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Influence of foliar application of water soluble fertilizers on soil nutrient dynamics, quality and yield of cowpea (*Vigna unguiculata* L.)

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Abstract
A field experiment entitled "Influence of Foliar Application of Water Soluble Fertilizers on Soil Nutrient Dynamics, Yield and Quality of Summer Cowpea (*Vigna unguiculata* L.) was carried out during the season 2021, at SSAC Departmental Research Farm, College of Agriculture, Latur. The experiment was laid out in randomized block design with 3 replications with 9 treatments among that one is of absolute control, one of recommended dose of nitrogen and phosphorous, 3 treatments are of foliar application of individual water soluble fertilizers *viz.*, Among the various treatments combination of foliar application of water soluble fertilizers with RNP (T9 RNP + foliar spray of 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ % + KNO_3 1.0% @ 60 DAS) showed significant increase in content and uptake of nutrients (N, P and K) yield and the quality parameter like protein content and test weight of cowpea than foliar application of individual water soluble fertilizers (T3 RNP + foliar spray of 19:19:19 @ 0.5% at 30 DAS) over control. So it can be concluded that the foliar application of combined of water soluble fertilizers along with RNP showed significantly superior effect on soil nutrient dynamics, yield and quality as compare to the foliar application of individual water soluble fertilizer with RNP over control of cowpea on low nitrogen content soil.

Keywords: Nodules, leaf area index, chlorophyll, available nutrient, yield

1. Introduction
Cowpea is native of central Africa. Cowpea belongs to family Leguminaceae with genus *Vigna* and possess chromosome number 2n = 22 with self-pollination as mode of reproduction. Cowpea is commonly known as Chawale, Lobia and black eye beans. Cowpea grows well at temperature between 27-35 °C. It can grow in kharif, rabi and summer. It can be cultivated in acidic to neutral soil. Cowpea (chawali) is a widely used and very varied crop that is grown all over the world as a pulse as well as a food (both grains and green peas), a cover crop, a green manure crop, an erosion-resistant crop, a fodder crop, and a drought-tolerant crop.

Cowpea seeds is a nutritious component in the human diet and cheap livestock feed as well. The beans are nutritious and provide complementary proteins to cereal diets. Some people eats as both fresh leaves and the dried seeds are popular ingredients in a variety of dishes. It is also known as vegetable meat because grain contains protein of about 24.8%, carbohydrates 63.6%, fat 1.9%, minerals and vitamins., it is also a rich source of phosphorus, calcium, iron are highly responsive to fertilizer application (Kumar *et al.* 2016) [17]. Green tender pods are used as vegetable, which contain 84.6% moisture, 4.3% protein, 8.0% carbohydrates, and 0.2% fat.

Phosphorus is involved in a variety of physiological processes that occur in developing and maturing plants. In plants, it is essential in enzymatic processes. Because phosphorus is a component element of nucleoproteins, which are involved in cell reproduction processes, it is an essential factor for cell division. It aids in the development of the plant's skeletal structure, preventing lodging. It also has an effect on grain quality and may improve disease resistance in plants (Singh *et al.* 2017) [13]. In general plant having less than 0.1% or 1000 ppm P is designated as phosphorus deficient. Nitrogen and Phosphorous was applied through soil but nowadays these fertilizers were applied through water soluble fertilizer as foliar spray to avoid losses and increase efficiency of fertilizers. In recent years, specialty fertilizers had been introduced exclusively for foliar feeding and fertilization which serve better for foliar application and may contain different ratios of N, P, and K with or without other nutrients with high solubility and so amenable for foliar nutrition (Shruthi and Vishwanath. 2018) [12].

In present investigation water soluble fertilizers i.e., 19:19:19, 00:52:34 and KNO_3 (13:00:45) were undertaken for the study. Complex fertilizers viz. 19:19:19 is a hundred percent water soluble complete fertilizers that contains nitrogen in three forms: (NO_3-N) (45.0 percent), NH_4-N (4.5 percent), and NH_2-N (10.5 percent), as well as water soluble phosphorus and potassium, each of which contains 19 percent and has a low salt index. As a result, it promotes speedy and healthy crop growth while also quickly fixing nutrient deficits. It improves pest and disease resistance by keeping plants healthy, resulting in less usage of pesticides and fungicides, as well as more uniform flowering and smaller droppings, resulting in higher crop yields. Similarly, the foliar spray of 0:52:34 provides vigour to the crops when crop is facing adverse conditions like pest infestation and water stress. (Mamthashree *et al.*, 2017) [6]. Potassium Nitrate (KNO_3) is a water soluble potassic fertilizers suitable for application containing 44 and 32% K_2O and NO_3-N, respectively nutritional levels than the desired optimum levels. By considering above fact, work on foliar fertilization with major nutrients through water soluble fertilizer on cowpea, was very less hence it was necessary to conduct present investigation entitled "Influence of Foliar Application of Water Soluble Fertilizers on Soil Nutrient Dynamics, Quality and Yield of Summer cowpea (*Vigna unguiculata* L.).

2. Materials and Methods

The experiment was conducted at SSAC department Research Field, College of Agriculture, Latur during summer season 2020-2021 on cowpea variety Parvati. The details of the material used to study the "Effect of Foliar Application of Water Soluble Fertilizers on Soil Nutrient Dynamics, Quality and Yield of Summer Cowpea (*Vigna unguiculata*)". Randomized Block Design (RBD) was followed with 9 treatments each replicated thrice. The treatment details are [T_1 – Control, T_2 - RNP (N, P2O5), T_3 - RNP + 0.5% 19:19:19 @ 30 DAS, T_4 - RNP + 1.0% 00:52:34 @ 45 DAS, T_5 - RNP + 1.0% KNO_3 (13:00:45) @ 60 DAS, T_6 - RNP + 0.5% 19:19:19 @ 30 DAS + 1.0% 00:52:34 @ 45 DAS, T_7 - RNP + 1.0% 00:52:34 @ 45 DAS + 1.0% KNO_3 (13:00:45) @ 60 DAS, T_8 - RNP + 0.5% 19:19:19 @ 30 DAS + 1.0% 00:52:34 @ 45 DAS, T_9 - RNP + 0.5% 19:19:19 @ 30 DAS + 1.0% 00:52:34 @ 45 DAS + 1.0% KNO_3 (13:00:45) @ 60 DAS]. The experiment was laid out in Randomized Block Design with three replications. The size of each plot treatment was 3 m x 2 m. There are four factors which are RNP (Recommended Nitrogen and Phosphorous), 19:19:19, 00:52:34, KNO_3 (13:00:45). The variety Parvati of cowpea was sown on 6th February 2021 by maintaining a spacing of 30×10 cm^2. The biometric analysis were nodulation, leaf area index and chlorophyll content, yield attributes are seed and straw yield. The results were statistically analyzed as per the "statistical methods for Agricultural workers" by Panse and Sukhatme (1967) [9].

3. Result and Discussion

3.1 Effect of foliar application of water soluble fertilizers on biometric observations of cowpea

3.1.1 Number of nodules

The increase in nodules due to foliar spray and soil application was varies from 19 to 24.46 at 45 DAS respectively. The foliar application of individual water soluble fertilizers at different stages of crop growth along with RNP significantly increased root nodule at 45 DAS of cowpea. The treatment (T_3) RNP + 19:19:19 @ 0.5% at 30 DAS found to be highest root nodules (20.64) at 45 DAS followed by (T_4) RNP + 0:52:34 @ 1.0% at 45 DAS (19.59) as compared to control (18.81) respectively.

The data revealed that combination of different water soluble fertilizers along with RNP at different stages of crop growth showed significant increase in root nodules at 45 DAS. Treatment (T_9) RNP + foliar spray of 19:19:19 @ 0.5% + 0:52:34 @ 1.0% + KNO_3 1.0% (25.73) at 45 DAS followed by (T_6) RNP + foliar spray of 19:19:19 @ 0.5% + 0:52:34 @ 1.0% (23.37) over control (18.81). The increase in nodules due to nutrient spraying could be related to nodulation activity in leguminous plants. The availability of phosphorus was essential for root which enhances the action of root nodule-forming bacteria. The foliar spray of P increased P absorption and induced root nodule production and rhizobial activity.

Similar result were reported by Jadhav *et al*. (2017) [5] stated that treatment (T_8) foliar application of RDF + 19:19:19 @ 1.0% at vegetative stage + 00:52:34 @ 1.0% at flowering stage + KNO_3 showed significant increase in number of nodules per plant at 45 and 60 DAS (20.33 and 34.20 respectively) followed by treatment (T_8) RDF + 19:19:19 @ 1.0% at vegetative stage + 00:52:34 @ 1.0% at flowering stage (16.57 and 31.53) at 45 and 60 DAS respectively as compare to control and found that the increase in number of nodules due to application of macronutrients through spraying and soil application by RDF.

Table 1: Effect of foliar application of water soluble fertilizers on number of nodules 45 DAS of cowpea

Treatments	Nodulation
T1 -Control	18.81
T2 -RNP	19.93
T3 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS	20.64
T4 -RNP + foliar application 0:52:34 @ 1.0% at 45 DAS	19.59
T5 -RNP + foliar application KNO_3 @ 1.0% at 60 DAS	19.15
T6 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS	23.37
T7 -RNP + foliar application 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS	23.04
T8 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + KNO_3 @ 1.0% at 60 DAS	23.02
T9 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS	25.73
SE±	0.187
CD @ 5%	0.56

3.1.2 Leaf Area Index (LAI)

The effect of foliar application of water soluble fertilizers on Leaf Area Index (LAI) at 45 DAS of the cowpea, found that the response of foliar application of water soluble fertilizers on Leaf Area Index ranges between (0.66 to 2.25) at 45 DAS. The foliar application of individual water soluble fertilizers at different stages of crop growth along with RNP significantly increased root nodule at 45 DAS of cowpea. Treatment (T_3) RNP + foliar application 19:19:19 @ 0.5% at 30 DAS recorded higher leaf area index (0.95) at 45 DAS followed by (T_4) RNP + foliar application of +0:52:34 @ 1.0% (0.94) recorded over the control (0.66).

The data showed that combination of different water soluble fertilizers along with RNP at different stages of crop growth significantly increased leaf area index at 45 DAS of cowpea. Treatment (T_{9}) RNP + foliar spray of 19:19:19 @ 0.5% + 0:52:34 @ 1.0% at 45 DAS + KNO_3 1.0% at 60 DAS recorded higher leaf area index (2.25) at 45 DAS followed by (T_6) RNP + foliar spray of 19:19:19 @ 0.5% + 0:52:34 @ 1.0% (1.82) over control (0.66). This increase leaf area index could be attributed due to increased nutrient availability from foliar nutrition, which may have resulted in increased nutrient uptake and better nutrient translocation. The beneficial effects of foliar nutrient spraying enhance cell division and cell elongation, which aided in growth and development.

These result were confirmatory with the findings of Mudalagiriyappa *et al.* (2016) [7] found that leaf area index of red gram recorded significantly higher at 2.0% (19:19:19) at flowering as well as pod development stages (1.18) which was on at par with 1.5% (1.17) and superior over its control and water spray. Increase in LAI was mainly due to additional foliar application of water soluble fertilizers which lead to increased uptake of nutrients which in turned help in increase leaf area index. Vanathi *et al.* (2020) [18] studied on the effect of foliar application of organic and inorganic nutrients on the phenotypic enhancement of black gram and concluded that foliar application of 1% pulse wonder spray on 25 DAS followed by 0.5% 19:19:19 spray on 45 DAS higher leaf area index (2.57).

Table 2: Effect of foliar application of water soluble fertilizers on Leaf Area Index (LAI) 45 DAS of cowpea

Treatments	LAI
T1 -Control	0.66
T2 -RNP	0.88
T3 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS	0.95
T4 -RNP + foliar application 0:52:34 @ 1.0% at 45 DAS	0.94
T5 -RNP + foliar application KNO_3 @ 1.0% at 60 DAS	0.92
T6 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS	1.82
T7 -RNP + foliar application 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS	1.74
T8 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + KNO_3 @ 1.0% at 60 DAS	1.72
T9 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS	2.25
SE±	0.038
CD @ 5%	0.115

3.1.3 Chlorophyll content

The effect of foliar application of water soluble fertilizers on chlorophyll content in leaf at 45 DAS of the cowpea was found that the response of foliar application of water soluble fertilizers on chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll ranges between (1.01, 0.56, 1.57 to 2.46, 1.47, 3.89) at 45 DAS respectively.

The foliar application of individual water soluble fertilizers at different stages of crop growth along with RNP significantly increased chlorophyll content at, 45 DAS of cowpea. The treatment (T_3) RNP + 19:19:19 @ 0.5% at 30 DAS recorded higher content of chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll (1.43, 0.88, 2.31 mg/g respectively) at 45 DAS followed by (T_4) RNP + 0:52:34 @ 1.0% at 45 DAS (1.3, 0.86, 2.16 mg/g) as compared to control (0.56, 1.01, 1.57 mg/g) respectively.

The effect of foliar application of combination of respective treatments at various stages of crop growth on chlorophyll a, chlorophyll b and total chlorophyll was recorded to be significant. The highest level of chlorophyll content was recorded by foliar application of combination treatment (T_9) RNP + foliar application 19:19:19 @ 0.5% at 30 DAS +0:52:34 @ 1.0% at 45 DAS+ KNO_3 @ 1.0% at 60 DAS was found highest chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll (2.46, 1.47, 3.89 mg/g, respectively) at 45 DAS as compare to (T_6) RNP + foliar application 19:19:19 @ 0.5% at 30 DAS+0:52:34 @ 1.0% at 45 DAS (2.42, 1.39, 3.8) over the control (0.56, 1.01, 1.57 mg/g).

Increase in chlorophyll content of leaves mainly due to supply of nutrient especially N, through foliar and soil application through RNP as well as FYM, as nitrogen was the integral part of chlorophyll, which was primary absorbed light energy needed for photosynthesis and imparts vigorous vegetative growth dark green color to plants. The results were close confirmatory with the investigation of Choudhary *et al.* (2011) [1] worked on effect of fertility levels and foliar nutrition on cowpea productivity and concluded that significantly higher total chlorophyll content 2.29 mg/g observed in treatment of foliar spray of 2% DAP as compared to control (1.85).

Table 3: Effect of foliar application of water soluble fertilizers on chlorophyll content of leaves (mg g^{-1}) at 45 DAS of cowpea

Treatments	Chl 'a'	Chl 'b'	TotalChl
T1 -Control	1.01	0.56	1.57
T2 -RNP	1.29	0.81	2.1
T3 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS	1.43	0.88	2.31
T4 -RNP + foliar application 0:52:34 @ 1.0% at 45 DAS	1.3	0.86	2.16
T5-RNP + foliar application KNO_3 @ 1.0% at 60 DAS	1.28	0.85	2.14
T6 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS	2.42	1.39	3.8
T7 -RNP + foliar application 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS	2.37	1.14	3.51
T8 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + KNO_3 @ 1.0% at 60 DAS	2.35	1.11	3.46
T9 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0%at 60 DAS	2.46	1.47	3.89
SE±	0.018	0.029	0.037
CD @ 5%	0.055	0.087	0.109

3.2 Impact of foliar application of water soluble fertilizers on Nutrient status

3.2.1 Available Nitrogen

The maximum N content in soil was found in range of 142.48 to 172.64 kg ha^{-1} at harvest of cowpea. The foliar application of individual water soluble fertilizers at different stages of crop growth with RNP significantly increased availability of nitrogen in soil, at harvest of cowpea. The treatment (T_3) RNP + 19:19:19 @ 0.5% at 30 DAS recorded higher content of nitrogen (163.08 kg ha^{-1}) followed by (T_4) RNP + 0:52:34 @ 1.0% at harvest (159.71 kg ha^{-1}) as compared to control (142.48 kg ha^{-1}), respectively.

The application of foliar application of combination of different water soluble fertilizers with RNP along with significantly increased the available N. The maximum available N was recorded in treatment (T_9) RNP + foliar application 19:19:19 @ 0.5%+0:52:34 @ 1.0% + KNO_3 @ 1.0% (172.64 kg ha^{-1}) followed by (T_8) RNP + foliar application 19:19:19 @ 0.5% + KNO_3 @ 1.0% (168.37 kg ha^{-1}) as compare to control (142.48 kg ha^{-1}).

Increase in available nitrogen might be due foliar application of nutrients with RNP and FYM which increased microbial activity and root length in the rhizosphere that helped to improve physical and chemical properties of soil as well as micro-organisms in soil converts organically bound nutrients in inorganic form by the process of mineralization which resulted in higher availability of nutrients in soil.

Similar results reported by Shashikumar *et al.* (2013) [11] revealed that Available N content of soil 278.12 kg ha^{-1} after harvest of crop was significantly higher in T_9 (RDF + foliar application of 40 ppm NAA + 0.5% chelated micronutrients + 2% DAP). This may be due to higher microbial activity and higher root activity in rhizosphere and improved soil physical and chemical properties.

3.2.2 Available Phosphorous

Available phosphorous ranges between 13.87 Kg ha^{-1} and 39.69 Kg ha^{-1}at harvest of crop. The foliar application of individual water soluble fertilizers at different stages of crop growth along with RNP significantly increased availability of nitrogen in soil, at harvest of cowpea. The treatment (T_3) RNP + 19:19:19 @ 0.5% at 30 DAS recorded higher availability of phosphorous in soil (15.79 Kg ha^{-1}) followed by (T_4) RNP + 0:52:34 @ 1.0% at harvest (15.8 Kg ha^{-1}) as compared to control (13.87 Kg ha^{-1}).

The combination of foliar application of different water soluble fertilizers along with the RNP increased the available P. The maximum P was recorded in treatment of (T_9) RNP + foliar application 19:19:19 @ 0.5% +0:52:34 @ 1.0% + KNO_3 @ 1.0% (39.69 kg ha^{-1}) followed by (T_8) RNP + foliar application 19:19:19 @ 0.5% +0:52:34 @ 1.0% (28.93 Kg ha^{-1}) as compare to control (13.87 Kg ha-1).

The higher soil available phosphorous may be due to higher activity of micro- organisms in the rhizosphere which improved physical and chemical properties of soil. As well as the application of FYM in soil before sowing helped to enhanced the microbial activity and availability of nutrients by decomposing the organic matter which formed organic acids in the soil. These result were similar with Jadhav *et al.* (2017) [5] found that foliar application of nutrients on soybean crop showed significantly increase in available phosphorous in the treatment of T_6 (RDF + Urea spray @ 2% at 30 and 45 DAS). The increase in available phosphorous might be due to higher microbial activity in rhizosphere and improve in chemical and physical properties of soil.

3.2.3 Available Potassium

Available potassium ranges between (239.81 and 287.1 Kg ha^{-1}) at harvest of crop. The foliar application of individual water soluble fertilizers at different stages of crop growth along with RNP significantly increased availability of potassium in soil, at harvest of cowpea. The availability of potassium was increased as a result of foliar application of fertilizers which enhanced vegetative development and increased the capacity of plants for metabolite production as well as reduced water stress and improved disease and pest resistance capacity in crops. Based on these findings, it can be stated that foliar nutrition spraying could promote vegetative growth and soil nutrient availability as well as availability of K enhanced due to the soil application of FYM that not only increases the availability of nutrients but also improved physical, chemical and microbial property of soil.

Table 4: Effect of foliar application of water soluble fertilizers available nitrogen, phosphorous and potassium (Kg ha^{-1}) at harvest of cowpea

Treatments	N	P	K
T1 -Control	142.48	13.87	239.81
T2 -RNP	150	14.73	243.65
T3 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS	163.08	15.79	247.87
T4 -RNP + foliar application 0:52:34 @ 1.0% at 45DAS	159.71	15.8	247.32
T5 -RNP + foliar application KNO_3 @ 1.0% at 60 DAS	161.69	15.65	252.03
T6 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS	168.37	28.93	267.93
T7 - RNP + foliar application 0:52:34 @ 1.0% at 45 DAS+ KNO_3 @ 1.0% at 60 DAS	166.75	28.00	268.66
T8 - RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + KNO_3 @ 1.0% at 60 DAS	166.66	27.33	269.71
T9 -RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS	172.64	39.69	287.1
SE±	1.4999	0.462	1.381
CD @ 5%	4.492	1.386	4.139

Similar results were recorded by Neethu *et al.* (2018) [8] observed that among the treatment the highest available K content was obtained in 0.5% KNO_3 + 2% DAP + micronutrient spray along with RDF. The available K status increased with the increased level of foliar application of fertilizers but there was a decreased trend that occurred between the stages.

3.3 Influence of foliar application of water soluble fertilizers on nutrient content (%) and uptake (kg ha^{-1})

3.3.1 Nitrogen

The nitrogen content in seed and straw ranges between (2.08 to 3.42 percent) and (0.34 to 1.23 percent) and nitrogen uptake (30.70 to 41.91 kg ha^{-1}) and (4.56 and 20.17 kg ha^{-1}) at after harvest of crops. The foliar application of individual water soluble fertilizers at different stages of crop growth along with RNP significantly increased nitrogen content and uptake in grain and straw of cowpea at harvest. The treatment (T_3) RNP + 19:19:19 @ 0.5% at 30 DAS recorded higher content (3.23 and 0.59 percent) and uptake (35.39 and 8.58 kg ha^{-1} respectively) of nitrogen in seed and straw respectively followed by (T_5) RNP+13:00:45 @1.0% at harvest (3.19 and 0.56 percent) and (34.52 and 8.27 kg ha^{-1}) in grain and straw respectively as compared to control (3.08 and 0.34 percent) and (30.70 and 4.56 kg ha^{-1}). The foliar application of combination of respective treatments significantly increased nitrogen content in seed and straw. The highest nitrogen content and uptake in seed and straw was recorded highest in combination of treatment (T_9) RNP + foliar spray of 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS + KNO_3 1.0% at 60 DAS (3.42 and 1.23 percent respectively) and (41.91 and 20.17 kg ha^{-1}) followed by (T_8) RNP + foliar spray of 19:19:19 @ 0.5% at 30 DAS + KNO_3 1.0% at 60 DAS (3.38 and 0.82 percent) and (40.91 and 13.29 kg ha^{-1}) as compare to control in seed (3.55 and 0.34) and (30.70 and 4.56 kg ha^{-1}) respectively. The increased in N content and uptake in seed and straw may be due to spraying of fertilizers directly on the leaves of crops because absorption of nutrients directly through leaves make nutrient availability faster to the crops as compare to soil by saving the time and loss of nutrients through transporting the nutrients from non-available to available form.

The results were confirmatory with the findings with the findings of Takankhar *et al.* (2018) [16] studied on effect of foliar application of macronutrients on nutrient uptake in different growth stages of green gram and reported that the concentration of nitrogen (3.54%) and uptake (48.48 kg ha^{-1}) in grain was significantly higher in the treatment T_8 (RDF + foliar application 19:19:19 @ 0.5% at vegetative stage + 0:52:34 @ 1.0% at flowering stage + KNO_3 @ 1.0% at grain filling stage and lower concentration found in treatment T_1 (control). The increase in content could be due to the high mobility of the nitrogen from vegetative tissues to reproductive organs after flowering stage and increase in uptake might be due to increased availability of nitrogen to the crop and higher biomass production.

3.4 Impact of foliar application of water soluble fertilizers on yield of summer cowpea

3.4.1 Seed Yield

Response of foliar application of water soluble fertilizers alone and in combination with RNP on seed yield of cowpea was ranges from (0.60 to 0.74 kg plot^{-1}) and (996.64 and 1226.59 kg ha^{-1}).The foliar application of individual water soluble fertilizers at different stages of crop growth and soil application of RNP at the time of sowing significantly increased seed yield of cowpea. The treatment (T_3) RNP + 19:19:19 @ 0.5% at 30 DAS recorded higher seed yield (1096.81 kg/ha and 0.66 kg plot^{-1}) which was 8.93% more over the control followed by (T_4) RNP +0:52:34 @ 1.0% at 45 DAS at harvest (1080.93 kg/ha and 0.65 kg plot^{-1}) in grain as compared to control (996.64 kg/ha and 0.60 kg plot^{-1}). The combination of respective treatments recorded as maximum seed yield of cowpea. The highest seed yield was recorded in treatment (T_9) RNP + foliar application of 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS (0.74 kg plot^{-1} and 1226.59 kg ha^{-1}) which was 21.82% more over the control followed by (T_6) RNP + foliar application of 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS (0.73 and 1210.48 kg ha^{-1}) as compare to control (996.64 kg ha^{-1} 0.60 kg plot^{-1}).

Increasing seed yield might be due to foliar spray of nutrients, which was the fastest method to directly improve crop growth and production since nutrients were available to plants in critical growth phases and the nutrients was reach the site of food synthesis directly resulting in lowering the requirement of fertilizers.

Similar results were line with Devaraju *et al.* (2018) conducted experiment on effect of foliar application of different sources of nutrients on growth, yield of blackgram under irrigated condition and concluded that the foliar application of All 19 @ 1.0 percent at flowering and 15 days after first spray was significantly increased higher straw yield (1398.40 kg ha^{-1}). Increase in yield attributes might be due to increased uptake of nutrients by blackgram by effective translocation of nutrient from sink to reproductive area of

crop.

3.4.2 Straw Yield

The data showed in respect effect of water soluble fertilizers alone and in combination with RNP on straw yield of cowpea range between 0.80 to 1.11 kg plot^{-1} and 1341.467 to kg ha^{-1}.The foliar application of individual water soluble fertilizers at different stages of crop growth along with RNP significantly increased seed yield of cowpea. The treatment (T_3) RNP + 19:19:19 @ 0.5% at 30 DAS recorded higher seed yield (1514.50 kg/ha) followed by (T_4) RNP +0:52:34 @ 1.0% at 45 DAS at harvest (1506.351 kg/ha) in grain and straw respectively as compared to control (1341.467 kg/ha).

The combination of respective treatments was recorded as maximum straw yield of cowpea. The highest straw yield was recorded in foliar application of water soluble fertilizers in treatment (T_9) RNP + foliar application of 19:19:19 @ 0.5% at 30 DAS + 0:52:34 @ 1.0% at 45 DAS + KNO_3 @ 1.0% at 60 DAS (1850.156 kg ha^{-1}) which was (%) more over the controlled by (T_8) RNP + 19:19:19 @ 0.5% at 30 DAS + KNO_3 @ 1.0% at 60 DAS (1559.138 kg ha^{-1}) as compare to control (1341.467 kg ha^{-1}).

The increase in straw yield might be due to foliar application of macro nutrients like as N, P, and K, which assisted to promote nutrient uptake and assimilate translocation to the growing sink, resulted in a higher straw yield profusely.

The results were confirmatory with Takankhar *et al.* (2017) [15] reported that treatment T8 i.e. RDF + 19:19:19 @ 1% at vegetative stage + 0:52:34 @ 1% at flowering stage + 13:00:45 @ 1% at grain filling stage recorded significantly higher straw yield (1399.42 kg ha^{-1}) than rest of treatment in the study conducted on effect of foliar nutrition on growth yield and quality of chickpea (*Cicer arietinum* L.).

4. Conclusion

The growth parameters i.e. number of nodules, leaf area index and chlorophyll content, found significantly increase due to foliar application of water soluble fertilizers. The increase in growth parameters might be due to direct availability of nutrients through leaves which is sprayed trough water soluble fertilizers at the early and vegetative stage of crop growth that also affects cell division and cell elongation, which aids in growth and development. Increase in available nutrients might be due foliar application of nutrients and application through RNP and FYM which increased microbial activity and root length in the rhizosphere that helped to improved physical and chemical properties of soil as well as micro-organisms in soil converts organically bound nutrients in inorganic form by the process of mineralization, which resulted in higher availability of nutrients in soil.

Thus, from above result it can be concluded that soil application of RNP with the foliar application of water soluble fertilizers alone T_3 (RNP + 19:19:19 @ 0.5% at 30 DAS) found to be superior followed by T4 (RNP + 00.52:34 @ 0.5% at 45 DAS) over control. Among the treatments application of RNP with combination of foliar application of water soluble fertilizers T_9 (RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 00:52:34 @ 1.0% at 45 DAS+ KNO_3 @ 1.0% at 60 DAS) was significantly superior followed by T_6 (RNP + foliar application 19:19:19 @ 0.5% at 30 DAS + 00:52:34 @ 1.0% at 45 DAS) in increase of nutrient dynamics, yield and quality of cowpea on low nitrogen content soil.

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