5 %	NS	NS	NS	NS	NS	NS	1.17	1.29	1.40	0.91	0.74	0.81
CV %	12.9	12.0	12.4	9.93	8.58	8.44	9.39	9.64	8.42	4.77	4.92	4.41
Phosphorus levels (P)												
P_1: 25 kg P_2O_5/ha	34.3	34.8	34.6	60.8	61.8	61.3	21.4	21.8	21.6	10.1	10.5	10.3
P_2: 50 kg P_2O_5/ha	37.9	38.3	38.1	65.7	65.9	65.8	23.0	23.5	23.2	12.5	13.2	12.9
P_3: 75 kg P_2O_5/ha	39.4	39.3	39.3	66.5	66.6	66.5	24.6	25.0	24.8	13.1	14.1	13.6
S.Em.±	0.55	0.58	0.57	0.71	0.65	0.68	0.57	0.53	0.57	0.25	0.33	0.27
C.D. at 5 %	1.62	1.72	1.69	2.11	1.92	2.03	1.69	1.58	1.70	0.73	0.97	0.81
Interaction (M × P)												
C.D. at 5 %	NS	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CV %	12.0	11.5	11.1	7.7	7.0	7.6	8.02	7.85	7.44	4.22	4.79	3.58
Sulphur levels (S)												
S_1: 20 kg S/ha	34.4	34.6	34.5	62.3	62.2	62.1	21.8	22.5	22.1	10.6	12.0	11.3
S_2: 40 kg S/ha	39.9	40.3	40.1	65.9	67.6	66.6	24.2	24.4	24.3	13.2	13.2	13.2
S.Em.±	0.46	0.56	0.67	0.83	0.92	0.93	0.40	0.44	0.41	0.23	0.31	0.28
C.D. at 5 %	1.34	1.62	1.93	2.41	2.67	2.71	1.17	1.27	1.19	0.68	0.91	0.82
Interaction (M × S)												
C.D. at 5 %	NS	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.	NS	NS	NS
Interaction (P × S)												
C.D. at 5 %	NS	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Interaction (M × P × S)												
C.D. at 5 %	NS	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.	NS	NS	NS
CV %	10.4	10.7	10.4	7.11	7.82	6.90	7.93	7.88	7.29	4.13	4.78	4.31

Table 2: Pod, haulm and kernel yields and seed index of summer groundnut as influenced by organic manures, phosphorus and sulphur

Treatments	Pod yield (kg/ha)			Haulm yield (kg/ha)			Kernel yield (kg/ha)			Seed index (g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Organic manures (M)												
M_1: 5 t FYM/ha	2057	2151	2104	3536	3675	3605	1398	1477	1437	41.3	41.5	41.4
M_2: 0.75 t castor cake/ha	2179	2204	2192	3676	3735	3705	1493	1516	1504	42.1	42.5	42.3
M_3: 2.5 t vermicompost/ha	2227	2311	2269	3739	3857	3798	1535	1598	1567	43.0	43.4	43.2
S.Em.±	47.0	30.3	41.7	39.7	33.0	38.4	29.1	26.0	28.7	0.38	0.29	0.40
C.D. at 5 %	163	105	144	137	114	133	100	90	99	1.31	1.00	1.38
CV %	12.5	12.7	11.3	14.9	13.3	12.7	11.6	10.2	10.2	3.83	4.62	3.27
Phosphorus levels (P)												
P_1: 25 kg P_2O_5/ha	1967	2075	2021	3438	3562	3500	1323	1415	1369	41.1	41.4	41.3
P_2: 50 kg P_2O_5/ha	2153	2212	2183	3650	3748	3699	1479	1526	1503	41.9	42.2	42.0
P_3: 75 kg P_2O_5/ha	2344	2379	2361	3863	3956	3909	1624	1649	1636	43.3	43.8	43.6
S.Em.±	67.0	71.5	66.5	53.3	54.8	61.4	32.8	37.1	31.0	0.54	0.64	0.61
C.D. at 5 %	199	212	198	158	163	182	97	110	92	1.61	1.89	1.82
Interaction (M × P)												
C.D. at 5 %	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	NS	NS	NS	NS	NS
CV %	11.2	11.0	10.4	12.0	12.4	11.5	11.1	10.9	10.0	3.34	4.01	3.26
Sulphur levels (S)												
S_1: 20 kg S/ha	1976	2065	2021	3458	3591	3525	1337	1408	1373	41.4	41.7	41.6
S_2: 40 kg S/ha	2333	2379	2356	3842	3920	3881	1614	1652	1633	42.8	43.2	43.0
S.Em.±	77.2	61.4	55.2	49.3	45.8	44.7	32.3	37.6	33.4	0.43	0.51	0.45
C.D. at 5 %	223	178	160	143	133	130	93	109	96	1.24	1.48	1.32
Interaction (M × S)												
C.D. at 5 %	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	NS	NS	NS	NS	NS
Interaction (P × S)												
C.D. at 5 %	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.	Sig.
Interaction (M × P × S)												
C.D. at 5 %	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	NS	NS	NS	NS	NS
CV %	11.1	10.3	10.3	12.0	11.5	11.0	10.2	10.9	9.4	3.34	3.97	3.31

Conclusion

On the basis of two years experimental findings, it is concluded that the combination of 2.5 t vermicompost/ha, 75 kg P_2O_5/ha, and 40 kg S/ha, or the separate applications of each, demonstrated synergistic outcomes, Notably, this combination created an ideal environment for plants, leading to robust growth and elevated yields. The study's findings underscore the significance of a holistic approach, integrating organic manures and essential nutrients, in optimizing summer groundnut cultivation. The findings provide valuable insights for farmers and agricultural practitioners seeking to optimize organic farming practices and nutrient management for improved summer groundnut yields.

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