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Nutrient content, uptake of emmer wheat (*Triticum dicoccum* L.) and available nutrients as influenced by different precision nitrogen management practices

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Abstract

Present investigation was undertaken at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad during *rabi* season of two consecutive years (2020-21 and 2021-22) to evaluate the nutrient content, uptake of emmer wheat (*Triticum dicoccum* L.) and available nutrients as influenced by different precision nitrogen management practices. The experiment was replicated thrice in RCBD with thirteen treatments for precision nitrogen management (Control, N-omission, RDN, LCC, SSNM, STCR and NE) in emmer wheat. On the basis of two year pooled results, significantly higher nitrogen (2.21, 0.66% and 114.69, 52.42 kg ha^{-1}, respectively), phosphorus (0.37, 0.20% and 19.25, 15.49 kg ha^{-1}, respectively) and potassium (0.52, 1.36% and 26.79, 107.59 kg ha^{-1}, respectively) content and uptake in grain and straw was observed in STCR based nitrogen management for targeted yield of 6.0 t ha^{-1} over absolute control. Thus, use of different precision nitrogen management practices for nitrogen nutrition is beneficial over absolute control and RDN in terms of nutrient content and uptake in grain and straw of emmer wheat. Significantly higher available nitrogen was reported in STCR based nitrogen management for targeted yield of 6.0 t ha^{-1} (293.1 kg ha^{-1}), phosphorus and potassium in absolute control (36.4 and 272.6 kg ha^{-1}, respectively).

Keywords: Soil test crop response (STCR), Site specific nutrient management (SSNM), emmer wheat, precision nitrogen management

Introduction

India has achieved remarkable progress in wheat production during the last four decades and is continue to be second largest wheat producing nation in the world. It is the second most important staple food and meets about 61 per cent of the protein requirement of the Indian population. Among the wheat, dicoccum wheat cultivation is unique in peninsular zone. It is nutritionally rich because of presence of higher protein content, more dietary fibre, resistant starch and high therapeutic value. Natural resource depletion and biotic-abiotic stresses, the multiple nutrient deficiencies are the key factors that contribute not only to yield plateaus but also to declining factor productivity, shrinking profits and environmental footprints. Existing fertilizer recommendations for wheat are mostly blanket application which often consists of predetermined rates of nitrogen (N), phosphorus (P) and potassium (K) for vast areas. Such recommendations assume that the need of a cereal crop like wheat for nutrients is constant over time and over large areas. Among the major nutrients, nitrogen is the most critical nutrient element in crop production. It is vital for maintaining and improving crop growth, yield and quality. The nitrogen demand of crop is met from native soil nitrogen supply and mineral fertilizer nitrogen application, where fertilizer N fills the gap between crop demand and native soil N supplies (Koyama, 1981) [8]. Multiple split applications of mineral nitrogenous fertilizers can reduce N losses (Datta and Buresh, 1989) [1]. Efficient use of N fertilizer is, therefore, important for economical crop production and also for ground and surface water quality. Insufficient N levels reduce profit and yield, while excessive N can pollute surface and ground water. Blanket fertilizer recommendations over large areas are not efficient because indigenous nutrient supply varies widely (Dobermann and White, 1999) [3]. Wheat crop also requires different amounts of nutrients for targeted yield in different fields, depending on native nutrient supply and demand. Farmers will benefit significantly if they can adjust N inputs to actual crop conditions and nutrient requirements.

Nutrient management is a major component in it's production management system. Knowing or applying the required quantities of nutrients for all stages of growth and understanding the soil ability to supply those nutrients is critical in profitable crop production.

Use of different precision nitrogen management practices for applying nutrients in required quantity for achieving desired yield from that particular location. Among the several aspects of soil test based nutrient management approaches, the site specific nutrient management (SSNM) and soil test crop response (STCR) are cost effective and plant need based approaches. The SSNM and STCR approach provide principles and tools for supplying crop nutrients as and when needed to achieve higher yield. The SSNM and STCR approach not specifically aim to either reduce or increase fertilizer use. Instead, they aim to apply nutrients at optimal rates and time to achieve higher yield and high efficiency of nutrient use by the crop, leading to more net returns per unit of fertilizer invested (Shankar and Umesh, 2008) [15]. Nutrient Expert (NE) is designed to help crop advisors to develop fertilizer recommendations best suited to a farmers field. It uses a systematic approach of capturing information, which is important for developing a location-specific recommendation. Along with the sustained remunerative yield, efficiency of fertilizer used is also need to be maintained for better soil fertility. In view of these facts, the present investigation aim to analyse the uptake and availability of nutrients after the harvest of emmer wheat through precise nitrogen management practices.

Material and Methods

A field experiment was carried out on “Nutrient content, uptake of emmer wheat (*Triticum dicoccum* L.) and available nutrients as influenced by precision nitrogen management practices” at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, Karnataka, during *rabi* 2020-21 and 2021-22. The soils of the experimental site was black clayey in texture, alkaline in pH (7.76) with normal in electrical conductivity (0.28 dS m^{-1}), low in organic carbon content (0.45%), low in available nitrogen (257 kg ha^{-1}), high in available phosphorous (32.6 kg ha^{-1}) and potassium (348 kg ha^{-1}). The treatments consist of precision nitrogen management practices *viz*., T_1: N omission (N-0), T_2: Recommended dose of N as per package of practices, T_3: Nitrogen management through SSNM for targeted yield of 4.0 t ha^{-1}, T_4: Nitrogen management through SSNM for targeted yield of 5.0 t ha^{-1}, T_5: Nitrogen management through SSNM for targeted yield of 6.0 t ha^{-1}, T_6: STCR based N management for targeted yield of 4.0 t ha^{-1}, T_7: STCR based N management for targeted yield of 5.0 t ha^{-1}, T_8: STCR based N management for targeted yield of 6.0 t ha^{-1}, T_9: Nitrogen management through nutrient expert for targeted yield of 4.0 t ha^{-1}, T_{10}: Nitrogen management through nutrient expert for targeted yield of 5.0 t ha^{-1}, T_{11}: Nitrogen management through nutrient expert for targeted yield of 6.0 t ha^{-1}, T_{12}: 30 kg N ha^{-1} Basal + LCC ≤ 5 + 20 kg N ha^{-1}, T_{13}: Absolute control and replicated three times in randomized block design. An emmer wheat variety “DDK 1029” was used for the study. The recommended dose of fertilizers for emmer wheat is 60-30-20 kg N-P_2O_5-K_2O ha^{-1} and FYM 7.5 t ha^{-1}. Nitrogen was applied as per the treatments (Table 1), recommended dose of phosphorus, potassium and farm yard manure were applied at the time of sowing. Uptake of nitrogen, phosphorus and potassium in grain and straw was estimated using standard procedure given by Jackson (1967) [6].

Nutrient uptake by wheat

The uptake of nutrients by different parts of wheat was worked out by multiplying the nutrient content in seed and straw yield of the plant using the following formula;

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration in grain (\%) X Grain yield (kg ha}^{-1}\text{)}}{100} + \frac{\text{Nutrient concentration in Straw (\%) X Straw yield (kg ha}^{-1}\text{)}}{100}$$

Soil samples were collected before sowing and after harvest from individual plots of experiment by taking slice of soil from the depth of 0-30 cm. Soil samples were shade dried, powdered using wooden pestle and mortar and sieved through 2 mm sieve and chemically analysed to estimate soil reaction (pH), EC (dS m^{-1}), organic carbon (OC%), available soil nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O). Data recorded from the experiments were analysed using Analysis of Variance (ANOVA) and mean comparisons were performed based on Duncan’s multiple range test (DMRT) at 5% probability level to separate treatment means.

Table 1: The total amount of nitrogen (kg ha^{-1}) applied in different treatments

Treatments	Basal		Top dressing						Total N	
			2020-21			2021-22				
	2020	2021	1st (20-25 DAS)	2nd (35-40 DAS)	3rd (50-55 DAS)	1st (20-25 DAS)	2nd (35-40 DAS)	3rd (50-55 DAS)	2020	2021
T_1	-	-	-	-	-	-	-	-	-	-
T_2	30	30	30 (30 DAS)	0	0	30 (30 DAS)	0	0	60	60
T_3	29	29	29	29	29	29	29	29	116	116
T_4	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	146	146
T_5	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	175	175
T_6	28	26	28	28	28	26	26	26	112	104
T_7	46.7	45	46.7	46.7	46.7	45	45	45	187	179
T_8	65.5	64	65.5	65.5	65.5	64	64	64	262	254
T_9	31.7	31.7	31.7	31.7	0	31.7	31.7	0	95	95
T_{10}	36.6	36.6	36.6	36.6	0	36.6	36.6	0	110	110
T_{11}	41.7	41.7	41.7	41.7	0	41.7	41.7	0	125	125
T_{12}	30	30	20	20	20	20	20	20	90	90
T_{13}	-	-	-	-	-	-	-	-	-	-

Results and Discussion

Nutrient content in grain, straw and total nutrient content in emmer wheat: The average pooled data pertaining to nutrient content in grain, straw and total nutrient content was indicated in Table 2. Significantly higher nitrogen content in grain, straw and total (2.21, 0.66 and 2.87%, respectively), phosphorus content in grain, straw and total (0.37, 0.20 and 0.57%, respectively) and potassium content in grain, straw and total (0.52, 1.36 and 1.87%, respectively) was recorded in nitrogen management through STCR for targeted yield of 6.0 t ha^{-1}. Potassium content in straw was found to be non significant among the treatments. Significantly lower total nitrogen, phosphorus and potassium content was observed in absolute control (1.95, 0.40 and 1.63%, respectively).

Nutrient uptake in grain, straw and total nutrient uptake in emmer wheat: Pooled analysis showed that the nitrogen uptake in grain, straw and total (114.69, 52.42 and 167.10 kg ha^{-1}, respectively), phosphorus uptake in grain, straw and total (19.25, 15.49 and 34.74 kg ha^{-1}, respectively) and potassium uptake in grain, straw and total (26.79, 107.59 and 134.38 kg ha^{-1}, respectively) was significantly higher with nitrogen management through STCR for targeted yield of 6.0 t ha^{-1} and found on par with nitrogen management through STCR for targeted yield of 5.0 t ha^{-1} and SSNM for targeted yield of 6.0 t ha^{-1} (Table 3 and Fig. 1, 2 and 3). Significantly lower total nitrogen, phosphorus and potassium uptake was noticed in absolute control (42.24, 9.52 and 55.25 kg ha^{-1}, respectively).

The results presented in (Table 2 and 3) were revealed that nutrient content and uptake of emmer wheat was significantly influenced by different precision nitrogen management practices. The increase in grain and straw yield due to increased uptake of nutrients. Application of higher quantity of nitrogen for STCR 6.0 t ha^{-1} targeted yield resulted in higher uptake of nutrients. The increased N uptake treatment was due to better timing and splitting of fertilizer N application during the season led to increased and uniform availability of total N throughout the growth period, which resulted in enhanced biomass and led to higher N, P and K accumulation in plants. The uptake of nutrients usually follows the yield pattern of the amount of nutrient uptake per unit amount of biomass production determine the yields, since the essential nutrients are involved in the metabolism of the plants. The increase in phosphorus uptake was due to substantial increase in available phosphorus in the soil. This was due to more availability of phosphorus with higher doses and deep penetration of roots must have facilitated in absorbing higher amount of nutrients from the rhizosphere. Potassium uptake by emmer wheat was also increased significantly due to more availability of potassium for plant uptake. Lower content and uptake of N, P and K was observed in absolute control on account of inadequate supply and availability of nutrients. Similar results are reported by Wuest and Cassman (1992) [16], Khurana *et al.* (2008) [7], Mohanty *et al.* (2016) [11], Kulkarni (2008) [9], Dineshkumar (2011) [2] and Nikhil Kumar (2019) [12].

Table 2: Nitrogen, phosphorus and potassium content (%) of emmer wheat as influenced by precision nitrogen management practices

Treatments	N content (%)			P content (%)			K content (%)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	1.67^{d}	0.37^{f}	2.04^{g}	0.31^{de}	0.14^{ef}	0.45^{ef}	0.43^{ef}	1.27^{bc}	1.69^{cd}
T_2	1.84^{c}	0.43^{e}	2.27^{f}	0.32^{cd}	0.15^{de}	0.47^{de}	0.44^{d-f}	1.29^{a-c}	1.72^{b-d}
T_3	2.09^{ab}	0.51^{de}	2.60^{c-e}	0.34^{a-d}	0.17^{b-d}	0.51^{cd}	0.47^{b-e}	1.31^{a-c}	1.78^{a-c}
T_4	2.15^{ab}	0.54^{b-d}	2.69^{b-d}	0.35^{a-c}	0.18^{a-c}	0.53^{a-c}	0.49^{a-c}	1.33^{a-c}	1.82^{a-c}
T_5	2.18^{a}	0.58^{a-c}	2.76^{a-c}	0.36^{ab}	0.19^{ab}	0.55^{ab}	0.51^{ab}	1.35^{ab}	1.85^{ab}
T_6	2.07^{ab}	0.50^{de}	2.57^{de}	0.33^{b-d}	0.17^{b-d}	0.50^{c-e}	0.46^{c-e}	1.31^{a-c}	1.77^{a-d}
T_7	2.19^{a}	0.60^{ab}	2.79^{ab}	0.37^{a}	0.20^{a}	0.57^{a}	0.51^{ab}	1.35^{ab}	1.85^{ab}
T_8	2.21^{a}	0.66^{a}	2.87^{a}	0.37^{a}	0.20^{a}	0.57^{a}	0.52^{a}	1.36^{a}	1.87^{a}
T_9	2.00^{b}	0.47^{de}	2.47^{ef}	0.33^{b-d}	0.15^{de}	0.47^{de}	0.45^{c-e}	1.30^{a-c}	1.74^{a-d}
T_{10}	2.06^{ab}	0.49^{de}	2.55^{de}	0.34^{a-d}	0.16^{c-e}	0.49^{c-e}	0.46^{c-e}	1.31^{a-c}	1.77^{a-d}
T_{11}	2.12^{ab}	0.53^{cd}	2.65^{b-d}	0.35^{a-c}	0.18^{a-c}	0.52^{a-d}	0.48^{a-d}	1.32^{a-c}	1.79^{a-c}
T_{12}	2.05^{ab}	0.48^{de}	2.53^{ef}	0.33^{b-d}	0.15^{de}	0.47^{de}	0.45^{c-e}	1.30^{a-c}	1.74^{a-d}
T_{13}	1.61^{d}	0.35^{f}	1.95^{g}	0.28^{e}	0.12^{f}	0.40^{g}	0.40^{f}	1.23^{c}	1.63^{d}
S.Em±	0.05	0.02	0.06	0.01	0.01	0.02	0.01	0.03	0.04

Table 3: Nitrogen, phosphorus and potassium uptake (kg ha^{-1}) of emmer wheat as influenced by precision nitrogen management practices.

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	37.62^{f}	17.04^{g}	54.66^{g}	6.99^{e}	6.22^{f}	13.21^{g}	9.57^{f}	58.23^{f}	67.80^{f}
T_2	66.12^{e}	27.72^{f}	93.83^{f}	11.53^{d}	9.34^{e}	20.88^{f}	15.67^{e}	82.78^{e}	98.45^{e}
T_3	91.46^{cd}	36.69^{d}	128.14^{de}	14.88^{cd}	11.87^{cd}	26.75^{c-e}	20.57^{cd}	94.20^{cd}	114.77^{cd}
T_4	101.26^{b}	40.41^{c}	141.68^{bc}	16.53^{bc}	13.10^{bc}	29.62^{bc}	22.90^{b}	99.51^{bc}	122.40^{bc}
T_5	109.74^{a}	44.23^{ab}	153.97^{ab}	18.13^{ab}	14.61^{ab}	32.74^{ab}	25.42^{a}	103.45^{ab}	128.87^{ab}
T_6	89.84^{cd}	35.36^{de}	125.20^{de}	14.32^{cd}	11.78^{cd}	26.11^{de}	19.96^{cd}	93.19^{cd}	113.15^{cd}
T_7	112.24^{a}	46.28^{ab}	158.52^{a}	18.97^{a}	15.17^{a}	34.13^{a}	25.88^{a}	104.60^{ab}	130.48^{ab}
T_8	114.69^{a}	52.42^{a}	167.10^{a}	19.25^{a}	15.49^{a}	34.74^{a}	26.79^{a}	107.59^{a}	134.38^{a}
T_9	84.72^{d}	32.49^{e}	117.21^{e}	13.80^{cd}	10.02^{e}	23.82^{ef}	18.90^{d}	89.50^{de}	108.40^{de}
T_{10}	89.62^{cd}	34.94^{de}	124.56^{de}	14.57^{cd}	11.05^{de}	25.63^{de}	20.01^{cd}	93.05^{cd}	113.06^{cd}
T_{11}	96.06^{bc}	38.33^{cd}	134.39^{cd}	15.63^{bc}	12.78^{cd}	28.41^{cd}	21.52^{bc}	95.98^{b-d}	117.50^{cd}
T_{12}	87.25^{d}	33.26^{e}	120.51^{de}	13.38^{de}	10.05^{e}	23.88^{ef}	18.94^{d}	89.71^{de}	108.65^{de}
T_{13}	28.71^{g}	13.53^{g}	42.24^{g}	5.01^{f}	4.51^{f}	9.52^{g}	7.07^{g}	48.18^{g}	55.25^{g}
S.Em±	2.15	1.16	4.37	0.75	0.56	1.11	0.65	2.84	3.49

Soil chemical properties and available nutrient status in soil: Among the different precision nitrogen management practices soil pH and organic carbon content in soil after harvest of emmer wheat was found to be non significant (Table 4). However, the pH varied from 7.70 to 7.76 and organic carbon varied from 0.46 to 0.50 per cent among the treatments. Electrical conductivity was significantly higher with nitrogen management through STCR for targeted yield of 6.0 t ha^{-1} (0.38 dS m^{-1}). The increased electrical conductivity had been reported due to the addition of soluble salts through the application of fertilizers (Prakasha, 2018) [13]. Available nitrogen in soil differed significantly due to precision nitrogen management practices. STCR based nitrogen management for targeted yield of 6.0 t ha^{-1} (293.1 kg ha^{-1}) has recorded significantly higher available nitrogen followed by nitrogen management through STCR for targeted yield of 5.0 t ha^{-1} (254.7 kg ha^{-1}) and SSNM for targeted yield of 6.0 t ha^{-1} (241.9 kg ha^{-1}) due to application of more quantity of nitrogen through STCR and SSNM to achieve target yields. Results were in conformity with Harikrishna *et al*. (2005) [5]. However, significantly lower available nitrogen noticed in N omission (173.2 kg ha^{-1}) followed by absolute control (178.3 kg ha^{-1}).

Precision nitrogen management practices influenced the available phosphorous significantly. Comparable and significantly higher available phosphorus was recorded in N omission and RDN (36.4 and 35.7 kg ha^{-1}, respectively). Whereas, significantly lower available phosphorus was observed in absolute control (15.8 kg ha^{-1}). Treatment receiving N omission and absolute control has significantly recorded higher available potassium (272.6 and 263.2 kg ha^{-1}, respectively). However, significantly lower available potassium was noticed in nitrogen management through STCR for targeted yield of 6.0 t ha^{-1} (199.7 kg ha^{-1}) and it was followed by nitrogen management through STCR for targeted yield of 5.0 t ha^{-1} and SSNM for targeted yield of 6.0 t ha^{-1} (206.9 and 209.4 kg ha^{-1}, respectively). This is attributed to higher initial available phosphorus and potassium and lower utilization of nutrients. Whereas, the lower availability of phosphorus and potassium in precision application method plots after harvest of emmer wheat was mainly due to more uptake of phosphorus and potassium. This was clearly indicated in the studies of Rekhi *et al*. (2000) [14], Mahala *et al*. (2006) [10], Goudra (2018) [4] and Prakasha (2018) [13].

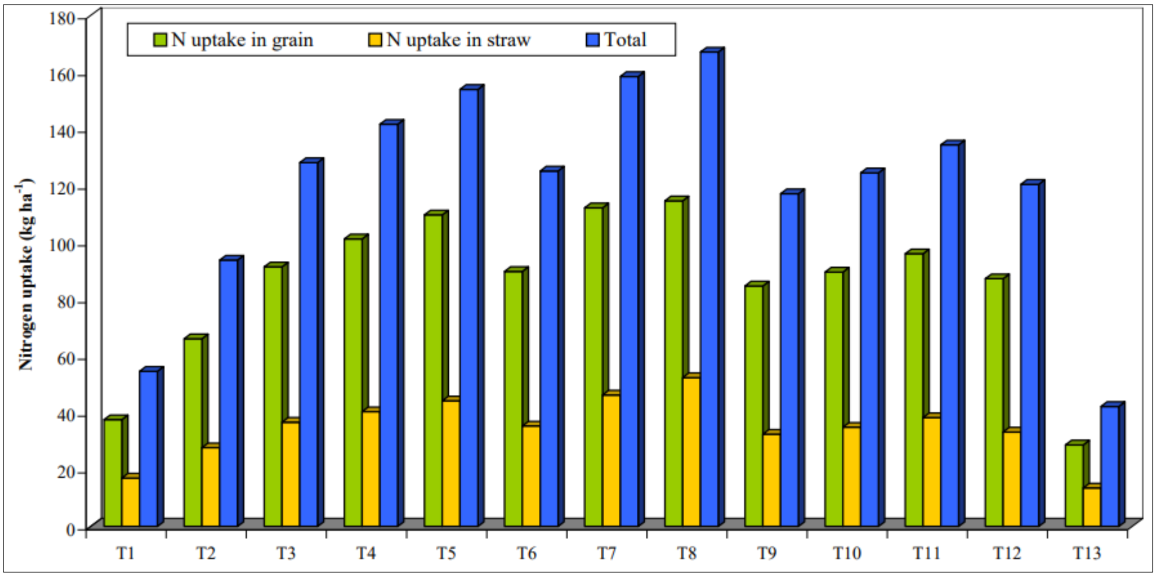

Fig 1: Nitrogen uptake in grain, straw and total uptake in emmer wheat

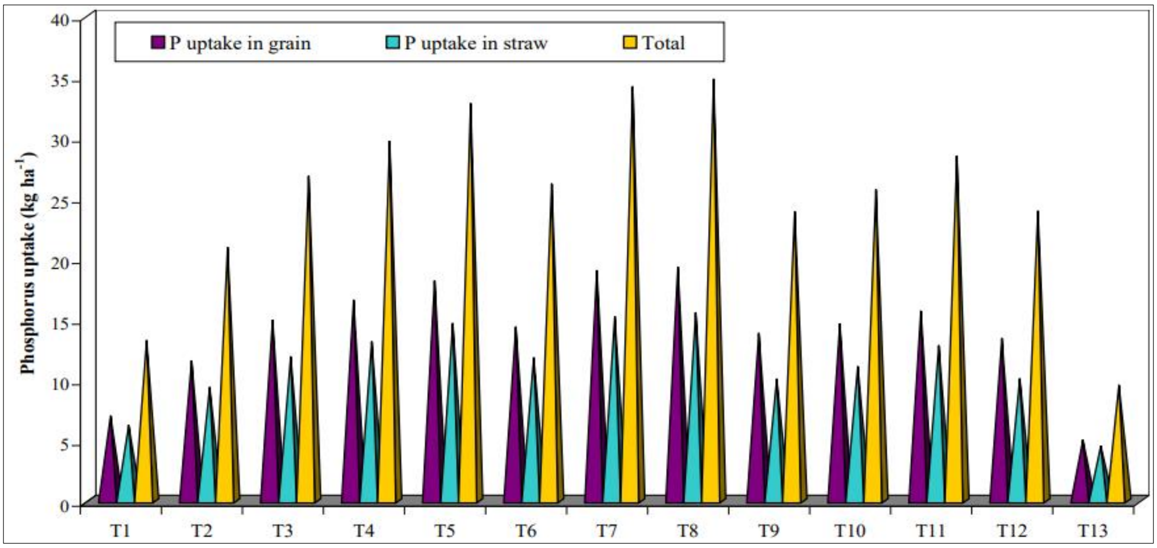

Fig 2: Phosphorus uptake in grain, straw and total uptake in emmer wheat

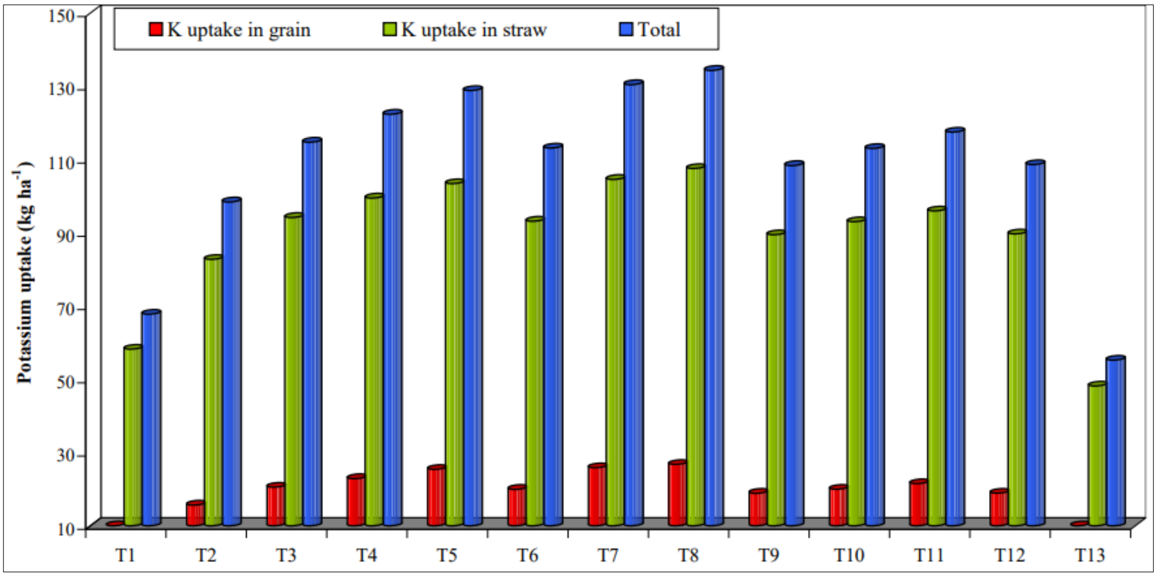

Fig 3: Potassium uptake in grain, straw and total uptake in emmer wheat

Table 4: Soil chemical properties and available nutrient status in soil after harvest of emmer wheat.

Treatments	pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	7.76^{a}	0.31^{de}	0.47^{a}	173.2^{g}	36.4^{a}	272.6^{a}
T_2	7.75^{a}	0.33^{cd}	0.47^{a}	183.9^{fg}	35.7^{a}	243.4^{b}
T_3	7.73^{a}	0.36^{a-c}	0.48^{a}	212.3^{cd}	27.2^{d}	225.3^{b-f}
T_4	7.72^{a}	0.37^{ab}	0.49^{a}	223.2^{c}	26.3^{de}	217.3^{c-h}
T_5	7.71^{a}	0.37^{ab}	0.49^{a}	241.9^{b}	25.7^{de}	209.4^{d-h}
T_6	7.74^{a}	0.36^{a-c}	0.48^{a}	207.4^{c-e}	29.6^{c}	228.0^{b-d}
T_7	7.71^{a}	0.37^{ab}	0.49^{a}	254.7^{b}	25.6^{de}	206.9^{gh}
T_8	7.70^{a}	0.38^{a}	0.50^{a}	293.1^{a}	24.7^{e}	199.7^{h}
T_9	7.74^{a}	0.35^{a-c}	0.48^{a}	201.5^{de}	33.5^{b}	233.4^{bc}
T_{10}	7.73^{a}	0.35^{a-c}	0.48^{a}	210.6^{c-e}	30.3^{c}	228.0^{b-e}
T_{11}	7.72^{a}	0.36^{a-c}	0.49^{a}	215.8^{cd}	26.9^{de}	221.7^{c-g}
T_{12}	7.74^{a}	0.34^{b-d}	0.48^{a}	194.4^{ef}	33.4^{b}	233.8^{bc}
T_{13}	7.76^{a}	0.29^{e}	0.46^{a}	178.3^{fg}	15.8^{f}	263.2^{a}
S.Em±	0.24	0.01	0.01	5.2	0.7	5.7

Conclusion

Based on the findings of two year pooled data, it can be concluded that balanced application of nutrients in emmer wheat can be efficiently practiced with precision nitrogen management practices. Nitrogen application through STCR for targeted yield of 6.0 t ha^{-1} had significantly influenced on the nitrogen, phosphorus and potassium content and uptake in grain and straw and also improvement in soil fertility as compared to without fertilizer application.

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