Indian Journal of Agricultural Sciences **93** (10): 1108–1113, October 2023/Article
https://doi.org/10.56093/ijas.v93i10.136234

Effect of various doses of basal and foliar application of nitrogen and potassium with trace elements on summer groundnut (*Arachis hypogaea*)

MADHU H S[1], SUNIL KUMAR GUNRI[1]*, DEBLINA ROY[1], OSMAN ALI[1], PRATEEM BISHNU[1] and BISWAPRIYA MALLIK[1]

Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741 252, India

Received: 11 May 2023; Accepted: 29 August 2023

ABSTRACT

The present field study was carried out during summer season of 2020 and 2021 at Jaguli Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal to study the effect of solid and foliar grade of N and K along with trace elements in groundnut (*Arachis hypogaea* L.). The experiment was laid out in a split-plot design with 3 replications. In main plot; F_0, control; F_1, 50% RDN and K; F_2, 75% RDN and K and; F_3, 100% RDN and K and sub-plot T_1, Starter dose of N and K @2% with 10:20 ratio + micronutrient mixture of Fe, B, Zn and Mo foliar spray at 30 DAE; T_2, Booster dose of N and K @2% with 5:40 ratio + micronutrient mixture of Fe, B, Zn and Mo foliar spray at 45 and 60 DAE; and T_3, Starter dose + Booster dose. Growth and yield attributes of groundnut were significantly influenced by application of inorganic fertilizer and maximum were recorded with 100% of RDN and K. Foliar applications of RDN and K with a micronutrient mixture responded better at later stages (45 and 60 DAE) than at an earlier stage (30 DAE). Higher groundnut pod yield was obtained with basal application of 100% of RDN and K but performed statistically same response to the treatment 75% of RDN and K. The pod yield increased by 5–12% with each incremental dose of inorganic fertilizer, while it decreased in control. Booster dose of N and K gave higher pod and oil yield to starter dose. Maximum BCR of 2.38 and 1.99 was found in 100% of RDN and K and in booster doses of N and K. Inorganic fertilizer as basal and foliar application + micronutrients increased the groundnut pod yield but foliar application was not substitute to any quantity of inorganic fertilizer.

Keywords: Foliar application, Groundnut, Micronutrient, NPK, Nutrient status

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop, grown on an area of 30.19 million hectares with a yield of 49.55 million metric tonnes and productivity of 1.64 metric tonnes/ha (USDA 2022). Although, it is an energy-rich crop, groundnuts are typically cultivated in energy-starved conditions in rain-fed environments and the productivity remains low. Aside from that, when the crop loses significant amount of nutrients, the soil is susceptible to a number of losses, including leaching, volatilization and fixation of basic, and secondary nutrients that support growth and production (Roy *et al*. 2016). Groundnut is a leguminous oilseed crop that is intrinsically unpredictable due to its subpar nutritional response (Sagveker *et al*. 2015). Foliar application that promotes root development and increases nutrient uptake actually significantly increases root absorption of nutrients and a rapid supply of food, reducing the need for fertilizer (Ahmad *et al*. 2019). Micronutrients are just as important as macronutrients, even though they are required in relatively smaller levels for plant growth. Micronutrients, in particular, are extremely important for the physiological processes of respiration and photosynthesis (Mengel *et al*. 2001), and the lack of them might be limiting yield improvement. Due to the ineffectiveness of soil-applied iron fertilizers, foliar spray is more frequently employed in crop production (Zhang *et al.* 2018, Malhotra *et al*. 2020). The creation of cell walls, both structural and functional integrity of the membrane, the breakdown of nucleic acids, carbohydrates, proteins, and indole acetic acid, as well as the metabolism of phenol are all metabolic processes that involve the element borax (Tanaka and Fujiwar 2008). Zinc is currently regarded as the fourth most important nutrient in India that restricts output, after nitrogen, phosphorus and potassium. Zinc enhances the energy source for chlorophyll synthesis, catalyzes the oxidation process in plant cells, facilitates plant water uptake, affects IAA production and slows dehydrogenase enzyme activity, which causes poor plant metabolism. Groundnut yields have decreased by 15–20% and 13–19%, respectively, due to Zn and Mo deficits (Singh 2001). Molybdenum acts as a catalyst for nitrate reduction and subsequent fixation in legumes and boosts nodulation in groundnut. Thus, an effort has been made to boost crop output by balancing the usage of solid

[1]Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. *Corresponding author email: sgunri@gmail.com

and liquid-grade fertiliser with varying quantities and ratios, as well as different application times.

MATERIALS AND METHODS

The field experiment was conducted during summer season of 2020 and 2021 at Jaguli Instructional Farm under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia (22°56'N and 86°48'E and 9.75 m amsl), West Bengal. The soil had an alluvial sandy loam texture and the soil's *p*H, electrical conductivity, and organic carbon content were all 7.21, 0.15 Ds/m and 0.42%, respectively. The initial soil's nitrogen, phosphorus, and potassium was 198.3, 23.1, and 143.6 kg/ha, respectively and the soil's micronutrients, including iron (Fe), manganese (Mn), and zinc (Zn), were 0.202, 1.854, and 0.624 parts per million, respectively. Average rainfall of 1498 mm (last five-year average), most rainfall occurred in rainy (*kharif*) season including some light rains throughout the summer. High temperatures and high relative humidity are traits of the summer season. The second fortnight of February marks the beginning of the temperature rise, which typically peaks in April–May. The experimental period's highest monthly average temperatures were recorded in April 2020 (33.9°C) and 2021 (36.5°C), while the lowest monthly average were in January 2020 (8.8°C) and 2021 (11.3°C). The amount of rain that fell throughout the experiment was 417.7 mm in 2020 and 379.8 mm in 2021. Maximum and minimum mean monthly relative humidity occurred in January 2020 (97.2%) and 2021 (95%) and March 2020 (62.3%) and 2021 (37%), respectively.

A split-plot design with 3 replications was considered to set up the experiment where the main plot comprising four fertilizer dosages, viz. F_0, control; F_1, 50% of RDN and K; F_2, 75% of RDN and K and; F_3, 100% of RDN and K and sub-plot containing water soluble fertilizer with micronutrients, viz. T_1, Starter dose of N and K @2% with 10:20 ratio + micronutrient mixture of Fe, B, Zn and Mo foliar spray at 30 DAE; T_2, Booster dose of N and K @2% with 5:40 ratio + micronutrient mixture of Fe, B, Zn and Mo foliar spray at 45 and 60 DAE and; T_3, Starter dose + Booster dose. Foliar application of water soluble nitrogen (urea) and potassium (muriate of potash) used in 10:20 and 5:40 ratio as starter and booster dose respectively, with trace elements (micronutrient mixture) like Fe (800 ppm), Boron (B) (200 ppm), Zn (200 ppm) and Mo (50 ppm) @2% were followed during both the years. The recommended fertilizer dosage was 20:60:40 kg/ha of $N:P_2O_5:K_2O$ administered as basal from the source of urea, single super phosphate, and muriate of potash (MOP), respectively. The same supply of urea and MOP commercial fertilizer was used to apply both the solid and foliar grade of inorganic nitrogen and potassium. With the exception of the control (F_0), Phosphorus was uniformly applied in all the treatments as basal. The administration of starter and booster doses of foliar grade fertilizer was accompanied by blanket water spraying in the control treatment. The individual experimental plot (sub-plot) has 36 unit plots, each measuring 3 m × 4 m. Groundnut variety TG51 was manually sown with 30 cm × 10 cm spacing in the last week of January and first week of February of 2020 and 2021, respectively.

Pre-harvest observations were made, including measurements of growth-related traits such plant height, generation of aerial dry matter, crop growth rate, and nodulation at various growth stages. Post-harvest observations, such as yield-attributing traits like number of pods and pod dry weight/plant, shelling out turn, hundred kernel weight, etc. were also recorded. The crop was manually harvested after it reached the physiological stage of maturity, sun-dried for a period of four to five days in the field, and then the total biomass output was calculated. The pod yield was measured at 12% moisture after stripping, cleaning and drying. Petroleum ether (40–60°C) was used to extract the oil using a Soxhlet device. Oil content and oil yield were determined as:

Oil content (%) = 100 × (Weight of oil extracted (g)/Weight of the seed sample).

Oil yield (kg/ha) = Seed yield (kg/ha) × Oil content (%)

Before the experiment began and after it was finished, soil samples were taken for analysis of available N and K, (Jackson 1973) and available P (Olsen *et al*. 1954). NPK balance sheets for each treatment were created, showing the initial availability of nutrients in the soil, nutrients added to grow the crop, nutrients absorbed by the crop, nutrients left in the soil after harvest, actual gain/loss over initial status, and apparent nutrient balance in the soil. The numerous inputs required and outputs realized in accordance with the prevalent cost of inputs and outputs during the relevant years were taken into consideration while calculating the economics of various treatments. Using the F-test method described by Gomez and Gomez (1984), all of the collected data were statistically analysed. The results showed a similar trend over the course of the two years, therefore, the data were pooled for analysis to produce results and make comparisons.

RESULTS AND DISCUSSION

Effect on crop growth: Application of inorganic fertilizer to groundnut had the advantageous impact of improving root, shoot, and leaf growth, as well as enhancing internode length (Table 1). Plant height increased with increasing doses of inorganic fertilizer and maximum plant height (53.4 cm) was recorded in the treatment F_3 (100% of NPK). This finding is in agreement with Chavan *et al*. (2014), according to their findings, each additional dose of inorganic fertilizer considerably increased plant height by 6.1–27.1%. Foliar grade fertilizer application (with micronutrient mixture), whether as a starter dose, booster dose, or both, significantly influenced the plant height at harvest. Foliar application was therefore, more advantageous during the crop growth phase. However, Aboyeji *et al*. (2019) revealed that B, compared to zinc, had a substantial impact on vegetative features, and both had a significant impact on the quantity, weight, and quality of seeds.

Table 1 Effect of water-soluble fertilizer on growth of summer groundnut (pooled over 2020 and 2021)

Treatment	Plant height (cm) at harvest	Dry matter production (g/m^2)				Crop growth rate (g/m^2/day)			No. of nodule/ plant		Nodule dry weight (mg/plant)	
		45 DAE	60 DAE	75 DAE	Harvest	45–60 DAE	60–75 DAE	75–harvest	45 DAE	60 DAE	45 DAE	60 DAE
Doses of fertilizer (F)												
F_0	41.3	138.0	158.1	175.6	224.4	1.33	1.17	1.53	15.7	26.2	0.29	0.49
F_1	46.3	168.3	263.1	345.8	433.6	6.32	5.51	2.74	26.2	34.4	0.51	0.65
F_2	48.7	184.1	286.3	393.4	458.5	6.81	6.92	2.03	29.7	43.9	0.79	0.93
F_3	53.4	201.6	304.3	407.9	480.5	6.84	7.15	2.27	34.0	46.1	0.74	1.04
SEm±	1.25	2.67	3.34	3.06	4.72	0.22	1.90	0.21	2.74	1.93	0.07	0.06
CD (P=0.05)	3.89	8.30	10.39	9.50	14.67	0.75	6.51	NS	8.53	6.01	0.21	0.18
Time of application (T)												
T_1	46.7	169.6	249.3	327.2	387.7	5.3	5.2	1.89	23.4	34.2	0.50	0.73
T_2	47.6	173.9	253.5	331.1	399.9	5.3	5.0	2.15	26.7	38.6	0.59	0.77
T_3	48.1	166.7	256.1	333.8	410.3	5.3	5.1	2.39	29.0	40.2	0.66	0.82
SEm±	0.19	0.51	0.45	0.36	0.96	0.19	0.09	0.14	2.50	1.04	0.01	0.04
CD (P=0.05)	0.56	1.49	1.30	1.06	2.81	NS	NS	NS	NS	3.02	0.04	NS

Treatment details are given under Materials and Methods.

Dry matter production peaked in the treatment F_3 (100% of RDN and K) which was statistically at par to F_2 (75% of RDN and K) but significantly better than F_1 (50% of RDN and K) and F_0 (control) during all stages of crop growth. Booster dose of foliar grade fertilizer was more conducive to starter dose and was more responsive at later stage as compared to early stage. This was because during the early stage crop received sufficient nutrients from soil reserve whereas at later stage of the crop the nutrient demand would be more to fasten the growth followed by developmental process and this stage was more sensitive to crop. Zn, Mn, B and their combinations were applied as foliar spray recorded the greatest value of all evaluated features of crop growth (Sabra *et al*. 2019).

Crop growth rate was faster in the early stages and persisted up to 45–60 DAE; after that, growth rate declined as crop age at maturity increased. Up to 75% of RDN and K, the crop growth rate was more consistent, but as fertilizer doses were further reduced, the growth rate likewise fell. Foliar grade fertilizer of N and K at different growth stages along with micronutrient mixture was more responsive to CGR.

With the application of foliar grade fertilizer, nodule numbers and dry weight increased at all growth stages, but there was little inter-stage variation. This might be because nitrogen fertilizer applications have a tendency to suppress the development of root nodules (Namo and Dowyaro 2009). According to data shown in Table 1, nodulation increased with crop age and peaked at 60 DAE regardless of the treatments.

Effect on yield attributes: The treatment F_3 (100% RDN and K) showed a significantly higher number of pods and pod dry weight/plant compared to other treatments, and rigorously decreased under control (without fertilizer). In comparison to either the starter or booster dose, the treatment T_3 (Starter + booster dose) was shown to produce the maximum pods and pod dry weight/plant (Table 2). This was caused by the different grades of foliar fertilizer and micronutrients application, which was continued from the early to the later stages. Shelling percentage or SMK, and hundred kernels weight, were increased with treatment F_3 (100% N and K), while there was no significant difference between fertilizer treatments.

Effect on yield: The higher pod yield (3974 kg/ha) was obtained with treatment F_3 (100% RDN and K). The pod yield increased by 5–12% with each additional dose of inorganic fertilizer, while it decreased significantly where fertilizer application was restricted (F_0). Similar findings were also stated by Satpute *et al.* (2020), they claimed that the different quantities of fertilizer had a substantial impact on the dry pod yield of groundnut. In order to maintain the groundnut yield, fertilizer application reduction by up to 75% of RDN and K was similarly effective. Manasa *et al*. (2020) agreed that the crop responded similarly by increasing the production of pods when RDF was cut by 15%, although 100% RDF would yield a larger yield. Dry pods and haulm was significantly impacted by N and K's foliar grade fertilizer, however, the yield of groundnut was directly correlated with the timing of application. Higher pod yield was obtained with treatment T_3 (Starter + booster dose) followed by T_2 (booster dose at 45 and 60 DAE) and T_1 (starter dose at 30 DAE). Data presented in the Table 2, revealed that the booster doses (T_2) responded higher yield to a tune of 3.2% over to starter doses (T_1). However, yield increment was recorded from 2.9–6.2% when both starter and booster dose (T_3) was followed. This finding is in

Table 2 Effect of water soluble fertilizer on yield attributes, yield and harvest index of summer groundnut (pooled over 2020 and 2021)

Treatment	Yield attributes and yield							Available N, P_2O_5 and K_2O (kg/ha)			Oil content		BCR
	Number of pods/ plant	Pod dry weight (g/plant)	Shelling (%)	SMK (%)	100 kernel weight (g)	Pod yield (kg/ha)	Haulm yield (kg/ha)	Nitrogen	P_2O_5	K_2O	Oil content (%)	Oil yield (kg/ha)	
Doses of fertilizer (F)													
F_0	12.2	10.7	64.1	75.6	44.0	1600	2250	140.5	21.9	92.4	46.9	750	1.05
F_1	25.1	38.4	70.1	88.2	46.6	3551	4336	176.7	31.6	104.5	47.6	1690	2.19
F_2	29.9	56.6	70.4	89.0	47.7	3787	4585	206.6	39.9	124.7	48.8	1848	2.28
F_3	33.4	65.0	70.9	90.3	48.3	3974	4805	231.3	45.2	132.1	49.8	1979	2.38
SEm±	0.31	0.46	0.69	0.88	0.48	4762	47.52	0.91	1.32	1.49	0.14	-	-
CD (P=0.05)	0.95	1.43	2.39	2.74	1.49	148.15	147.83	2.82	4.11	4.64	0.48	-	-
Time of application (T)													
T_1	22.4	38.3	68.1	85.0	46.0	3130	3878	182.8	32.6	109.6	47.7	1493	1.96
T_2	25.7	43.6	68.7	85.9	46.8	3230	3999	190.0	35.0	113.0	48.2	1557	1.98
T_3	27.1	46.2	69.5	86.4	47.3	3323	4104	193.5	36.3	117.8	48.8	1622	1.99
SEm±	0.31	0.49	0.23	0.28	0.08	8.97	9.55	0.64	0.30	0.61	0.12	-	-
CD (P=0.05)	0.90	1.44	0.66	0.81	0.23	26.13	27.81	1.85	0.88	1.78	0.36	-	-

BCR, Benefit:cost ratio. Treatment details are given under Materials and Methods.

agreement with Roy *et al.* (2016) where they reported that the liquid grade fertilizer was applied, either as a starter dosage, booster dose, or both, the groundnut pod yield increased by up to 4–6% over RDF alone; foliar urea spraying at 30 and 60 DAS improved pod yield by 11.6% compared to control (Patro *et al*. 2014); combining basal and foliar treatments considerably increased yields (Shahid *et al*. 1999); combination of B, Zn, Mn, Fe and Mo at 100 ppm and 50 ppm, respectively, reported a noticeably greater output from the control (Patil *et al*. 2014); comparison to RDF, combined foliar application of secondary and micronutrients resulted in conspicuously higher pod and haulm yield (Rajitha *et al*. 2018). According to the above stated results it may be assumed that the foliar grade fertilizer, regardless of dose, administered at the end of the growth phase (45 and 60 DAE) was relatively more beneficial to early stage (30 DAE) of the plant growth. This might be because foliar application of nutrients typically minimizes loss through absorption, leaching, and other processes related to soil application, and legume being a protein-rich, high-energy crop, direct absorption through foliar application in particular, N was more crucial components to take part in developmental processes including other macro and micronutrients.

Effect on available NPK: The highest fertilizer doses, i.e. F_3 (100% of RDN and K), were found to have the most soil nitrogen, phosphorus, and potassium that was readily available. The foliar grade fertilizer coupled with a combination of micronutrients increased the availability of nitrogen, phosphorous and potassium in the soil. The booster dose performed better than the starter dose (Table 2).

Effect on oil content and economics: Higher oil content and oil yield were obtained with treatment F_3. Oil yield continued to drop when fertilizer dosages were progressively decreased, and it was determined to be at its lowest under treatment F_1 or F_2. The starter dose was more suitable than the booster dose. Even though the starter dosage + booster dose, achieved the highest oil output and content (Table 2). Similar finding was also reported by Reddy *et al*. (2020) where they revealed that DAP, humic acid and micronutrient mixture foliar application records higher values oil content and oil yield. The treatment F_3 recorded the highest BCR and lowest was F_0 (control) where both starter and booster dose was comparatively more remunerative to individual ones.

Effect on matrix of nutrient uptake pattern: The percentage of fertilizer recovery, partial factor productivity, agronomic efficiency, physiological efficiency, and recovery efficiency of individual nutrients (NPK) all increased with increasing fertilizer doses up to 75% of RDN and K, after which they decreased with increasing fertilizer doses (Table 3). The total nutrient productivity (NPK) peaked at F_2 (50% N and K), after which it started to decrease as the doses were increased. Both starter and booster dose (T_3) boosted higher value of the total fertilizer recovery, the recovery efficiency of NPK, and the nutrient uptake efficiency including other matrixes compared to individual ones.

Therefore, it can be concluded that with each subsequent dose of inorganic fertilizer, yield increased by 5–12%, and booster doses resulted in greater yields by 3.2% compared to starter doses. On the other hand, when both the starter and booster doses were used, a yield increment of 2.9–6.2% was noted. In addition, water soluble fertilizer that was

Table 3 Effect of water soluble fertilizer on nutrient uptake pattern of summer groundnut (mean over 2020 and 2021)

Treatment	Per cent fertilizer recovery	Partial factor productivity	Agronomic efficiency	Physio-logical efficiency	Matrix of nutrient uptake pattern: Recovery efficiency (%)			Nutrient productivity (kg/kg/day)			Nutrient uptake efficiency (kg/kg)		
					N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Doses of fertilizer (F)													
F_0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	1.30	0.58	0.33	0.59	0.31
F_1	2.98	44.16	21.67	40.62	1.67	0.13	1.18	0.59	1.79	0.71	0.27	0.46	0.50
F_2	4.44	36.07	20.82	22.61	2.91	0.24	1.29	0.44	1.44	0.59	0.44	0.69	0.54
F_3	4.28	29.59	19.79	19.76	2.83	0.28	1.17	0.40	1.40	0.55	0.58	0.96	0.58
SEm±	-	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-	-	-	-
Time of application (T)													
T_1	3.75	35.67	20.69	29.26	2.44	0.22	1.09	0.45	1.52	0.60	0.41	0.68	0.49
T_2	4.09	36.62	20.74	25.70	2.54	0.23	1.32	0.44	1.40	0.61	0.41	0.71	0.49
T_3	3.87	37.53	20.85	28.02	2.42	0.22	1.23	0.47	1.54	0.62	0.40	0.64	0.48
SEm±	-	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-	-	-	-

Treatment details are given under Materials and Methods.

applied at the end of the growth phase (45 and 60 DAE), regardless of dose, was considerably more advantageous to early stages (30 DAE) of the plant growth. Furthermore, it was stated that, supplementation of water-soluble fertilizer + micronutrient mixture along with each incremental doses of inorganic fertilizer as basal, increased the groundnut pod yield but water-soluble fertilizer along with or without mixture of micronutrients was not substitute to any quantity of inorganic fertilizer.

REFERENCES

Aboyeji C, Dunsin O, Adekiya A O, Chinedum C, Suleiman K O, Okunlola F O, Charity O, Aremu, Iyiola O, Owolabi and Temidayo A J Olofintoye. 2019. Zinc sulphate and boron-based foliar fertilizer effect on growth, yield, minerals, and heavy metal composition of groundnut (*Arachis hypogaea* L.) grown on an Alfisol. *International Journal of Agronomy* **1**: 1–7.

Ahmad Z, Hussain R, Riaz M, Khan M A, Nadeem M, Akram K, Rafay M, Rashid M F, Asif A R and Ghaffar A. 2019. Mitigation of toxic effects caused by tartrazine in Wistar rats through oral administration of melon seed oil. *Pakistan Journal of Agricultural Sciences* **56**(2): 435–42.

Chavan A P, Jain N K, Sagvekar V and Taresh Kumar. 2014. Integrated nutrient management in groundnut (*Arachis hypogaea* L.). *Research on Crops* **15**(2): 454–60.

Gomez K A and Gomez A A. 1984. *Statistical Procedures for Agricultural Research*, 2nd edn, pp. 680. John Wiley and Sons, New York.

Jackson M L.1973. *Soil Chemical Analysis*, pp. 498. Prentice Hall of India Pvt. Ltd., New Delhi.

Malhotra H, Pandey R, Sharma S and Bindraban P S. 2020. Foliar fertilization: Possible routes of iron transport from leaf surface to cell organelles. *Archives of Agronomy and Soil Science* **66**: 279–300.

Manasa V, Hebsur N S, Malligawad L H, Gobinath R and Ramakrishna B. 2020. Effect of water-soluble fertilizers on yield, oil content and economics of groundnut. *Current Journal of Applied Science and Technology* **39**(23): 89–96.

Mengel K, Kirkby E A, Kosegarten H and Appel T. 2001. *Principles of Plant Nutrition*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Namo O A T and Dowyaro L L G. 2009. The influence of rate and time of nitrogen fertilization on nodulation and yield of rain-fed groundnut (*Arachis hypogaea* L.). *Discovery and Innovation* **21(**3/4): 50–55.

Olsen S R, Cole C V, Watanabe F S and Dean L A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular 939, U.S. Government Printing Office, Washington, D.C.

Patil A B, Chavan L S and Jagtap D N. 2014. Response of groundnut (*Arachis hypogaea* L.) varieties to nutrient management in *rabi*-hot weather season. *Legume Research-An International Journal* **37**(4): 395.

Patro H, Alim M A and Behura A K. 2014. Nutrient management through the soil and foliar application on production maximization of rainy season groundnut. *Asian Journal of Soil Science* **9**(2): 165–68.

Rajitha G, Reddy M S and Babu P V. 2018. Yield and uptake of primary nutrients by groundnut (*Arachis hypogaea* L.) as influenced by foliar spray of secondary and micronutrients. *Crop Research* **53**(5 and 6): 230–32.

Reddy Swetha K, Bhuvaneswari R and Karthikeyan P K. 2020. Effect of DAP, humic acid and micronutrient mixture foliar application on yield and quality characters of groundnut (*Arachis hypogaea* L.) var. TMV 7 in sandy loam soil. *Plant Archives* **20**(1): 521–25.

Roy S, Gunri S K, Puste A M, Sengupta A and Saha D. 2016. Growth and yield of summer groundnut (*Arachis hypogaea* L.) as influenced by foliar application of water-soluble fertilizer. *Journal of Applied and Natural Science* **8**(1): 245–50.

Sabra D M, Olfat H El-Bagoury, El Habasha S F, Fergani M A, Mekki B B, El-Housini, Ebtesam A and Abou-Hadid A F. 2019. Response of growth characters, yield and yield attributes of groundnut (*Arachis hypogaea* L.) cultivars to some micronutrients foliar spraying application. *Plant Archives* **19**: 1896–903.

Sagvekar V V, Waghmode B D, Kamble A S and Navhale V C. 2015. Relevance of water-soluble foliar grade fertilizers on groundnut *(Arachis hypogaea* L.) under Konkan condition. *Indian Journal of Agronomy* **60**(4): 585–88.

Shahid Umar, Bansal S K, Patricia Imas and Magen H. 1999. Effect of foliar fertilization of potassium on yield, quality, and nutrient uptake of groundnut. *Journal of Plant Nutrition* **22**(11): 1785–95.

Satpute A V, Patil J B, Gedam V B and Ghule N S. 2020. Effect of inorganic and bio-fertilizers on quality of summer groundnut (*Arachis hypogaea* L.). *International Journal of Chemical Studies* **8**(6): 1534–37.

Singh A L. 2001. Yield losses in groundnut due to micronutrient deficiencies in calcareous soils of India. Plant-Nutrition: Food security and sustainability of Agro-ecosystems through Basic and Applied Research. *(In) Proceedings of the 14th International Plant Nutrition Colloquium*, Hannover, Germany 27th July-3rd August, Kluwer Academic Publisher, Dordrecht, Netherlands.

Tanaka M and Fujiwar T. 2008. Physiological roles and transport mechanisms of boron: Perspectives from plants. *European Journal of Physiology* **456**: 671–77.

USDA. 2022. World Agricultural Production. United States Department of Agriculture. Foreign Agricultural Service. Circular Series WAP 2–22, February 2022.

Zhang C M, Zhao W Y, Gao A X, Su T T, Wang Y K, Zhang Y Q, Zhou X B and He X H. 2018. How could agronomic biofortification of rice be an alternative and stress tolerance. *Journal of Agricultural and Food Chemistry* **68**: 1935–47.