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Response of groundnut (*Arachis hypogaea* L.) to foliar nutrition of urea phosphate

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Abstract
A field investigation entitled "Response of Groundnut (*Arachis hypogaea* L.) to foliar nutrition of urea phosphate" was conducted in summer season of 2024 at the AICRP on Groundnut, Mahatma Phule Krishi Vidyapeeth, Rahuri to study effect of foliar nutrition of urea phosphate in summer groundnut. The experiment was laid out in randomized block design (RBD) with three replications. The experiment consists of eight treatments *viz.,* The experiment consists of eight treatments *viz,* T_1: 100% RDNP, T_2: 75% RDNP, T_3: T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage, T_4: T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage, T_5: T_2 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage, T_6: T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage, T_7: T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage, T_8: T_2 + Foliar application of DAP @ 2% at flowering and peg formation stage. As regards yield attributing characters, significantly higher dry pod yield (40.11 q ha^{-1}), kernel yield (25.99 q ha^{-1}), haulm yield (49.07 q ha^{-1}), biological yield (89.18 q ha^{-1}) were recorded under treatment T_4: 100% RDNP+ Foliar application of urea phosphate @ 2% at flowering and peg formation stage Significantly the highest gross monetary returns (₹188848ha^{-1}) was obtained in T_4: 100% RDNP+ Foliar application of urea phosphate @ 2% at flowering and peg formation stage which also recorded a significantly maximum net monetary returns (₹124884ha^{-1}) and B:C ratio (2.95) than other treatments. While, T_2: 75% RDNP obtained minimum gross monetary returns, net monetary returns and B:C ratio among all the treatments.

Keywords: Urea phosphate, groundnut, yield, DAP, foliar

1. Introduction

Groundnut is an important oilseed crop. It belongs to family Fabaceae (*Leguminoceae*) and genus *Arachis* and species *hypogaea.* The word *Arachis hypogea* has been derived from Greek word, *Arachis* meaning legume, *hypogaea* meaning below ground.The groundnut, also known as the king of vegetable oilseed crops or the poor man's nut, is a significant food and oilseed crop. It is originally from South America. Groundnut (*Arachis hypogaea* L.) is the 13th important global crop, the 4th most crucial oilseed crop, and the 3rd leading source of vegetable protein. This crop is essential for global edible oil supplies and provides a vital source of nutrition for impoverished populations to address protein-energy malnutrition (Sardana and Kandhola, 2007) [9]. Roasted groundnut kernels are used in cooking, while raw peanut kernels are processed into peanut milk, butter, curd, and chutney. Groundnut is a crucial protein source for cattle and poultry feed and is also enjoyed as a confectionery item. Additionally, groundnut serves as a beneficial rotation crop. As a legume with root nodules, it can fix atmospheric nitrogen, enhancing soil fertility.India is the second largest groundnut producing country in the world after China.

Foliar feeding is a method of providing nutrients to plants by spraying liquid fertilizer directly to their canopy. If foliar nutrition treatment is extensively employed, it can be more efficient, cost effective, environmentally friendly, and target-oriented. Nowadays, foliar feeding is a widely utilized method in modern crop management to assure greater or optimal crop performance by promoting crop growth.

Flower drop is a key factor in determining production and yield-attributing characteristics in most pulse crops. The plant's retention of blossoms results in higher yields than planned. Research suggests that foliar application of growth regulators and macro nutrients during flower initiation and pod development, as well as soil nutrient application, can help retain flowers in various crops worldwide, including in India. Foliar nutrition is now acknowledged as an important form of fertilization in modern agriculture (Chaurasia *et al*., 2005) [1].

2. Materials and Methods

A field experiment entitled "Response of Groundnut (*Arachis hypogaea* L.) to foliar nutrition of urea phosphate" was conducted at the AICRP on Groundnut, Mahatma Phule Krishi Vidyapeeth, Rahuri during Summer season of 2024. Geographically, the AICRP on Groundnut is situated in between 19° 47' N and 19° 57' N latitude and between 74° 32' E and 74°19' E longitude. The altitude above mean sea level is about 525 meters. The soil in the experimental field belongs to sandy clay loam having depth more than 30 cm and the topography is uniform and levelled. For assessment of initial soil fertility status representative initial soil sample was created and evaluated for physical and chemical soil parameters. The soil texture of the experimental site was found to be sandy clay loam. Soil was low in available nitrogen (172.34 kg ha^{-1}), medium in available phosphorus (17.43 kg ha^{-1}) and high in potassium (321.29 kg ha^{-1}). The soil was slightly alkaline in reaction (pH 8.12) with normal in electrical conductivity of 0.32 dSm^{-1}. In terms of climate, the experimental unit is located in a semi-arid region and subtropical zone with annual rainfall ranges between 307 to 619 mm. Agro-climatically this area falls under scarcity zone (drought prone area) of Maharashtra state with an annual rainfall range from 307 to 619 with average of 520 mm. Over the most of the accommodate area, rainfall and its distribution are unpredictable and variable. The average annual maximum temperature varies from 28.1 °C to 38.3 °C, on other side annual mean minimum temperature ranges from 9.3 °C to 17.5 °C. There were eight treatments used during the course of the experiment and they are comprised of T_1: 100% RDNP, T_2: 75% RDNP, T_3: T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage, T_4: T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage, T_5: T_2 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage, T_6: T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage, T_7: T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage, T_8: T_2 + Foliar application of DAP @ 2% at flowering and peg formation stage. Genetically pure seed of Groundnut *var.* Phule Unnati was obtained from AICRP on Groundnut, Mahatma Phule Krishi Vidyapeeth, Rahuri. The recommended seed rate of 100 kg ha^{-1} was used. Sowing was done on 12th February 2024 by dibbling method with spacing 30 cm x 10 cm. Harvesting was done manually on 120 DAS of maturity. Immediately after uprooting, pods were separated from plants

3. Results and Discussion

3.1 Yield characters

3.1.1 Dry pod yield (q ha^{-1})

The data pertaining to dry pod yield (q ha^{-1}) of groundnut as affected by different treatments are presented in Table 1. The mean dry pod yield was 36.25 q ha^{-1}.

In summer groundnut, application of treatment T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (40.11 q ha^{-1}) recorded significantly highest dry pod yield than rest of all treatment but, it was at par with the application of T_3 *i.e.*, T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (37.59 q ha^{-1}), T_7 *i.e.*, T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (36.85 q ha^{-1}) and T_6 *i.e.*, T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (36.05 q ha^{-1}). The lowest dry pod yield was obtained in T_2 *i.e.*, 75% RDNP (33.50 q ha^{-1}).

Thus, the application of T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage resulted in enhancing various growth and yield contributing characters of groundnut and finally gave significantly higher pod yield over all other treatments. There is significant increase in dry pod yield in groundnut due to foliar spray of urea phosphate as it enhances nutrient uptake, supporting pod growth and development. It also regulates phytohormones, promoting flower and pod formation. It also helps to increase cytokinin levels stimulating cell division and expansion resulting in increased dry pod yield. These results are in agreement with those of Meresa *et al*. (2020) [4] and Sitani and Morrill (1989) [10].

3.1.2 Kernel yield (q ha^{-1})

The data pertaining to kernel yield (q ha^{-1}) of groundnut as affected by different treatments are presented in Table 1. The mean kernel yield was 23.29 q ha^{-1}.

In summer groundnut, application of treatment T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (25.99 q ha^{-1}) recorded significantly highest kernel yield than rest of all treatment, but it was at par with the application of T_3 *i.e.*, T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (24.34 q ha^{-1}), T_7 *i.e.*, T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (23.83 q ha^{-1}) and T_6 *i.e.*, T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (23.16 q ha^{-1}). The lowest kernel yield was obtained in T_2 *i.e.*, 75% RDNP (21.26 q ha^{-1}).

Thus, the application of T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage resulted in enhancing various growth and yield contributing characters of groundnut and finally gave significantly higher kernel yield over all other treatments. There is significant increase in kernel yield in groundnut due to foliar spray of urea phosphate as it enhances nutrient uptake, supporting kernel growth and development. It also regulates phytohormones, promoting kernel filling and maturation. It also helps to increase cytokinin levels stimulating cell division and expansion resulting in increased kernel yield. These results are in concurrence with Pandian *et al*. (2001) [7] and Subramani *et al*. (2002) [11].

3.1.3 Haulm yield (q ha^{-1})

The data pertaining to haulm yield (q ha^{-1}) of groundnut as affected by different treatments are presented in Table 1. The mean haulm yield was 45.84 q ha^{-1}.

In summer groundnut, application of treatment T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (49.07 q ha^{-1}) recorded significantly highest haulm yield than rest of all treatment but, it was at par with the application of T_3 *i.e.*, T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (46.49 q ha^{-1}), T_7 *i.e.*, T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (45.73 q ha^{-1}) and T_6 *i.e.*, T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (45.38 q ha^{-1}). The lowest haulm yield was obtained in T_2 *i.e.*, 75% RDNP (43.88 q ha^{-1}).

Thus, the application of T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage resulted in enhancing various growth and yield contributing characters of groundnut and finally gave significantly higher haulm yield over all other treatments. There is significant increase in haulm yield in groundnut due to foliar spray of urea phosphate as it enhances nutrient uptake, supporting vegetative growth. It also regulates phytohormones, promoting cell elongation and expansion. It also helps to increase cytokinin levels stimulating cell division and differentiation resulting in increased haulm yield. These results are in concurrence with Meresa *et al*. (2020) [4] and Sitani and Morrill (1989) [10].

3.1.4 Biological yield (q ha^{-1})

The data pertaining to biological yield (q ha^{-1}) of groundnut as affected by different treatments are presented in Table 1.

The mean biological yield was 82.09 q ha^{-1}. In summer groundnut, application of treatment T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (89.18 q ha^{-1}) recorded significantly highest haulm yield than rest of all treatment but, it was at par with the application of T_3 *i.e.*, T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (84.04 q ha^{-1}), T_7 *i.e.*, T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (82.53 q ha^{-1}) and T_6 *i.e.*, T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (81.23 q ha^{-1}). The lowest haulm yield was obtained in T_2 *i.e.*, 75% RDNP treatment (77.38 q ha^{-1}).

Table 1: Dry pod yield, haulm yield, biological yield, harvest index as influenced by different treatments at harvest of groundnut

Tr. No	Treatments	Dry pod yield (q ha^{-1})	Kernal yield (q ha^{-1})	Haulm yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
T_1	100% RDNP.	35.14	22.53	45.77	81.00	43.49
T_2	75% RDNP.	33.50	21.26	43.88	77.38	43.29
T_3	T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage.	37.59	24.34	46.49	84.04	44.34
T_4	T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage.	40.11	25.99	49.07	89.18	44.93
T_5	T_2 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage.	35.49	22.91	45.44	80.93	43.85
T_6	T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage.	36.05	23.16	45.38	81.23	44.13
T_7	T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage.	36.85	23.83	45.73	82.53	44.62
T_8	T_2 + Foliar application of DAP @ 2% at flowering and peg formation stage.	35.23	22.30	45.32	80.46	43.67
	S.E(m)±	1.02	0.85	0.60	1.81	0.61
	C.D. at 0.05	3.10	2.60	1.84	5.49	NS
	General Mean	36.25	23.29	45.84	82.09	44.04

Thus, the application of T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage resulted in enhancing various growth and yield contributing characters of groundnut and finally gave significantly higher dry pod and haulm yield over all other treatments. There is significant increase in biological yield in groundnut due to foliar spray of urea phosphate as it enhances nutrient uptake, supporting overall plant growth. It also regulates phytohormones, promoting cell elongation and expansion. It also helps to increase cytokinin levels stimulating cell division and differentiation resulting in increased biological yield. Biological yield is a critical factor in groundnut production directly affecting biomass production, seed yield and quality, overall plant growth and development. These results are in concurrence with Pandian *et al*. (2001) [7] and Subramani *et al*. (2002) [11].

3.1.5 Harvest index (%)

The data regarding to harvest index as influenced by different treatments are given in Table 1. The mean harvest index 44.04%.

The data pertaining to harvest index was not significantly affected by different treatments. The treatment T_4 *i.e.*, T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage recorded maximum harvest index (44.93%) followed by the treatments T_3 *i.e.*, T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (44.34%), T_7 *i.e.*, T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (44.62%).

The lowest harvest index was recorded by T_2 *i.e.*, 75% RDNP (43.29%). This might be due to T_2 *i.e.*, 75% RDNP plot has minimum pod yield and biological yield. Due to lower availability of nitrogen and phosphorous. This reduces pod yield and biological yield leading to minimum harvesting index. Harvest index as influenced by urea phosphate in groundnut results in better reproductive growth and development, improved seed yield and quality, increased biomass production. Similar trend of observations was reported by Pandian *et al*. (2001) [7] and Salakinkop and Ashoka (2019) [8].

3.2 Economics

The data pertaining to the effect of different foliar treatments on economics of groundnut are presented in Table 2.

Table 2: Gross monetary returns, cost of cultivation, net monetary returns and B:C ratio as influenced by different treatments

Tr. No	Treatments	Gross monetary returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C ratio
T_1	100% RDNP.	152134	60446	91688	2.52
T_2	75% RDNP.	150220	60042	90178	2.50
T_3	T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage.	177480	62465	115015	2.84
T_4	T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage.	188848	63964	124884	2.95
T_5	T_2 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage.	172202	62331	109871	2.74
T_6	T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage.	174000	63290	110710	2.76
T_7	T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage.	175740	62105	113635	2.82
T_8	T_2 + Foliar application of DAP @ 2% at flowering and peg formation stage.	164372	61310	103062	2.68
	S.E(m)±	8257	-	5759	-
	C.D. at 0.05	25044	-	17467	-
	General Mean	168749	-	115019	-

3.2.1 Gross monetary returns
Gross monetary returns were significantly influenced by different treatments. Maximum gross monetary returns was obtained in T_4 *i.e.,* T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (₹ 188848 ha^{-1}) which was followed by T_3 *i.e.,* T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (₹ 177480 ha^{-1}), T_7 *i.e.,* T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (₹ 175740 ha^{-1}) and T_6 *i.e.,* T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (₹ 174000 ha^{-1}). The lowest gross monetary returns were obtained in T_2 *i.e.,* 75% RDNP (₹ 150220 ha^{-1}). Effective foliar application of urea phosphate resulted in vigorous crop growth which resulted in to higher yield as well as gross monetary returns. The highest gross monetary returns documented because of higher kernel yield and haulm yield due to foliar application of urea phosphate to groundnut crop. Similar result were recorded by Kirnapure *et al.* (2020) [3], Pal *et al.* (2019) [6] and Garud *et al.* (2015) [2].

3.2.2 Cost of cultivation
Cost of cultivation were significantly influenced by different treatments. Maximum cost of cultivation was observed in T_4 *i.e.,* T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (₹ 63964 ha^{-1}) due to high cost of labour and additional requirement of fertilizers and spraying cost which was followed by T_3 *i.e.,* T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (₹ 62465 ha^{-1}), T_7 *i.e.,* T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (₹ 62105 ha^{-1}) and T_6 *i.e.,* T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (₹ 63290 ha^{-1}). The lowest cost of cultivation was observed in T_2 *i.e.,* 75% RDNP (₹ 60042 ha^{-1}). Similar results were recorded by Monica *et al.* (2022), Kirnapure *et al.* (2020) [3], Pal *et al.* (2019) [6] and Garud *et al.* (2015) [2].

3.2.3 Net monetary returns
The net monetary returns were significantly influenced by different treatments. Significantly highest net monetary return was obtained in the treatment T_4 *i.e.,* T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (₹ 124884 ha^{-1}) which was at par with treatment T_3 *i.e.,* T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (₹ 115015 ha^{-1}), T_7 *i.e.,* T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (₹ 113635 ha^{-1}) and T_6 *i.e.,* T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (₹ 110710 ha^{-1}). The lowest net monetary returns were obtained in T_2 *i.e.,* 75% RDNP (₹ 90178 ha^{-1}).

Higher dry pod and haulm yields as well as lower cost of cultivation costs, were responsible for the higher net monetary returns in treatment T_4 *i.e.,* T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage. The above findings are consistent with the results of Kirnapure *et al.* (2020) [3], Pal *et al.* (2022) and Garud *et al.* (2015) [2].

3.2.4 B:C ratio
The B:C ratio is related with gross monetary returns and cost of cultivation. The highest benefit cost ratio was recorded by the treatments T_4 *i.e.,* T_1 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (2.95) which is followed by T_3 *i.e.,* T_1 + Foliar application of urea phosphate @ 1% at flowering and peg formation stage (2.84), T_7 *i.e.,* T_1 + Foliar application of DAP @ 2% at flowering and peg formation stage (2.82) and T_6 *i.e.,* T_2 + Foliar application of urea phosphate @ 2% at flowering and peg formation stage (2.76). The lowest benefit cost ratio was observed in T_2 *i.e.,* 75% RDNP (2.50).These results are in agreement with those of Garud *et al.* (2015) [2], (2019) [6] and Kirnapure *et al.* (2020) [3].

4. Conclusion
Amongst the application of different treatments to summer groundnut crop, the treatment of application of GRDF (25:50:00 $N:P_2O_5:K_2O$ kg ha^{-1} + FYM 10 t ha^{-1}) along with foliar application of urea phosphate @ 2% at flowering and peg formation stage in groundnut recorded significantly higher dry pod, kernel yield, haulm and biological yield (36.25, 23.29, 45.84 and 82.09 q ha^{-1}, respectively) and harvest index (44.04%). The same treatment also obtained maximum net monetary return (₹124884 ha^{-1}) and B:C ratio (2.95) than rest of all treatments.

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