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Performance of Oilseed Crops to Foliar Fertilization-A Review

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Abstract **– India is the 4th largest oilseeds producer in the world. In 2020-21, the production of the country was 365.65 lakh tonne which was a 10% increase from that of the previous year. The top oilseed producing states in India are Rajasthan, Gujarat, Madhya Pradesh and Maharashtra. In the current scenario, it is essential to adopt modern agricultural practices capable of meeting the demand for food, using more sustainable approaches that reduce soil degradation and water contamination. Foliar fertilization is one among the effective approaches in this regard. Foliar fertilization draws attention as a quick, target-oriented, and environmentally compatible insurance to pursue higher crop productivity under optimal and unfavourable growth conditions. At later growth stages crops require supplemental application through the foliage to fulfill the growth requirements and mitigate soil nutritional constraints. Further, farmers usually do not supply micronutrients to the soil, and due to many edaphic and biological factors, the availability of soil applied micronutrients is reduced. Under such conditions, foliar application of micronutrients fulfills the nutritional requirements of plants and their translocation into edible parts. Foliar application of nutrients (Urea 2%) along with RDF had significant effect on availability of macro and micro nutrients in soil after harvest of the soybean. Foliar application of micronutrients at a time when the plant requirement is high (flowering or pod initiation) improves the growth and yield of the soybean crop.**

Keywords **– Foliar Fertilization, Sustainable Crop Production, Oilseed, Micronutrients, Cuticle Penetration.**

I. Introduction

Oilseed crops are primarily grown for edible oil. Recently, oilseeds attracted more attention due to an increasing demand for their healthy vegetable oils, livestock feeds, pharmaceuticals, biofuels, and other oleo chemical industrial uses. The increased interest resulted in an 82% expansion of oilseed crop cultivation areas and about a 240% increase in total world production over the last 30 years. India is the 4th largest oilseeds producer in the world. It has 20.8% of the total area under cultivation globally, accounting for 10% of global production. The production of oilseeds in India has been growing for the last five years. In the budget 2022-23, the Government of India allocated a total of Rs. 1,500 crore towards developing the oilseed industry.

With the Green revolution, the cultivation of high-yielding fertilizer responsive cultivars has amplified the requirement of primary nutrients, mainly nitrogen (N), phosphorus (P) and potassium (K), to produce better yield at the expense of soil nutrient mining. On the other hand, rhizosphere-induced pH changes, soil nutrient deficiency, and climate change induced abiotic stresses, *ie*., drought, salinity, heat and cold stress limit the uptake of soil-derived minerals. Soil-applied fertilizers are important component of crop production; however, later growth stages may require supplemental application through the foliage to fulfill the growth requirements due to limited uptake by soil. These supplemental foliar-applied mineral elements can mitigate soil nutritional constraints via modulation in physiological processes, including photosynthetic pigments, nutrient assimilation, and stomatal response [1], [2], [3]. Foliar fertilization has a high effectiveness because it enters the plant's metabolism directly and is not affected by leaching or soil barriers like soil-applied fertilizers. The foliar fertilization of P and K at early growth stages improve root systems and help to increase the uptake of soil-derived P and K [4], [5], [6]. Likely, under calcareous and high pH soils, deficiency of micro nutrients such as zinc (Zn), iron (Fe), boron (B), copper (Cu), and manganese (Mn) constraints crop yield and nutritional quality of produce. Further, farmers usually do not supply these micronutrients to the soil, and due to many edaphic and biological factors, the availability of soil-applied micro-nutrients is reduced. Under such conditions, foliar application of micronutrients fulfil the nutritional requirements of plants and their translocation into edible parts [7], [8], [9]. However, shortcomings include the need for numerous foliar sprays of macronutrients, rain-washed off the nutrients, insufficient leaf surface area for feeding, and tissue damage from the high concentration of active ingredients. Despite these difficulties, foliar fertilization of nutrients has a high use efficiency and is an efficient and cost-effective method [10].

II. Foliar Fertilization

The practice of feeding plants by putting liquid fertilizer straight on their leaves is known as foliar feeding. Through their leaves, plants are able to collect necessary nutrients. It involves providing foliar sprays of one or more mineral nutrients to plants in addition to conventional soil fertilizer applications.

Foliar Fertilization History

Although soil enrichment techniques such as adding manure, bone meals, and other materials have been used for ages, the actual science of fertilization by improving soil quality to increase plant health and vitality began in the 1800s. Due to the Agricultural Revolution and chemical advancements, farmers were able to detect requirements in the soil and in plants, and then apply nutrients to remedy such deficiencies. In the late 1980s, Floratine pioneered technologies to apply micronutrients directly to the plant. The earliest application of foliar fertilization was in 1844, when iron sprays were sprayed on plants to treat chlorosis.

Importance & Scope

- When root activity or soil nutrient availability are diminished, foliar nutrient absorption serves as a quick source of nutrients.
- When timely treatment of nutrient deficits is necessary, foliar spray is also the recommended option.
- During the growth season, nutrient sprays can be used at any time to enhance the fruit's appearance, color, size, and quality.
- Foliar fertilization can be applied in combination with herbicides, insecticides, fungicides etc.
- Foliar sprays work better in unfavorable situations like disease, drought, or pest infestation.

Need for Foliar Nutrition

- It is feasible to apply nutrients directly to the site of metabolism.
- Can prevent nutrient depletion.
- It can increase yields from 12% to 25%.
- More than 90% of fertilizer is utilized by plants.
- Foliar applied fertilizers are upto 20 times more effective than the soil applied fertilizers.

- Foliar feeding bypasses nutrient uptake through root.
- Deficiencies can be corrected within short time period.

Mechanism of Foliar Fertilization

Before the nutrient may enter the cytoplasm of a leaf cell, it must first enter the leaf. *ie.,* the nutrient needs to successfully pass through both the underlying epidermal cell wall and the outer leaf cuticle. After a nutrient has penetrated the plant, its absorption by leaves and roots is likely similar, with the main distinction being the environments in which the two plant organs exist. There are two possible channels for penetration of foliar-applied compounds into the leaf (through the stomata, through the external cuticle) before they can produce a response. Although it is widely acknowledged that the cuticle accounts for the majority of nutrient intake, solutes can also enter the leaf indirectly through the stomata. Ion uptake rates from foliar sprays are usually higher at night, when the stomata are closed, than during the day, when the stomata are open. Only in the short time following application, when spray deposits are still liquid, can stomatal penetration take place. Therefore, cuticle penetration remains the sole pathway of uptake.

III. Types of Fertilizer Material for Foliar Nutrition

Criteria for Fertilizer Materials:

A. Not every fertilizer can be sprayed on leaves or in vegetation. Aiming for the maximum absorption of nutrients into the plant tissue is the main goal of foliar fertilizer applications; foliar fertilizer formulas should adhere to specific guidelines to limit damage to the leaves.

B. Low salt index, high purity, and high solubility are requirements for fertilizer ingredients.

Nitrogen Fertilizer:

- Comparing urea's low salt index and high solubility to other nitrogen sources, urea is the most suited nitrogen source for foliar applications.
- To reduce urea foliage burn, foliar sprays containing urea should have a low biuret concentration.

Phosphorus Fertilizer:

- A mix of poly and ortho-phosphates has been demonstrated to reduce leaf burn and facilitate the uptake of phosphate in leaves. If provided in both ortho and polyphosphate forms, the polyphosphate advantage might possibly arise.

Potassium Fertilizer:

- Potassium polyphosphates, when available, are a great source for highly soluble, low-salt potassium.
- Potassium sulfate-low salt index, but a rather low solubility.
- Potassium hydroxide, potassium nitrate and potassium thiosulfate - low salt index and high solubility characteristics.

Secondary and Micronutrient Fertilizers:

Secondary nutrients can be applied foliar, however due to challenges in the absorption and translocation of leaf tissue, it is crucial to select the right fertilizer sources for these nutrients [11]. $CaCl_2$, $CaNO_3$ and calcium ammonium nitrate are some sources.

Table 1. Meteorological Conditions Required.

S. No.	Meteorological Conditions	Mineral Nutrient sprays
1	Time of day	Late evening: After 6pm Early morning: Before 9 am
2	Temperature	Between 25- 30 ° C
3	Humidity	Greater than 70% relative humidity
4	Wind speed	Less than 5 mph

IV. Results and Discussions

A. *Groundnut*

A study conducted at Chimanbhai Patel College of Agriculture, Dantiwada Agricultural University, Sardar krushinagar in loamy sand revealed that Panchagavya + neem leaf extract quanted for maximum uptake of Nitrogen by kernels (75.40) and haulm (65.80 kg ha^{-1}) which were significantly higher than other treatments. Significantly higher nitrogen uptake by kernels (59.72 kg ha^{-1}) and haulm (58.76 kg ha^{-1}) was recorded with foliar application both at branching + flowering over single application at flowering in case of kernels. The cow urine rich in uric acid, a source of nitrogen was readily soluble and liquid form, one of the important compounds in panchagavya and was readily available to the plants directly influencing the nitrogen content of leaves. Maximum phosphorus uptake in kernels (9.50 kg ha^{-1}) and haulm (6.10 kg ha^{-1}) was recorded with foliar application of leaf extract with panchagavya both at branching and flowering stage over single application either at branching or flowering, but it was at par with single application at branching in case of haulm [12].

Table 2. Effect of foliar nutrition on yield parameters of groundnut crop.

Sl. No	Treatments	Number of Pods Plant $^{-1}$	Wt of Pods Plant $^{-1}$ (g)	Kernal Weight (g)	Test Weight (g)	Pod Yield (Kg ha^{-1})
T_1	RDF +2% DAP spray	11.3	11.1	69.4	85.8	1492
T_2	RDF +2% Urea spray	12.1	13.4	90.4	115.7	1871
T_3	RDF +3% Panchagavya spray	11.8	14.3	84.7	109.2	2084
T_4	RDF +10% Vermiwash spray	11.9	14.4	89.4	116.6	2165
T_5	RDF +1% 19:19:19 spray	12.1	15.3	98.8	122.6	2698
T_6	RDF +1% Multinutrient spray	12.3	14.3	94.4	116.3	2458
T_7	RDF +10% Cow urine spray	11.2	13.9	82.9	104.1	2336
T_8	RDF +3% Biomax spray	12.3	15.5	90.7	108.7	2551
T_9	RDF +2% K_2Ospray	12.9	14.2	83.7	109.4	1985
T_{10}	Control (25:75:25 kg $N:P_2O_5:K_2O$)	11.5	11.4	72.6	95.0	1757
CD @ 5%		NS	2.7	17.3	20.5	451.01

Field experiment conducted in Karnataka concluded that the yield parameters have shown significant differences among the treatments (Table 2). The number of pods per plant was highest (12.9) by the application of RDF + 2% K_20 spray, the weight of pods per plant was highest (15.5 g) in application of RDF + 3% Biomax spray, the kernel weight (98.8 g) and test weight (122.6) was highest in application of RDF +1% 19:19:19 spray. Improved kernel weight and test weight under foliar treatments was mainly because of increased translocation of photosynthates from leaves and stem to developing pods resulted in sound mature pods and bolder seeds. This might be due to foliar feeding maintains the leaf area for longer duration which extends period of photosynthates translocation to developing seeds and hence helps in recording bolder and well-shaped seeds [13].

A field experiment was conducted at Prayagraj (U.P) in sandy loam soil and results revealed that groundnut the crop fertilized with 40kg sulphur and panchagavya @ 3%, in addition to the recommended doses of fertilizers gave the maximum yield attributes. The improvement in yield attributes seems to be due to the balanced nutritional environment. Another probable reason could be efficient and greater partitioning of metabolites and adequate translocation of nutrients towards the developing reproductive structures i.e. sinks. Improvement in yield parameters was attributed to diversion of greater proportion of assimilates to the developing pods due to increased sink strength reflected through its larger demand of photosynthates. Supply of sulphur in adequate amount also helps in the development of floral primordia i.e. reproductive parts, which results in the development of capsules and seeds in plant. The application of sulphur thus might have increased the yield attributing parameters in sesame. The yield of a crop is the cumulative effect of yield attributing characters such as capsules per plant, seeds per capsule and test weight. Thus, the seed yield of ground nut also increased significantly due to application of sulphur as a consequence of highest values [14].

A field experiment conducted in Prayagraj (U.P.) in sandy loam soil revealed that At 100 DAS, Significantly higher plant height (54.50 cm), dry weight (54.14 g), no. of nodules per plant^{-1} (47.47 plant^{-1}) were recorded in treatment with application of 1.5kg ha^{-1} molybdenum along with 0.75% zinc foliar spray. However, application of 2.0 kg ha^{-1} molybdenum along with 0.75% zinc foliar was found to be statistically par to 1.5 kg ha^{-1} molybdenum along with 0.75% zinc foliar spray. The improvement in these growth characters might be due to the fact that molybdenum is a constituent of enzyme nitrogenase, which is essential for the process of symbiotic N_2 fixation. The increase in plant height and dry weight may be attributed to role of zinc as a catalyst or stimulant in most of physiological and metabolic process and it also important in synthesis of trytophane, a component of some protein and a compound needed for production of growth hormones (auxins) like indole acetic acid. Molybdenum has favoured plant vegetative growth. Zinc might have stimulated the activities of microorganisms that made the plant nutrients readily available to the crops which augmented higher nodule growth resulted in higher photosynthesis and consequently the higher growth rate [15].

B. *Sunflower*

A study conducted at Dharwad, India in clay loam soil concluded that application of Nano ZnS @ 400 ppm + boron @ 0.5 % recorded the highest head diameter (10.52 cm), head weight plant^{-1} (15.96 g), Seed yield plant^{-1} (10.24 g), Stalk yield plant^{-1} (15.38 g), Harvest index (39.97%), 100 seed weight (4.36 g), Seed filling (81.53%). This might be partly due to more availability of soluble forms of sulphur and zinc in ZnS nano-formulation. This might be also due to higher biomass production leading to higher uptake of nutrients from soil and fertilizers encapsulated in nanoparticles will increase the uptake of nutrients. The uptake rate depends on the size and the surface properties of the nanoparticles. Nanoparticles could enter the xylem via the cortex and the central cylinder and may accumulate in the vacuole [16].

A field experiment conducted at baruipur in clayloam soil recorded the maximum number of capsules per plant, length of pod (cm), number of seeds per capsule, test weight (gm), yield under the treatment of Urea (0.4%) + KC1 (1.0%). This may be due to the influence of nitrogen supplied by foliar urea on metabolic process resulting in increased production of photosynthates which resulted in increased seed yield. Other side K^+ ion may enhance photosynthetic activity and facilitate partitioning of photosynthates resulting in higher seed yield [17].

A field experiment conducted at the Experimental Farm, Latur in clayey soil revealed that the application of RDF + FYM @ 5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} soil application and of $FeSO_4$ @ 0.5 % foliar spray recorded higher growth attributes, yield attributes, seed yield (1768 kg ha^{-1}) and stalk yield (3499 kg ha^{-1}) of sunflower. An increase in plant height might be attributed to positive effect of FYM, along with RDF and micronutrients (Fe and Zn) which supplied the required nutrients at an optimum rate at all growth stages of crop. Nitrogen is associated with protoplasm synthesis and vigorous vegetative growth. Increase in dry matter productions in the treatments were attributed to higher photosynthetic rate of plants, which depends upon number of functional leaves, plant height, and dry matter accumulation in plants. The increase in head diameter may be attributed due to iron which plays an important role in cell wall synthesis and absorption of anions, pollen viability and carbohydrates and fats metabolism. Zinc plays an important role in starch and nitrogen metabolism, flowering and fruit set [18].

Table 3. Effect of sulphur and nano urea on growth attributes of sunflower.

S. No.	Treatments	Plant Height (cm)	Plant Dry Weight (g)
1	S (20kg ha^{-1}) + Nano urea (2ml/l)	104.80	59.83
2	S (20kg ha^{-1}) + Nano urea (3ml/l)	108.43	62.50
3	S (20kg ha^{-1}) + Nano urea (4ml/l)	108.47	63.33
4	S (30kg ha^{-1}) + Nano urea (2ml/l)	104.80	60.50
5	S (30kg ha^{-1}) + Nano urea (3ml/l)	112.67	64.58
6	S (30kg ha^{-1}) + Nano urea (4ml/l)	114.33	67.00
7	S (40kg ha^{-1}) + Nano urea (2ml/l)	110.50	63.92
8	S (40kg ha^{-1}) + Nano urea (3ml/l)	114.53	68.58
9	S (40kg ha^{-1}) + Nano urea (4ml/l)	118.83	70.08
10	Control (RDF 60-30-30 kg ha^{-1} N-P_2O_5-K_2O)	103.67	58.58
	CD (p = 0.05)	9.45	7.03

A field experiment conducted in sandy loam soil revealed that (Table 3) significant and higher plant height (118.83cm) and plant dry weight (70.08 g) was observed with application of 40 kg ha^{-1} Sulphur + 4ml/l Nano Urea. However, application of 40 kg ha^{-1} Sulphur + 3ml/l Nano Urea, 30 kg ha^{-1} Sulphur + 4ml/l Nano Urea and 30kg ha^{-1} Sulphur + 3ml/l Nano Urea was found to be statistically at par with 40 kg ha^{-1} Sulphur + 4ml/l Nano Urea. This might be due to increase cell multiplication, elongation and cell expansion throughout the entire period of crop growth, higher levels of Sulphur in protein and carbohydrate metabolism, activating many enzymes which influences shoot length. Further, the application of nano capsulated nitrogen effectively releases nutrients, regulates plant development and enhances target activity and nano fertilizer is a colloidal farming fertilization additive that aids in nutrient uptake, transportation and absorption. Significant and higher plant dry weight might be due to more synthesis of amino acids, increase in chlorophyll content in growing region and improving the photosynthetic activity, ultimately enhancing cell division [19].

C. *Sesame*

A field experiment conducted at Jabalpur, Madhya Pradesh in vertisols revealed that application of 100% RDF coupled with foliar spraying of 2% DAP twice at flowering (F) and capsule formation (C) stages produced maximum seeds (681 kg/ha) and straw (5210 kg/ha) yields, among all nutrient managements, but differences were not significant for straw yields. The cost of cultivation was highest (Rs. 15360/ha) with application of 100% RDF + two foliar applications of 2% DAP at flowering + capsule formation. The nutrient management consisted with application of 100% RDF + 2 foliar spraying of 2% DAP at flowering + capsule formation recorded highest net monetary returns (NMR) and gross monetary returns (GMR). Because of a very marginal deviation in cost of cultivation as well as gross monetary returns based on comparable seed yields due to different nutrient management, the benefit cost ratio values did not show any remarkable differences between different nutrient management. As a whole application of 100% RDF + foliar spraying of DAP 2% twice at flowering and capsule formation stages proved to be most economically viable [20].

Table 4. Effect of seaweed extract on total nutrient uptake of sesame.

Treatments	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
	Seed	Stick	Seed	Stick	Seed	Stick
T_1: Water+RDF	7.56	2.00	1.45	0.29	1.12	6.45
T_2: 5% K+100% RDF	12.67	5.93	4.60	0.67	2.69	13.20
T_3: 7.5% K+100% RDF	12.95	6.95	4.93	0.69	2.80	14.27
T_4: 10% K+100% RDF	14.38	8.29	5.62	0.74	3.09	17.51
T_5: 15% K+100% RDF	16.72	9.30	5.97	0.79	3.27	20.43
T_6: 5% G+100% RDF	20.47	6.55	6.11	0.80	3.36	21.18
T_7: 7.5% G+100% RDF	21.01	8.00	6.40	0.78	3.73	21.24
T_8: 10% G+100% RDF	21.96	9.16	6.77	0.85	3.67	25.36
T_9: 15% G+100% RDF	24.62	10.11	7.94	1.03	4.21	28.10
T_{10}: 7.5% K+75% RDF	11.25	5.29	2.97	0.70	2.25	10.29
T_{11}: 7.5% G+75% RDF	11.18	5.76	3.13	0.73	2.46	12.59
T_{12}: 7.5% K+50% RDF	10.72	4.30	2.75	0.65	1.99	10.06
T_{13}: 7.5% G+50% RDF	10.91	5.05	2.96	0.64	2.23	11.15
CD (p = 0.05)	2.75	1.27	0.83	0.11	0.47	2.53

A field experiment conducted in red lateritic soil of West Bengal cocluded that the highest total N, P and K up-

-take values were observed in the application of 15% *Gracilaria* +100% RDF which was statistically at par with the treatment application of 10% *Gracilaria* +100% RDF and it was significantly higher than all other treatments (Table 4). Higher uptake of nutrients with above treatments was attributed to higher biological yield due to sufficient availability of nutrients in suitable proportion from diversified sources, prolonged availability of nutrients and probably availability of growth regulators to crop. The lowest value was recorded in the water plots [21].

A field experiment was conducted at Naini Agriculture Institute, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Prayagraj, UP in sandy loam soil and found that the yield attributes i.e., no. of branches plant^{-1} (4.87) was significantly highest with application of 30 kg ha^{-1} of sulfur along with 1500 ppm of boron, whereas application of 30 kg ha^{-1} of sulphur along with 1250 ppm of boron (4.53) and application of 30 kg ha^{-1} of sulfur along with 1000 ppm of boron (4.60) were found to be statistically at par with highest. No. of capsules plant^{-1} (49.07), no. of seeds per capsule (71.47), grain yield (0.91 t/ha), stover yield (1.77 t ha^{-1}) were significantly highest with application of 30 kg ha^{-1} of sulfur along with 1500 ppm of boron. While application of 30 kg ha^{-1} sulfur along with 1000 ppm of boron was found to be statistically at par with highest. Significantly highest oil content (48.07%) was recorded with application of 30 kg ha of sulfur along with 1500 ppm of boron. Application of boron helped in availability of enhanced leaf chlorophyll content, leaf stomatal conductance net photosynthetic rate and non-structural carbohydrate export from leaf to yield attributing sink the increase in oil content might be due to the fact that sulfur is a constituent of glutathione which helps in the synthesis of oil. Boron also had a positive role on the enhancement of oil content probably due to its indirect effect on the synthesis of fat [22].

A field experiment conducted at Prayagraj, Uttar Pradesh in sandy loam soil concluded that Treatment Zinc 100 ppm+ Boron 100 ppm + iron 100 ppm resulted in significantly highest number of capsules plant^{-1}, Number of seeds capsule^{-1}, Grain Yield (t ha^{-1}), Stover Yield (t ha^{-1}). Zinc is required for the synthesis of carbohydrates and therefore plays an important role in photosynthesis and cell elongation. Iron is directly or indirectly involved in chlorophyll production, and iron deficiency irreversibly damages chlorophyll synthesis. In foliar application of peanuts, iron availability is unaffected by soil pH and works in concert to ensure higher yield characteristics of peanuts. The enhancing effect of seeds per capsule was attributed to the beneficial effects of boron application to crops on nutrient metabolism, biological activity, and growth parameters, which affected higher enzymatic activity, which resulted in higher Capsules plants^{-1} and seeds capsules^{-1} promoted. The increase in yield components is likely due to more available water increasing nutrient availability. This improves the absorption of nitrogen and other macro- and micro-elements, improving dry matter content production and transport from source to sink. Seed yield advantage through foliar application of supplemented micronutrients enhances nutrient efficiency according to crop needs [23].

D. *Mustard*

An experiment conducted at a farm of KVK Ujhani, Uttar Pradesh, in a field having sandy loam soil with slightly alkaline in nature (pH 7.7), low organic carbon and potash, medium in phosphorus showed that application of sulphur had significant influence on yield attributes, grain & oil yield of mustard. Maximum values of plant height (150.2 cm), seeds per pod (17), thousand grain weight (6.54 g), grain yield (21.94 q ha^{-1}) and oil content (42.4 %) were recorded with dual application basal along with 80 % WP @ 1.25 kg ha^{-1}

foliar sprayed at 75 DAS. Sulphur and related nutrients aid in quick cell division and higher chlorophyll levels, which speed up photosynthesis and increase the amount of nutrients available to plants, increasing their growth in terms of a larger canopy and plant height at various growth stages. Supply of sulphur in adequate amount also helps in the development of floral primordia i.e. reproductive parts, which results in the development of capsules and seeds in plant [24].

A field experiment conducted in Rajasthan agricultural research institute reported that one spray of 1.0 % urea phosphate + 2nd spray of 2.0 % urea phosphate with sulphate of potash and 3rd spray of 2.0% sulphate of potash gave the maximum Length of siliqua (cm), Seeds siliqua^{-1}, Total siliqua plant $^{-1}$, Seed yield (kg ha^{-1}). The higher yield of mustard seemed to be the cumulative effect of yield attributes which was boosted by application of water soluble fertilizers. These findings clearly indicate that the highest crop response in terms of yield was found with timely application of nutrients through water soluble fertilizers [25].

E. *Soybean*

A field carried out at experiment at Birsa Agricultural University experimental farm, Ranchi, Jharkhand in sandy loam soil reported that the maximum Branches plant^{-1}, Pods plant^{-1}, 100 seed weight (g), Seed yield (kg ha^{-1}), Straw yield (kg ha^{-1}) were observed by the application of RDF + 19:19:19 (NPK) 2% at pod initiation this may be due to the fact that, Urea increase the photosynthetic activity and delay the senescence of leaves, which enhances the supply of photosynthate available for grain filling, thus resulted in bigger grains and ultimately yield will be increased. The same application generated maximum and significantly higher gross return and net returns, the benefit: cost ratio was obtained highest with application of RDF + Urea 2% spray which may be due to increase in yield with foliar application of Urea which involves low input cost [26].

Table 5. Effect of foliar nutrition on soil nutritional status of soybean crop.

Treatments	**OC%**	**Initial Soil (kg ha^{-1})**			**OC %**	**Post-Harvest Soil (kg ha^{-1})**		
		N	**P**	**K**		**N**	**P**	**K**
T_1: RDF + Water spray	0.79	488	32.00	306	0.73	507	24.50	432
T_2: RDF + Urea 2%	0.92	546	31.00	363	0.95	723	28.67	485
T_3: RDF + DAP 2%	0.77	526	30.00	313	0.93	694	28.00	470
T_4: RDF + MOP 0.5%	0.85	518	29.00	385	0.78	645	25.00	450
T_5: RDF + 19:19:19 (NPK) 2%	0.83	550	29.00	317	0.81	662	27.67	462
T_6: RDF + Mo 0.1%	0.92	569	29.00	300	0.84	632	23.83	472
T_7: RDF + B 0.5%	0.86	526	29.00	320	0.76	549	26.00	462
T_8: RDF + Zn chelated 0.5%	0.77	558	29.00	332	0.86	597	28.47	453
T_9: RDF only (Control)	0.81	505	26.00	374	0.74	555	26.67	443
CD (P = 0.05)	NS	NS	4.00	56	0.10	96	4.00	38

A field experiment conducted in a vertisol concluded that the values for organic carbon content and available nitrogen in soil were non-significantly different whereas, the values for phosphorus and potassium was significantly differed, this might be due to the initial richness of soil in available nutrients. Foliar application of nutrients (Urea 2%) along with RDF had significant effect on availability of nutrients in soil after harvest of the crop (Table 5). Available soil nitrogen might be high due to the high activity of root nodules which helped the atmospheric nitrogen fixation, ultimately resulted in increase in nitrogen status of soil. Similarly, maximum phosphorus and potassium content of soil might have resulted due to its fixation into the soil and also shading of leaves and senescence of root nodules helped in increase in Phosphorus and potassium content [27].

A field experiment conducted at experimental farm Oilseed Research Station, Latur (M.H) found that the application of 50 per cent N (RDN) and 100 percent P and K through soil + two foliar applications of nano-N @ 0.4 percent at 20 and 40 DAS resulted in the maximum grain yield and straw yield. However, the values are found to be at par with application of 25 percent N (RDN) and 100 percent P and K + three foliar sprays of nano-N @ 0.4 percent at 20, 40, and 60 DAS at harvest of linseed. The increase in yield of linseed could be due to foliar application of nano fertilizers offer a higher surface area due to the tiny particle size, which provides more surface area to facilitate different metabolic functions in the plant system as a result of more photosynthates being produced. The synergistic effect of nano fertilizers on the efficiency of chemical fertilizer for greater absorption of nutrients by plant cells, resulting in maximum growth of plant parts and metabolic activities such as photosynthesis, which leads to higher photosynthates accumulation and translocation to the plants economic parts, thus resulting in high yield which attributed to increased source and sink strength [28].

V. Conclusion

In an era where farmers are always looking for through ways to increase crop productivity, foliar fertilization is a crucial tool for enhancing crop growth and yield. Through nutrient spraying, the nutrients get effectively absorbed approximately 20 times faster through leaves and translocated nutrients creates stimuli in the plant system which can increase the production of growth regulators in the cell system and inturn stimulates necessary growth & development of the plant resulting in higher yield by 20% in oilseed crops. So, by utilizing foliar fertilization to complement the soil's nutritional requirements and minimizing soil nutrient depletion, our demands as crop growers can be satisfied in an environmentally responsible manner.

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