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Effect of POLY4 Application on the Growth and Yield of Groundnut (*Arachis hypogaea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the effect of POLY4 Application on the Growth and Yield of Groundnut.
Study Design: Randomized Block Design.
Place and Duration of Study: Gungal Research Farm, ICAR-Central Research Institute for Dry land Agriculture, Hyderabad, India between June 2022 and October 2022.
Methodology: A field experiment was conducted at Gungal Research Farm, ICAR-Central Research Institute for Dry land Agriculture, Hyderabad, and Telangana during the *Kharif* season of 2022 to the evaluate the Impact of POLY4 Application on the Growth and Yield of Groundnut**.** The

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experiment was assigned in ten treatments, laid out in Randomized Block design with three replications. The treatments were T_1-Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1}, T_2-Recommended NP only, T_3-Recommended NPK, T_4-Recommended NP + 50% K through MOP, T_5-Recommended NP + 100% of rec. K through Poly4, T_6-Recommended NP + 100% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}, T_7-Recommended NP + 50% of rec. K through Poly4, T_8-Recommended NP + 50% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}, T_9-Recommended NP + gypsum @ 500 kg ha^{-1} and T_{10}-Control.

Results: The application of Recommended NP(20:40 kg ha^{-1}) + 100% of rec. K(50 kg ha^{-1}) through POLY4 (T_5) treatment resulted in a significant increase in both plant height and leaf area at vegetative (18.1 cm and 320.4 cm^2 $plant^{-1}$), at flowering (31.9 cm and 554.7 cm^2 $plant^{-1}$),at pegging (39.5 cm and 785.3 cm^2 $plant^{-1}$), at pod formation (48.5 cm and 1088.5 cm^2 $plant^{-1}$), and at the harvest (54.4 cm and 359.5 cm^2 $plant^{-1}$) respectively compared to the control. Significantly higher pod yield (1556 kg ha^{-1}) was recorded under Recommended NP (20:40 kg ha^{-1}) + 100% K (50 kg ha^{-1}) through POLY4 (T_5). The lower yield (844 kg ha^{-1}) was recorded in control (T_{10}).

Conclusion: Polyhalite, also known as POLY4, is a highly effective fertilizer that provides potassium (K), sulfur (S), magnesium (Mg), and calcium (Ca) in a more efficient manner compared to equivalent soluble salts. Based on the findings of the current study, it can be concluded that application of 100% K through polyhalite (POLY4) along with recommended doses of nitrogen and phosphorus (20:40 kg ha^{-1}) in sandy loam soil was the best performing treatment.

Keywords: POLY4; DAS; growth; yield attributes; groundnut.

1. INTRODUCTION

Groundnut is the fourth most important source of edible oil and a third most important source of vegetable protein in the world. In terms of acreage, groundnut occupies first position in India with an area of 6.09 million hectares and 101 lakh tonnes of production with productivity of 1863 kg ha^{-1} [1]. Although India ranks first in area and production of groundnut, its productivity (1893 kg ha^{-1}) is much less than U.S.A., China and few other countries. The crop is cultivated in *kharif* in about 0.15 lakh acres across Telangana region. It is widely grown in Mahbubnagar, Warangal, Nalgonda and Karimnagar Districts [2]. The main reasons for low yield are that this energy rich crop is grown under energy starved conditions, mainly under rainfed (85%), and in less fertile light-textured soils. Further, groundnut being drought tolerant in nature, suffers from the nutrient deficiencies resulting in low yield. On an average, the groundnut crop requires 160-180 kg N, 20-25 kg P, 80-100 kg K, 60-80 kg Ca, 15-20 kg S, 30-45 kg Mg, 3-4 kg Fe, 300-400 g Mn, 150-200 g Zn, 140-180 g B, 30-40 g Cu and 8-10 g Mo, to produce 2.0 to 2.5 t ha^{-1} of economic yield [3]. In addition to this, there are widespread deficiencies of macro, micro, and secondary nutrients under rainfed conditions, it is estimated as 89% for N (63% low and 26% medium); 80% for P (42% low and 38% medium); 50% for K (13% low and 37% medium), 41% for S; 48% for Zn; 33% for B; 12% for Fe; 13% for Mo; 5% for Mn; and 3% for Cu [4]. Large-scale deficiencies of Mg and Ca have been reported recently in red and lateritic sandy soils. Several crops including groundnut is affected by deficiency of Ca and Mg. So, among macronutrients the K, Ca, Mg and S are to be managed properly because these elements play a key role in the kernel filling and oil synthesis of groundnut. In Southern Telangana, the major soil constraints in the descending order are dry soil moisture, gravelliness, low K reserve, low organic carbon content, and low cation exchange capacity [5]. Further, semiarid regions of Telangana are deficient in micronutrients in an order of Mn> B>Zn> Fe>Cu in groundnut growing soils [6]. Polyhalite is a natural combination of four (K, S, Mg and Ca) of the total six essential macronutrients required for growth and development of plants. POLY4 contains 14% K_2O, 17% CaO, 6% MgO and 19% S. It is obtained from polyhalite ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$), a potassium-bearing mineral in UK [7]. However, meager information is available on the effect of POLY4 on the performance of groundnut in India. The present study is therefore proposed to study the effect of POLY4 on groundnut growth, yield and yield attributes under rainfed conditions.

2. MATERIALS AND METHODS

A field experiment was conducted during the *Kharif* season of 2022 at Gungal Research Farm, ICAR-Central Research Institute for Dry land Agriculture, Hyderabad, and Telangana. The

experimental site is situated at 17°40' 40.4" N latitude and 78°39', 55.7" E longitude. The study was conducted in a randomized block design with three replications, and ten treatments. The treatments were T_1-Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1}, T_2-Recommended NP only, T_3-Recommended NPK, T_4-Recommended NP + 50% K through MOP, T_5-Recommended NP + 100% of rec. K through Poly4, T_6-Recommended NP + 100% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}, T_7-Recommended NP + 50% of rec. K through Poly4, T_8-Recommended NP + 50% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}, T_9-Recommended NP + gypsum @ 500 kg ha^{-1} and T_{10}-Control. A healthy and mature seed of the groundnut variety Kadiri-9 was selected for sowing. The seeds were sown with a plant spacing of 30 cm x 10 cm on flat beds. Nitrogen, phosphorous, and potassium fertilizers were applied at the rates of 20:40:50 kg N, P_2O_5, and K_2O per ha, respectively using urea, DAP, MOP, POLY4, and gypsum at 310 kg ha^{-1}, as per the treatments. All fertilizers, except gypsum, were applied as a basal dose, while gypsum was applied at the flowering stage of the crop. The crop was grown by following standard agricultural practices and was manually harvested in the second week of October. Throughout the experiment, growth parameters such as plant height (cm) and leaf area (cm^2 $plant^{-1}$) were recorded during the vegetative stage, flowering stage, peg formation stage, pod formation stage, and harvest stage of the groundnut. Yield parameters, including the number of pods $plant^{-1}$, pod yield (kg ha^{-1}), haulm yield (kg ha^{-1}), and test weight (g), were also measured. Observations were collected at regular intervals from five randomly selected plants within each plot and replication. All the replicated data obtained from the experiment were statistically analyzed using the F test as per the procedure given by Gomez and Gomez [8].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The effect of Poly4 application on plant height and leaf area was found significant at vegetative, flowering, pegging, pod formation and harvest stages. Application of Recommended NP (20:40 kg ha^{-1}) + 100% K (50 kg ha^{-1}) through POLY4 (T_5) resulted in significantly higher plant height at vegetative (18.1cm), flowering (31.9 cm), pegging (39.5 cm), pod formation (48.5 cm) and harvest stages (54.4 cm) compared to control (Table 1). However, these measurements were comparable to Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1} (T_1), Recommended NP + 100% of rec. K through POLY4 + gypsum @ 310 kg ha^{-1} (T_6), Recommended NPK (T_3) and Recommended NP + 50% of rec. K through POLY4 (T_7). The use of Poly4 can promote vegetative growth and increase the plant height in groundnut Karthikeyan et al. [9], Beer et al. [10] and Hemeid et al. [11]. The increased plant height may be attributed to the balanced supply of potassium, calcium, magnesium, and sulfur through the use of POLY4. These associated nutrients likely contributed to rapid cell division and elongation, thereby enhancing photosynthesis rate and activity. Leaf area was also significantly higher in Recommended NP (20:40 kg ha^{-1}) + 100% K (50 kg ha^{-1}) through POLY4 (T_5) treatment at vegetative, flowering, pegging, pod formation and harvest stages (320.4, 554.7, 785.3, 1088.5, and 359.5 cm^2 $plant^{-1}$ respectively) compared to control (Table 2); however the treatments Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1} (T_1), Recommended NP + 100% of rec. K through POLY4 + gypsum @ 310 kg ha^{-1} (T_6), Recommended NPK (T_3) and Recommended NP + 50% of rec. K through POLY4 (T_7) were statistically on par with each other. The results are similar with the findings of Truong et al. [12] and Baraker et al. [13].

3.2 Yield

The Table 3 shows the effect of Poly4 application on yield. The effect of application of Poly4 in conjunction with recommended NP (T_5) on yield was found significant and resulted in higher pod yield of 1556 kg ha^{-1} compared to control. This yield was comparable to the yields obtained from treatments Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1} (T_1), Recommended NP + 100% of rec. K through POLY4 + gypsum @ 310 kg ha^{-1} (T_6), Recommended NPK (T_3) and Recommended NP + 50% of rec. K through POLY4 (T_7) and Recommended NP + 50% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1} (T_8), which yielded 1549, 1544, 14790, 1461, and 1456 kg ha^{-1}, respectively. The plots treated with recommended NP + 100% K through Poly4 recorded 45.8% increase in yield compared to the control, while the recommended NPK treatment showed a 42.1% increase over control. Hoang et al. [14], Kumar et al. [15], Xue et al. [16] and Pramanick et al. [17] also reported similar results observed with application of different doses of Poly4 improved the yield

due to availability of all essential nutrients. However, application of POLY4 in groundnut did not result in any significant difference in haulm yield.

3.3 Yield Attributes

The plots applied with recommended NP + 100% of recommended K through Poly4 recorded significantly higher number of pods per plant (36.7) compared to control (27.3), although this count was comparable to treatments Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1} (T_1), Recommended NP + 100% of rec. K through POLY4 + gypsum @ 310 kg ha^{-1} (T_6), Recommended NPK (T_3) and Recommended NP + 50% of rec. K through POLY4 (T_7) (Table 3). The increase in the number of pods per plant can be attributed to the improved availability of essential nutrients provided by Poly4. Higher number of pods per plant was also recorded due to application of Poly4 was reported by Gashti et al. [18], Melgar et al. [19] and Sireesha et al. [20]. Test weight being a genetical character, it was not significantly influenced by the application of Poly4. Test weight was 30.7 and 33.7 g, respectively for control and Recommended NP + 100% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1} applied plots.

Table 1. Effect of POLY4 fertilization on plant height (cm) of groundnut

Treatment	Crop stage				
	VS	FS	PS	PFS	HS
T_1-Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1}	17.2	29.8	38.3	47.2	53.7
T_2-Recommended NP only	13.3	20.2	27.3	36.5	39.8
T_3-Recommended NPK	16.0	27.9	35.3	43.4	51.6
T_4-Recommended NP + 50% K through MOP	14.6	22.7	29.8	38.2	44.7
T_5-Recommended NP + 100% of rec. K through Poly4	18.1	31.9	39.5	48.5	54.4
T_6-Recommended NP + 100% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}	16.3	28.5	37.7	45.8	52.9
T_7-Recommended NP + 50% of rec. K through Poly4	15.2	26.2	33.5	41.5	48.5
T_8-Recommended NP + 50% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}	15.1	24.5	31.4	39.3	45.2
T_9-Recommended NP + gypsum @ 500 kg ha^{-1}	14.0	21.3	28.2	33.6	41.3
T_{10} -Control	12.7	18.3	25.5	31.5	36.5
SEm±	1.0	1.7	2.2	2.7	3.0
CD at 5%	3.0	5.0	6.5	8.1	8.9

*(**VS:** Vegetative stage, **FS:** Flowering stage, **PS:** Pegging stage, **PFS:** Pod formation stage, **HS:** Harvest stage)*

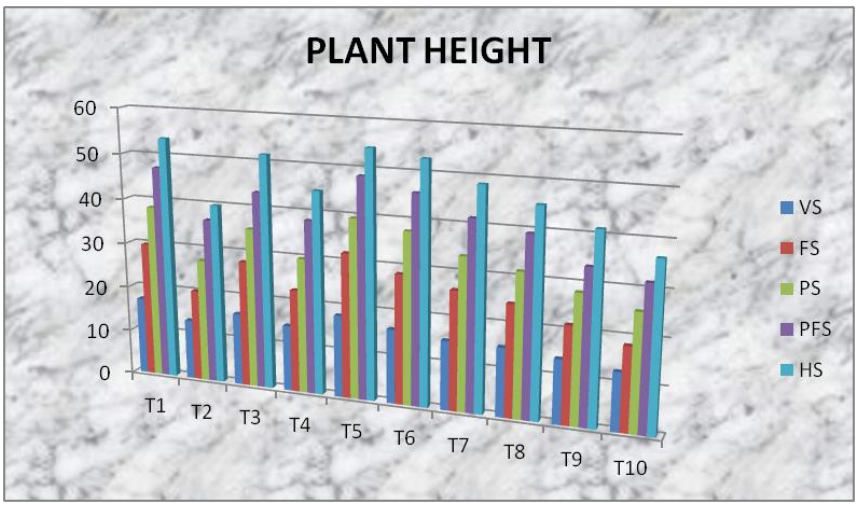

Fig. 1. Effect of POLY4 on plant height of groundnut at different stages

Table 2. Effect of POLY4 fertilization on leaf area (cm^2 plant^{-1}) of groundnut

Treatment	Crop stage				
	VS	FS	PS	PFS	HS
T_1-Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1}	314.5	541.4	759.6	1052.6	332.3
T_2-Recommended NP only	208.9	452.9	589.1	861.3	245.0
T_3-Recommended NPK	276.7	509.9	729.7	999.8	304.0
T_4-Recommended NP + 50% K through MOP	226.8	486.3	611.6	911.7	268.0
T_5-Recommended NP + 100% of rec. K through Poly4	320.4	554.7	785.3	1088.5	359.5
T_6-Recommended NP + 100% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}	299.3	515.8	731.2	1020.0	317.0
T_7-Recommended NP + 50% of rec. K through Poly4	263.7	504.8	715.2	971.4	288.7
T_8-Recommended NP + 50% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}	236.3	491.3	667.8	950.0	270.7
T_9-Recommended NP + gypsum @ 500 kg ha^{-1}	217.5	476.5	597.5	907.4	253.0
T_{10} -Control	182.4	418.6	575.2	792.3	227.7
SEm±	19.4	21.2	31.1	39.0	19.3
CD at 5%	57.6	63.0	92.4	115.9	57.5

*(**VS:** Vegetative stage, **FS:** Flowering stage, **PS:** Pegging stage, **PFS:** Pod formation stage, **HS:** Harvest stage)*

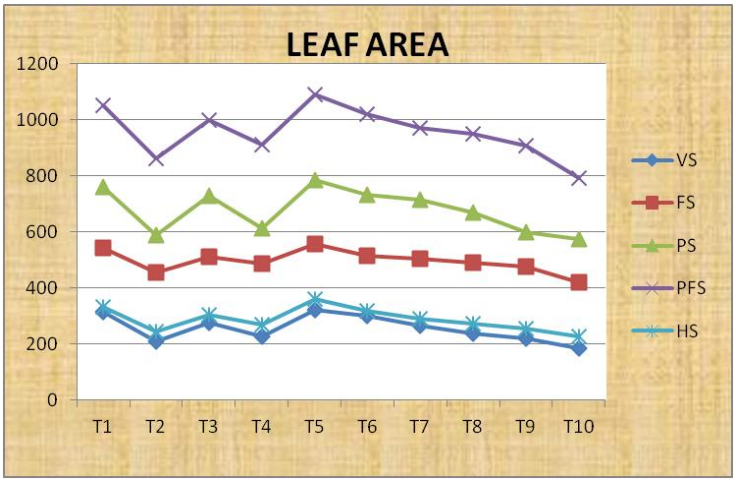

Fig. 2. Effect of POLY4 on leaf area of groundnut at different stages

Table 3. Effect of POLY4 fertilization on yield attributes and yield of groundnut

Treatment	Pods plant^{-1}	Test weight (g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1-Recommended NPK (20:40:50 kg ha^{-1}) + gypsum @ 500 kg ha^{-1}	35.7	33.1	1549	1939
T_2-Recommended NP only	32.3	31.6	1248	1854
T_3-Recommended NPK	35.0	33.2	1479	1911
T_4-Recommended NP + 50% K through MOP	32.7	32.0	1386	1944
T_5-Recommended NP + 100% of rec. K through Poly4	36.7	33.6	1556	1782
T_6-Recommended NP + 100% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}	36.0	33.7	1544	1916
T_7-Recommended NP + 50% of rec. K	33.7	32.9	1461	1915

Treatment	Pods plant^{-1}	Test weight (g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
through Poly4				
T_8-Recommended NP + 50% of rec. K through Poly4 + gypsum @ 310 kg ha^{-1}	34.7	33.4	1456	1853
T_9-Recommended NP + gypsum @ 500 kg ha^{-1}	32.3	31.7	1318	1737
T_{10} -Control	27.3	30.7	844	1668
SEm±	1.0	0.7	47.6	115.8
CD at 5%	2.8	NS	142	NS

4. CONCLUSION

Polyhalite, also known as POLY4, is a highly effective fertilizer that provides potassium (K), sulfur (S), magnesium (Mg), and calcium (Ca) in a more efficient manner compared to equivalent soluble salts. Based on the findings of the current study that application of 100% K through polyhalite (POLY4) along with recommended doses of nitrogen and phosphorus (20:40 kg ha^{-1}) (T_5) in sandy loam soil was found the best performing treatment in increasing growth and yield of groundnut.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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