

Formulation, Development and Characterization of an Eco-Friendly N-P-K Fertilizer with Multi Micronutrient Matrix

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In modern agriculture for receiving better crop yield and plant growth fertilizers are obligatory. Micronutrient support is very essential for balanced crop nutrition. For elevated crop yield the optimal nutrient supply is very much necessary and it is possible only the presence of micronutrient matrix. Minute quantities of micronutrients are required for better physiology of plant kingdom. The purpose of the study was to formulate a new Nitrogen-Phosphorous-Potassium fertilizer with five micronutrients mould. The author developed water soluble (100%) 15-15-15 grade fertilizer with 0.5%Zn,0.5%Mn,0.5%Fe, 0.5%Mg, 0.2%Mo as micronutrients support. The physical properties such as moisture,pH,conductivity ,critical relative humidity etc were studied and found superior as compared to the normal grade without micronutrient support. The presence of Chloride content in the soil diminishes the capacity of the plants to take up water and this results in leaf burn or drying of leaf tissues. The chloride content in the proposed fertilizer is 0.27%. Nitrogen-Phosphorous-Potassium fertilizer fortified with five-micronutrient matrix and its application for finest Plant augmentation shown unsurpassed results and more crop yield. The proposed fertilizer with multi micronutrient matrix shown enhanced physical properties as compared to available branded fertilizers.

Keywords: Critical relative humidity; Chloride Content; Micronutrient Matrix; N-P-K fertilizer; Plant growth.

Fertilizers plays vital role in high yield production, crop growth. nutrients supplied to plant or crop are completely utilized due to several reasons including leaching through rains or due to usage of excess water for crops. Some of them are undergoing volatilizations also and it leads to environmental problems such as ground water pollution, green house gas emissions etc. Development of water soluble, slow-release, efficient, fertilizers have become very important. Simultaneously, the rapid development of fertilizer manufacturing has created new opportunities

to feasibly obtain and use soluble, slow release fertilizers¹. Water soluble fertilizers(WSF) were introduced in India in 1990s. Up to 2005, their usage was very less. World population increasing day by day. To feed these population modern technologies required in Agricultural sector. WSF are more efficient than traditional fertilizer to balance this factor².

Water soluble fertilizers (WSFs)

WSFs dissolve completely in water. WSFs having low salt index and they do not show adverse effect on plant tissues³. WSFs are suitable

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for both foliar and fertigation process. WSFs are mostly used in drip irrigation. The WSFs applied through drip irrigation (Fertigation) and foliar application enhances the nutrient use efficiency, uptake efficiency and uptake speed of the nutrients contained therein. right fertilizer application in the right time will give more benefits and good yield⁴⁻⁵. These are mostly combination of N, P, K Ca & Mg & S with micronutrients with different ratios. The applied fertilizers are not fully utilized by the plants and due to this reason the uptake of necessary nutrient elements becomes difficult for the plant. Based on the reports & investigations available, use of water soluble fertilizers recorded the highest growth rates⁶. The growth control and

quality of crop are based on effective Fertilizer management. It lessens the ground water pollution which causes ecological disturbances and health risks by fertilizer leaching and accumulation of nitrates. Water soluble fertilizers through fertigation resulted in higher yield⁷⁻⁸.

Nutrients are applied along with the irrigation water and opens new possibilities for controlling water and nutrient supplies to crops besides maintaining the desired concentration and distribution of water and nutrients to the soil⁹⁻¹⁰. The fertilizer absorption takes place through the stomata of the leaves and also through the epidermis.

A small amount of nutrients from dilute solutions sprayed on to the leaves in plants due to

Table 1. Selected micronutrients

Metal	Role
Zinc	Essential for reproductive growth of plants and low supply of Zn results in reduced size of anther, poor pollen producing capacity, reduced pollen size and its viability Zn deficiency recorded world wide ranging from 4 to 73% in various countries. .
Iron	Iron is a part in PSI, Ferredoxin & various metabolic enzymes. Ferredoxin and chlorophyll content was lower in iron deficient leaves when compared with normal leaves. Iron plays an important role in the electron transfer chain respiration and photosynthesis, however it becomes toxin when accumulated at higher level. Oxidation- reduction processes in soil are one of the important determinants of the iron availability by conversion of Fe (III) to Fe (II).
Manganese	Active role in oxidation and reduction process and activator of many enzymes in plants. Manganese deficiency mostly observed in calcareous soils, soils with high pH & soils with poor aeration. Mn deficiency leads to reduction in the efficiency of photosynthesis ²⁰ . It also affects plant growth and development. The metal is an essential cofactor for the oxygen-evolving complex (OEC) of the photosynthetic machinery, catalysing the water-splitting reaction in photosystem II (PSII). The behavior of manganese is similar to iron in terms of its deficiency under upland and coarse textured soils and toxicity in the reduced conditions. Mn supply through foliar application is very effective ²¹ . Mn deficiency resulting in inferior pollen tube growth. Moreover, under Mn deficiency, alterations of another enzymes and reductions of their efficacies affect development of reproductive tissues.
Magnesium	Optimal plant growth and productivity through CO ₂ assimilation ²² . Mg released from soil minerals is not sufficient for high crop yield and quality. Mg is very mobile in soils resulting leads to higher risk of leaching ²³ . Mg is required for photosynthesis, glycolysis. It promotes operation of photosynthetic rings and photosynthesis ²⁴ .
Molybdenum	vital for the process of symbiotic nitrogen (N) fixation by Rhizobia bacteria in legume root modules. Molybdenum forms the essential component of nitrate reductase enzyme and nitrogenase, thus required for N metabolism. In wheat, molybdenum starvation was also shown to reduce maximum NR activities (lower potential VMAX) irrespective of the regulatory control of NR by light and dark periods. Molybdenum promotes fixation of nitrogen and also improves the Phosphorus uptake by plants. Lower Erucic and eicosenoic acid content were reported in Indian mustard with application of Molybdenum @ 4kgha-1 when compared to control. Molybdenum is the least found micronutrient in the lithosphere.

absorption¹¹. Many investigations in this field are proved that the application of inorganic fertilizers can be reduced up to 15% with application of foliar grade water soluble fertilizer¹²⁻¹³. Water soluble fertilizers and inorganic fertilizers tested foliar application of 7 sprays of NPK (19:19:19) along

with the 100% application of inorganic fertilizer (200:150:100 kg NPK ha⁻¹) recorded the highest growth parameters in Brinjal. The application of foliar NPK fertilizers at 125% resulted in a remarkable increase in the all investigated parameters of corn plants¹⁴.

Role of micronutrient

To increase the yield, excess amount of NPK fertilizers are used, which leads to depletion of micronutrients. Micronutrients role is very important as slight excess or deficit may depression in yields, and it effects the nutritional balance in human beings¹⁵⁻¹⁶. The different micronutrients are required in different quantities at different levels of plant growth. Zn, B, Fe, Mn, Mo, Cu and Mg are considered as micronutrients. These affects formation of flower, viable seed, floral and grain formation. crop yield losses and human health problem observed due to deficiency of Zn & Fe deficiency. Low concentrations of micronutrients are required by plants¹⁷.

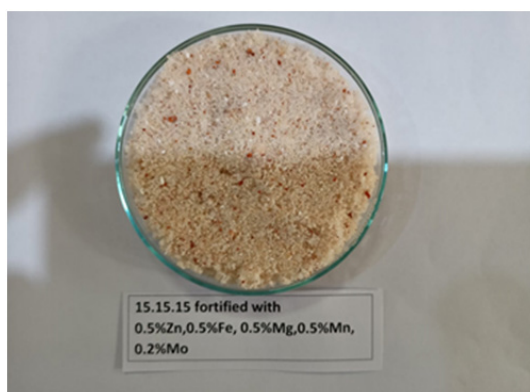


Fig. 1. Nitrogen-Phosphorous-Potassium fertilizer fortified with five -micronutrients

Table 2. Raw materials used for the study

S.No	Materials	Molecular formula
1	Ammonium sulphate(AS)	(NH ₄) ₂ SO ₄
2	Mono ammonium phosphate(100% water soluble)(MAP)	NH ₄ H ₂ PO ₄
3	Urea	NH ₂ CO NH ₂
4	Potassium nitrate	KNO ₃
5	Chelated Zinc	Zn EDTA
6	Ferrous sulphate	FeSO ₄ · 7H ₂ O
7	Magnesium sulphate	MgSO ₄ · 6H ₂ O
8	Manganese sulphate	MnSO ₄ · 1H ₂ O
9	Ammonium molybdate	(NH ₄) ₆ Mo ₇ O ₂₄ · 4H ₂ O

Table 3. The analysis results of the raw materials

Material	Parameter	Result
(NH ₄) ₂ SO ₄	%Ammoniacal Nitrogen as N	20.2
	%Sulphate sulphur as S	23.2
NH ₄ H ₂ PO ₄	%Ammoniacal Nitrogen as N	11.5
	% water soluble Phosphorous as P	60.2
Urea	%Urea nitrogen as N	46.1
KNO ₃	% water soluble potassium as K ₂ O	44.5
	% Nitrate nitrogen as N	12.5
Zn EDTA	%Zn	12.1
MnSO ₄ · 1H ₂ O	%Mn	30.5
FeSO ₄ · 7H ₂ O	%Fe	19.3
MgSO ₄	%Mg	19.5
(NH ₄) ₆ Mo ₇ O ₂₄ · 4H ₂ O	%Mo	52

Application of micronutrients through foliar spray was found more beneficial than the soil application for oilseed crops¹⁸. Nutrient based subsidy and soil health card has been encouraged rationalized nutrient use.

Micronutrient management is important for crop, livestock and human equally. Most of the places in India, Zn and B, were observed in most of the soils in our country, especially under

intensive agriculture. Micronutrients are not only important for better crop productivity but are also essential for sustaining human and animal health due to range between deficiency and toxicity limits of micronutrient in soil and it is narrow for most of the crops¹⁹.

The intensive cultivation and imbalance of nutrients use in last four decades shown the deficiency of micronutrients have developed in

Table 4. Instrumentation

Instrument	Make	Model	Purpose
ICP –OES	Perkin elmer	Optima 7000DV	To check Mn and Mo
Segmented flow analyzer	Skalar	SAN++	To check N, P
Hot air oven	Tempo	TI 175	For gravimetric drying
Weighing balance	Sartorius	BSA 225, BSA3202	For weighing

Table 5. Weights of material taken for preparation

Material	Quantity in grams
AS	17.2
MAP	25.3
Urea	12.06
Potassium nitrate	33.96
Chelated Zinc	4.17
Ferrous sulphate	2.70
Magnesium sulphate	2.56
Manganese sulphate	1.67
Ammonium molybdate	0.38

addition to N, P and K. Therefore micronutrient support is essential to achieve better crop yield and quality of crops.

MATERIALS AND METHODS

An 100%WSF with five micronutrients (15-15-15-2.8S with 0.5%Zn,0.5%Mn,0.5%Fe, 0.5%Mg, 0.2%Mo) was made and checked. The raw materials used are given in Table 2.

The above raw materials were analyzed by using Fertilizer control order(FCO) methods and accordingly final product formulation was

Table 6. Nutrients content

Test parameter	Specification	Trail-1	Trail-2	Reference method
Total Nitrogen per cent by weight	>15	15.2	15.2	FCO 1985
Nitrate nitrogen per cent by weight	>4.2	4.22	4.3	FCO 1985
Ammonical nitrogen per cent by weight	>5.7	5.75	5.7	segmented flow analysis
Urea Nitrogen percent by weight	<5.1	5.2	5.2	segmented flow analysis
Water Soluble phosphate(as P ₂ O ₅) per cent by weight	>15	15	15.1	segmented flow analysis
Water soluble potash (as K ₂ O) per cent by weight	>15	15.1	15	FCO 1985
Sulphate sulphur (as S) percent by weight	>2.8	2.85	2.9	FCO 1985
Zinc as Zn per cent by weight	>0.5	0.51	0.53	Journal of AOAC
Iron as Fe per cent by weight	>0.5	0.54	0.52	Journal of AOAC
Magnesium as Mg per cent by weight	>0.5	0.53	0.5	Journal of AOAC
manganese as Mn per cent by weight	>0.5	0.5	0.51	Journal of AOAC
Molybdenum as Mo per cent by weight	0.2-0.3	0.22	0.2	AOAC

prepared. Calibrations were done to all instruments used (given in table 4) for the analysis. All solutions were standardized as per FCO. Each parameter analyzed twice to conform the contents and average was taken as final result given in table 3.

Preparation of proposed grade fertilizer

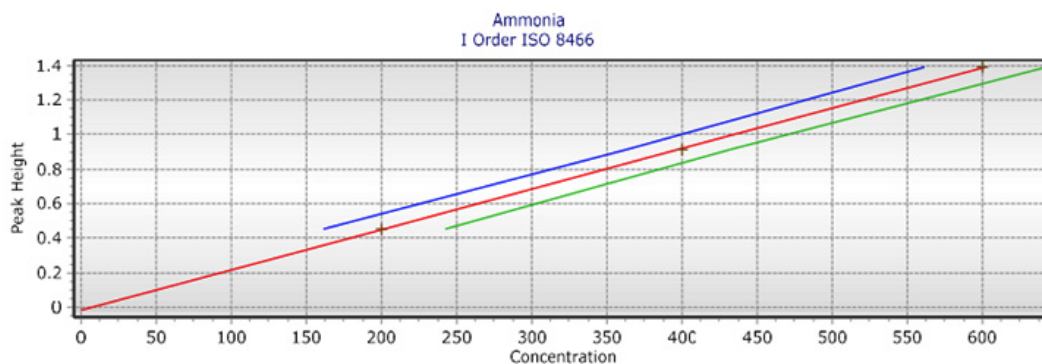
All the raw materials are grounded to fine powder individually and dried. After drying the materials are stored in polythene bottles to avoid

moisture penetration. Triplicate mixtures were prepared by taking the weights of components as mentioned in table 5.

The above quantities are mixed properly and grounded finely in the mixer @ 8000rpm. Prepared mixtures are dried to remove surface moisture gained in the preparation. Nitrogen-Phosphorous-Potassium with five micronutrient fertilizer product was revealed in figure 1.

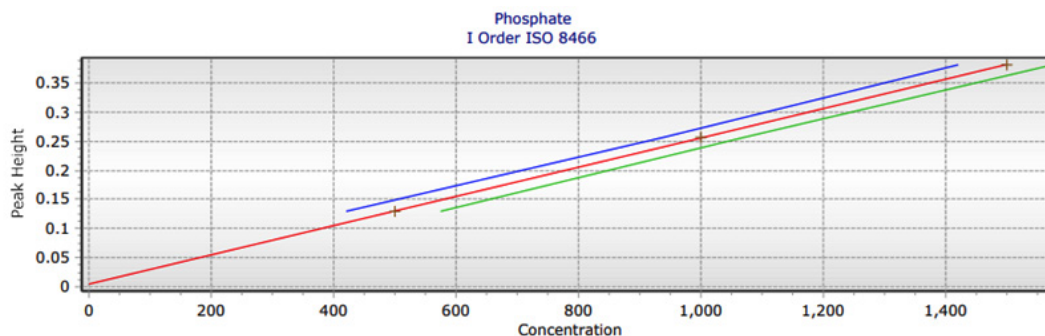
Table 7. Impurities

Test parameter	Specification	Trail-1	Trail-2	Reference method
Arsenic as As, ppm by weight	<100	5	4	Journal of AOAC
Lead as pb, ppm by weight	<30	1	<1	Journal of AOAC
Cadmium as Cd, ppm by weight	<25	<1	<1	Journal of AOAC
Total chlorides as Cl per cent by weight	<1.5	0.26	0.28	FCO 1985
Sodium as NaCl per cent by weight	<0.5	0.12	0.12	FCO 1985
Matter insoluble in water per cent by weight	<0.5	0.21	0.214	FCO 1985



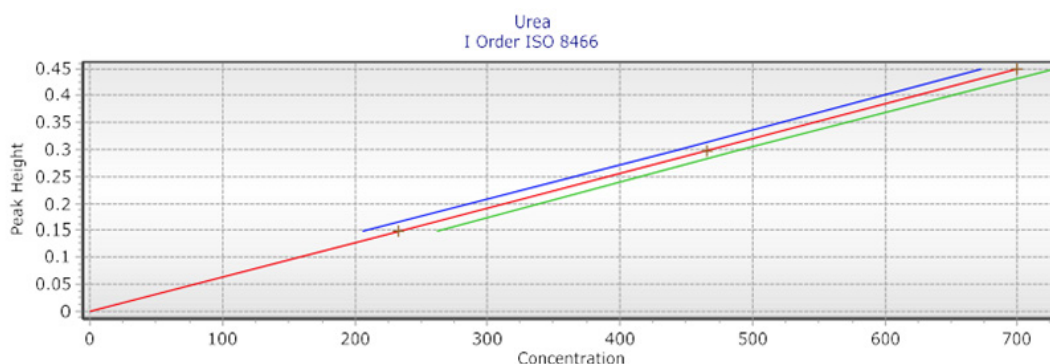
$a = -0.015655333333333$ $b = 0.00233425000000$ $RSD = 0.00551196301995$
 $r = 0.99993030807407$ $R^2 = 0.99986062100510$ $Determination\ Limit = 53.6458792086351$

Fig. 2. Ammonical Nitrogen Calibration graph on auto analyser



$a = 0.0047273333333333$ $b = 0.00025164650000$ $RSD = 0.00113940075625$
 $r = 0.99995900088291$ $R^2 = 0.99991800344675$ $Determination\ Limit = 103.741148587397$

Fig. 3. Phosphate Calibration graph on auto analyser



$a = -0.00098600000000$ $b = 0.00064301287554$ $RSD = 0.00103057023050$
 $r = 0.99997634305835$ $R^2 = 0.99995268667635$ $Determination\ Limit = 36.9704560821373$

Fig. 4. Urea Nitrogen Calibration graph on auto analyser

Table 8. Physical properties of the proposed Nitrogen-Phosphorous-Potassium fertilizer with and without micronutrients

Parameter	N-P-K fertilizer without micronutrients			N-P-K fertilizer with micronutrients			Specification
	Trial-1	Trial-2	Average	Trial-1	Trial-2	Average	
Moisture per cent by weight	0.68	0.61	0.64	0.35	0.42	0.385	FCO 1985
pH of 5% solution	3.9	3.4	3.65	4.6	4.7	4.65	FCO 1985
Conductivity , ms/cm	13.8	14.3	14.05	15.5	15.8	15.65	FCO 1985
%Critical relative humidity	81	77	79	68	70	69	IFDC

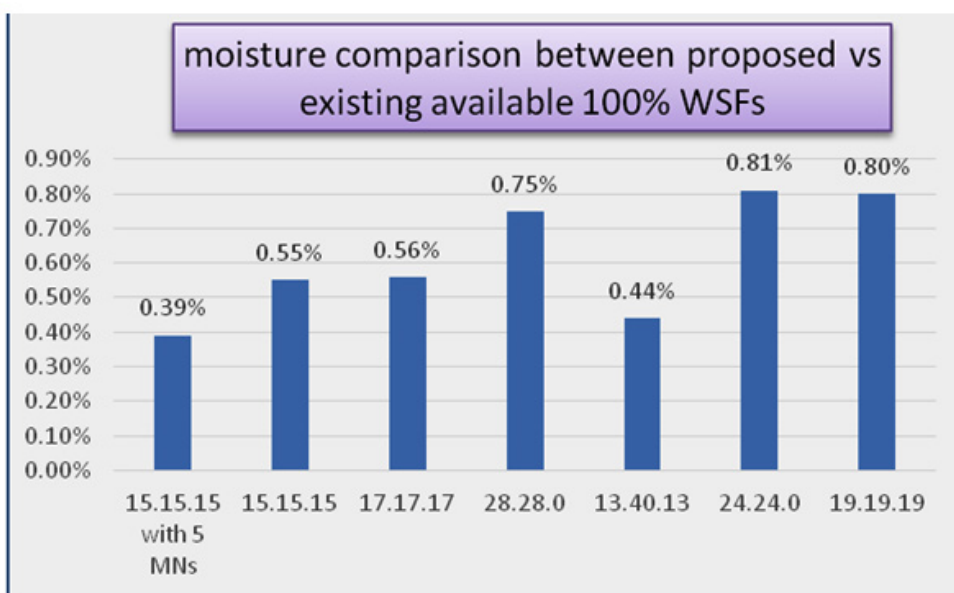


Fig. 5. Moisture comparison between proposed vs existing available 100% WSFs

RESULTS AND DISCUSSION

The final product samples were analysed, and results were given in the table 6 and 7. The calibration graphs of flow analyzer, auto analyzer for Ammonical Nitrogen, Phosphate and Urea Nitrogen were shown in figures 2-4. Study on the determination of physical properties of the proposed Nitrogen-Phosphorous-Potassium

fertilizer with and without micronutrients were given in table 8. From this comparison it reveals that the proposed fertilizer has superior physical properties

Determination of physical properties
Moisture

Moisture is the major problem for the fertilizer manufacturing process. Fertilizers with

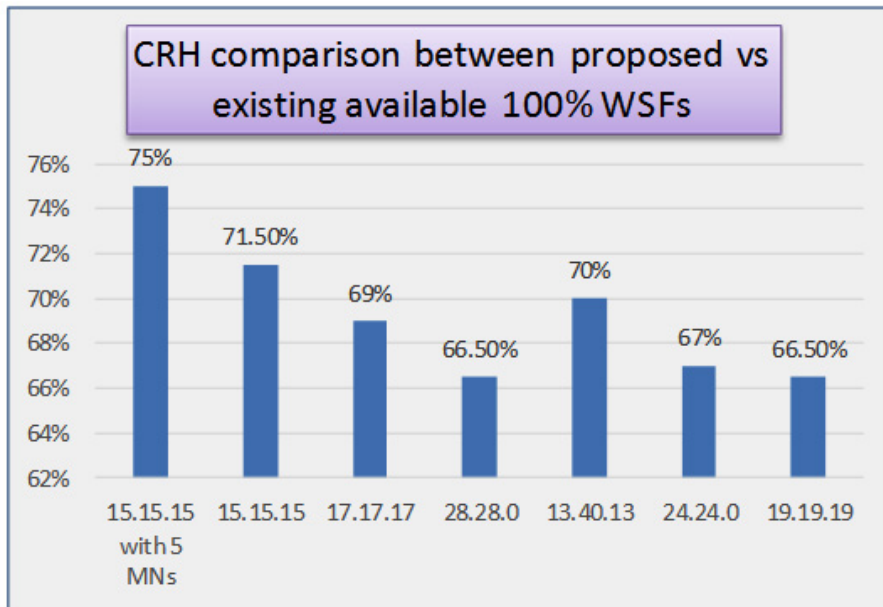


Fig. 6. CRH comparison between proposed vs existing available 100% WSFs

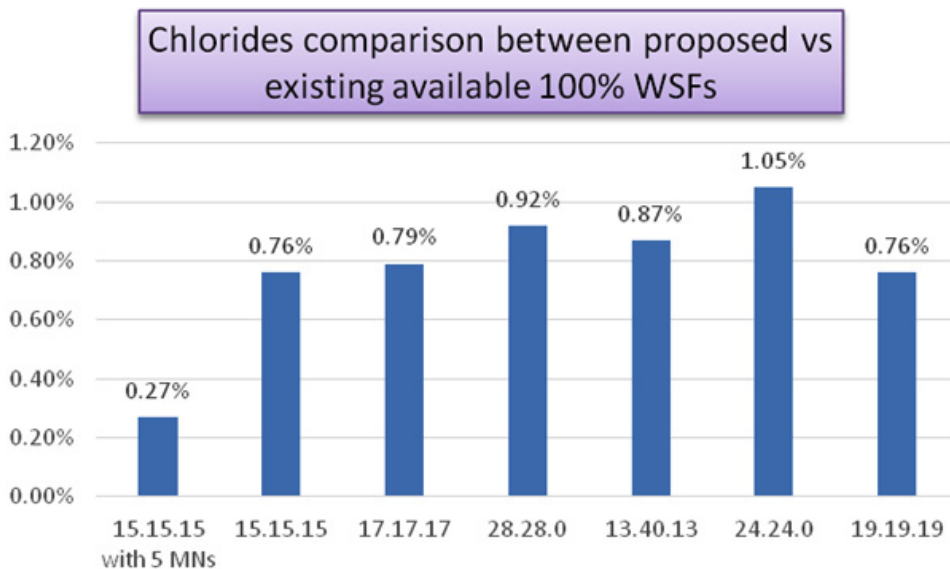


Fig. 7. Chlorides comparison between proposed vs existing available 100% WSFs

higher concentrations of nutrients tends to absorb moisture most readily. Moisture absorption possibility may be in the process, packing and storage. it leads to caking, lumps formation, reduction in flowability, generation of ammonia fumes by the decomposition of urea based fertilisers. in the proposed fertilizer moisture content is very less compared with existing available reputed products like 28-28-0 and 19-19-19.

Critical relative humidity(CRH)

Each fertiliser has a CRH and at this point the fertilizer starts absorbing moisture from the atmosphere which leads to caking phenomena. so if the material having higher CRH , then it forms less caking. Caking can cause safety concerns due to formation of hard and big lumps. uniform application is not possible due to formation of caking and lumps. In the proposed fertiliser CRH value is high when compared with existing products available in the markets-28-28-0 and 19-19-19. moisture absorption was reduced by the addition of anhydrous MgSO₄.

Chloride toxicity in plant includes necrosis of leaf margins and tips, which typically occur in old leaf. Leaf drop was observed when excessive leaf burns. The presence of Cl in the soil also reduces the ability of the plants to take up water and this results in leaf burn or drying of leaf tissues. generally leaf tips affected first and then severity increase along the leaf . higher chloride content in either soil or fertiliser leads to less crop yield. proposed fertilizer chloride content is less than fertilizers available in the market.

CONCLUSIONS

Micronutrient support is very essential for balanced crop nutrition. Minute quantities of micronutrients are required for better physiology of plant kingdom. Significant plant functions are restricted if micronutrients are unavailable, resulting in plant abnormalities, reduced growth and lower yield Nitrogen-Phosphorous-Potassium fertilizer fortified with five-micronutrient matrix and it is very important for achieving the optimal Plant growth. The proposed fertilizer with five micronutrient support revealed enhanced physical properties when compared to normal grade fertilizer.

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Conflict of Interest

The authors declare the no conflicts of interest

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