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RESEARCH PAPER

Grain quality of emmer wheat (*Triticum dicoccum* L.) as influenced by precision nitrogen management practices

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Abstract: A field experiment was conducted during *rabi* season of 2020-21 and 2021-22 to find out the effect of different precision nitrogen management practices on the quality of emmer wheat at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, on black clay soil conditions. The experiment was replicated thrice in RCBD with thirteen treatments for precision nitrogen management (Control, N-omission, RDN, LCC, SSNM, STCR andNutrient Expert) in emmer wheat. The results revealed that application of nitrogen through STCR for targeted yield of 6.0 t ha^{-1} recorded significantly maximum grain yield (5201 kg ha^{-1}), nitrogen content in grain (2.21%), straw (0.66%) and nitrogen uptake in grain (114.69 kg ha^{-1}) and straw (52.42 kg ha^{-1}) in pooled analysis. The quality parameters of emmer wheat were significantly influenced by different precision nitrogen management practices, the maximum crude protein (12.57%), sedimentation value (32.31 ml) and β-Carotenecontent (4.86 ppm) in grain was noticed in nitrogen management through STCRfor targeted yield of 6.0 t ha^{-1} over absolute control (9.15%, 20.98 ml and 3.52 ppm, respectively) and N- omission (9.52%, 22.68 ml and 3.72 ppm, respectively). There was 65 per cent increase in grain yield in STCR for targeted yield of 6.0 t ha^{-1} over absolute control. The near perfect linear relationship of grain yield withgrain crude protein content (R^2=0.9737), sedimentation value (R^2=0.8967) and yellow pigment (R^2=0.9589) was suggested that higher grain yield with better quality of wheat grains.

Key words: β-Carotene, Crude protein, Emmer wheat, Nitrogen, Sedimentation value

Introduction

Wheat is the second most important staple crop in the world after rice and India is the major wheat producing country in the world. A member of wheat family, emmer wheat (*Triticum dicoccum* L.) is an annual grass and it is reported to be grown on a very restricted scale in Gujarat, Maharashtra and Karnataka, where it is known under the names *Popathiya*, *Khapli*, and *Samba*, respectively. Emmer wheat is tetraploid wheat derived from the intersections of the wild species of *Triticum dicoccoides* and *Triticum durum* (Pagnotta *et al*., 2005). In general emmer wheat varieties are rich source of protein and complex carbohydrate (dietary fibre) compared to bread wheat (Zaharieva *et al*., 2010). It possesses excellent grain quality traits and is rich source of dietary fibres of more than 16 per cent, protein (11.8 to 15.3%) and total carbohydrates (78.7 to 83.2%). The traditional products of emmer wheat varieties have better taste, texture and flavour. In the changing scenario both consumers and processors are becoming quality conscious and at global level, the quality of wheat plays an important role. The low glycaemic index value of emmer wheat makes it particularly suitable for diabetes (Buvaneshwari *et al*., 2003) and because of its richness in minerals, fibre and poor in fats it is recommended in the diet of people suffering from allergies and high blood cholesterol (Barcaccia *et al.*, 2002).

Among the various agronomic manipulations, nutrient management practices plays an important role in influencing the quality (grain protein content, beta carotene content and sedimentation value) and grain yield of wheat. The quality of wheat, flour and also the quality of the cereal products are mainly dependent on the protein composition. Wheat protein content depends on multiple genes interacting with environmental factors, such as nitrogen availability, water, and temperature. Various essential nutrients play pivotal role in maintaining the quality of grains. Nitrogen is generally the most limiting nutrient factor for wheat production by influencing on chlorophyll production, photosynthesis process, and grain yield and quality. Increasing nitrogen supply to wheat crop can increase photosynthetic rate and consequently increase canopy biomass, grain yield and protein content. However, excessive nitrogen fertilization in cultivated land has profound environmental impacts such as nitrate leaching, soil denitrification, ammonia volatilization, and nitrous oxide emissions, which contaminate water and air and aggravate the climate change.

Proteins are the most important constituent of wheat in relation to its major uses in bread making. Various protein fractions are considered responsible for the quality of grains. Glutenins and gliadins are the major components of the storage protein and make a significant contribution in dough rheology and baking quality (Panazzo and Eagles, 2000). The sedimentation value describes the degree of sedimentation of flour suspended in a lactic acid solution during a standard time interval and this is taken as a measure of the baking quality. β-

Carotene content is another quality parameter that imparts attractive yellow colour to the wheat products. It is a precursor of vitamin "A" and hence has immense nutritional importance. Precise application of nitrogen fertilizers through various decision support systems is considered as most effective in obtaining higher grain quality and grain yield. Therefore, the availability of nitrogen to emmer wheat during various phases of its growth and development is an important factor influencing the grain yield and quality. Hence, the present study was carried out to investigate the effect of different precision nitrogen management practices on the yield and quality of emmer wheat.

Material and methods

A field experiment was conducted during *rabi* (2020-21 and 2021-22) at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad (15º30'6"N 74º 59'13.2" E and 678 meters above mean sea level), located in the Northern Transition Zone (Zone-8) of Karnataka. The soil of the experimental site belonging to *Vertic Inceptisols*, which were deep black and clay in texture, with pH 7.76, EC (0.28 dS m^{-1}), organic carbon (0.45 %) and available N (257 kg ha^{-1}), P (32.6 kg ha^{-1}) and K (348 kg ha^{-1}), respectively at 0-15 cm soil depth. The mean weekly maximum and minimum temperatures fluctuated between 27.0 ºC to 35.3 ºC and 12.8 ºC to 20.0 ºC and the total rainfall was 37.6 mm during crop growing period (2020-21). The mean weekly maximum and minimum temperatures fluctuated between 26.7 ºC to 33.6 ºC and 11.0 ºC to 20.2 ºC and the total rainfall was 183.6 mm during crop growing period (2021-22).

The experiment was laid out in randomized block design and replicated thrice. 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. 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}.

Crude protein content (McDonald, 1977) was calculated by multiplying nitrogen content in grain with a factor of 5.7 (Crude protein of wheat = Per cent nitrogen x 5.7), nitrogen content in grain is determined by a method of chemical analysis known as the Kjeldahl procedure. The sedimentation value of the grain was estimated by sodium dodecyl sulphate (SDS) test by following standard analytical procedure as described by Mishra and Gupta (1995). β-Carotene in wheat grain was analysed by procedure as described by Mishra and Gupta (1995). The formula used to calculate β-carotene or yellow pigment content in grain is β-carotene content (ppm) = 0.0105 + 23.5366 × absorbance. 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. Regression equations were developed in Microsoft excel.

Results and discussion

Grain crude protein content

The perusal of pooled data revealed that grain crude protein content significantly differed among the precision nitrogen management practices (Table 1). Application of nitrogen through STCR for targeted yield of 6.0 t ha^{-1} (12.57%)recorded comparable and significantly maximum grain crude protein content compared to the rest of the treatments and it was found on par with all other treatments except nitrogen management through Nutrient Expert for targeted yield of 4.0 t ha^{-1}, RDN, N omission and absolute control (11.37, 10.46, 9.52 and 9.15%, respectively). The quality of grain improved in terms of increased protein content by nitrogen application over absolute control and N omission. Triboi *et al.* (2000) concluded that

Table 1. Quality parameters of emmer wheat as influenced by precision nitrogen management practices (Pool over two years)

Treatments	Grain crude protein (%)	Sedimentation value (ml)	β Carotene (ppm)
T_1: N omission (N-0)	9.52^{d}	22.68^{ef}	3.72^{c}
T_2: Recommended dose of N as per package of practices	10.46^{c}	24.62^{de}	4.45^{b}
T_3: Nitrogen management through SSNM for targeted yield of 4.0 t ha^{-1}	11.91^{ab}	30.02^{ab}	4.73^{ab}
T_4: Nitrogen management through SSNM for targeted yield of 5.0 t ha^{-1}	12.23^{ab}	31.27^{a-c}	4.80^{ab}
T_5: Nitrogen management through SSNM for targeted yield of 6.0 t ha^{-1}	12.43^{a}	31.71^{ab}	4.82^{ab}
T_6: STCR based N management for targeted yield of 4.0 t ha^{-1}	11.80^{ab}	29.31^{bc}	4.71^{ab}
T_7: STCR based N management for targeted yield of 5.0 t ha^{-1}	12.48^{a}	32.19^{ab}	4.84^{a}
T_8: STCR based N management for targeted yield of 6.0 t ha^{-1}	12.57^{a}	32.31^{a}	4.86^{a}
T_9: Nitrogen management through Nutrient Expert for targeted yield of 4.0 t ha^{-1}	11.37^{b}	26.57^{d}	4.68^{ab}
T_{10}: Nitrogen management through Nutrient Expert for targeted yield of 5.0 t ha^{-1}	11.74^{ab}	29.29^{bc}	4.70^{ab}
T_{11}: Nitrogen management through Nutrient Expert for targeted yield of 6.0 t ha^{-1}	12.08^{ab}	30.74^{a-c}	4.75^{ab}
T_{12}: 30 kg N ha^{-1} Basal + LCC ≤ 5 + 20 kg N ha^{-1}	11.69^{ab}	26.57^{d}	4.68^{ab}
T_{13}: Absolute control	9.15^{d}	20.98^{f}	3.52^{c}
S. Em±	0.28	0.69	0.11

Note: Means followed by the same alphabet within a column are not significantly differed by DMRT (P=0.05)

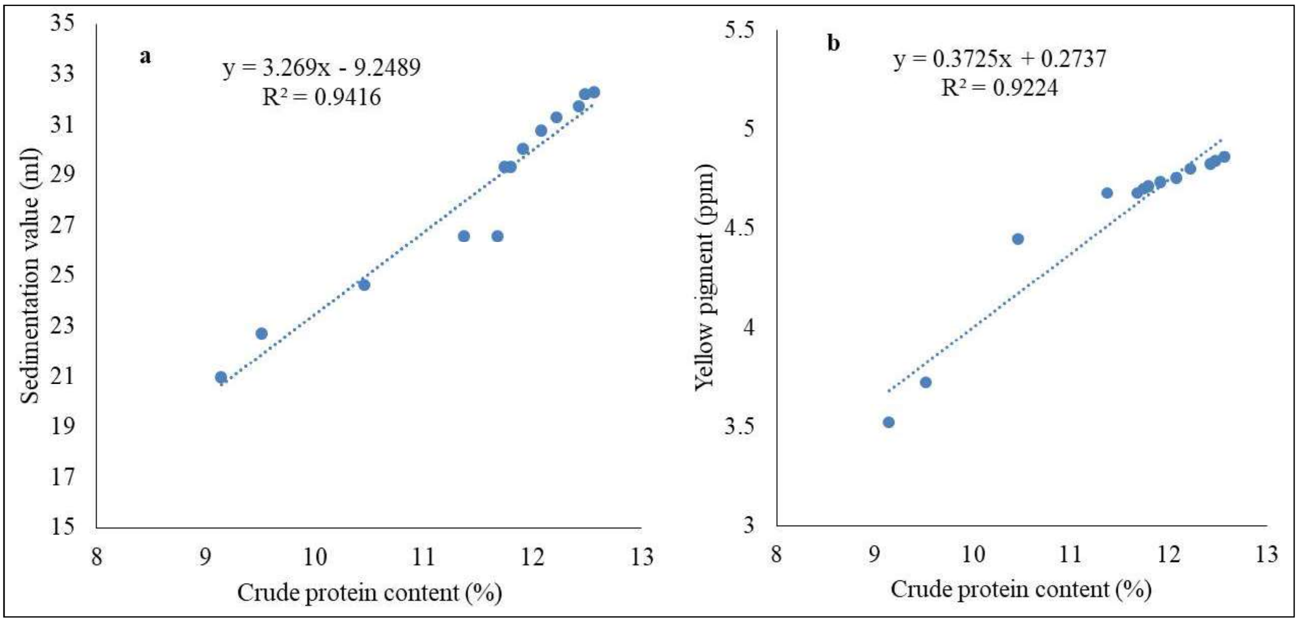

Fig1. Relationship of crude protein content with sedimentation value (a) and yellow pigment (b)

nitrogen application is the most important factor affecting the protein content and its composition. The contribution is also evident from the regression analysis between nitrogen content in grain and crude protein content. There was a significant positive relationship was observed (Fig. 2), 100 per cent contribution towards nitrogen content in grain. The increase in crude protein content due to higher availability, absorption and nitrogen uptake in these treatments (Table 2). Proteins are formed by different amino acids whose concentration are higher due to higher availability of nitrogen. Secondly, split application of nitrogen at different growth stages significantly increased the prolamin, globulin and glutenin content in wheat grain. The lower sedimentation value in absolute control due to nitrogen starvation.

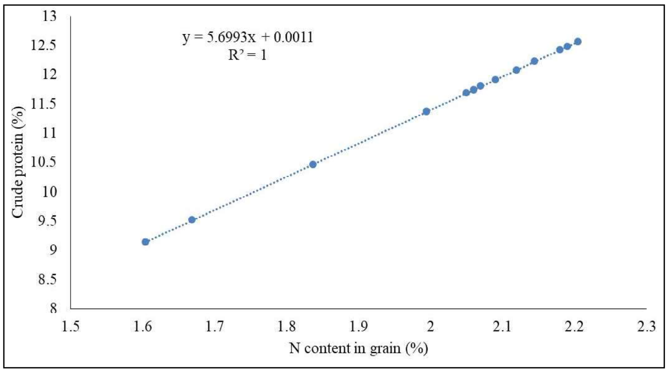

Fig 2. Relationship of nitrogen content in grain and crude protein content

Sedimentation value

Different precision nitrogen management practices significantly influenced the sedimentation value over absolute control (Table 1). Significantly higher sedimentation value was recorded with nitrogen management through STCR for targeted yield of 6.0 t ha^{-1} (32.31 ml) and it was found on par with nitrogen management through STCR for targeted yield of 5.0 t ha^{-1},

Table 2. Effect of precision nitrogen management practices on grain yield, N content and uptake of emmer wheat (Pool over two years)

Treatments	Grain yield (kg ha^{-1})	N content (%)		N uptake (kg ha^{-1})	
		Grain	Straw	Grain	Straw
T_1: N omission (N-0)	2252^{f}	1.67^{d}	0.37^{f}	37.62^{f}	17.04^{g}
T_2: Recommended dose of N as per package of practices	3603^{e}	1.84^{c}	0.43^{e}	66.12^{e}	27.72^{f}
T_3: Nitrogen management through SSNM for targeted yield of 4.0 t ha^{-1}	4375^{cd}	2.09^{ab}	0.51^{de}	91.46^{cd}	36.69^{d}
T_4: Nitrogen management through SSNM for targeted yield of 5.0 t ha^{-1}	4721^{bc}	2.15^{ab}	0.54^{b-d}	101.26^{b}	40.41^{c}
T_5: Nitrogen management through SSNM for targeted yield of 6.0 t ha^{-1}	5034^{ab}	2.18^{a}	0.58^{a-c}	109.74^{a}	44.23^{ab}
T_6: STCR based N management for targeted yield of 4.0 t ha^{-1}	4339^{cd}	2.07^{ab}	0.50^{de}	89.84^{cd}	35.36^{de}
T_7: STCR based N management for targeted yield of 5.0 t ha^{-1}	5125^{ab}	2.19^{a}	0.60^{ab}	112.24^{a}	46.28^{ab}
T_8: STCR based N management for targeted yield of 6.0 t ha^{-1}	5201^{a}	2.21^{a}	0.66^{a}	114.69^{a}	52.42^{a}
T_9: Nitrogen management through Nutrient Expert for targeted yield of 4.0 t ha^{-1}	4247^{d}	2.00^{b}	0.47^{de}	84.72^{d}	32.49^{e}
T_{10}: Nitrogen management through Nutrient Expert for targeted yield of 5.0 t ha^{-1}	4350^{cd}	2.06^{ab}	0.49^{de}	89.62^{cd}	34.94^{de}
T_{11}: Nitrogen management through Nutrient Expert for targeted yield of 6.0 t ha^{-1}	4531^{cd}	2.12^{ab}	0.53^{cd}	96.06^{bc}	38.33^{cd}
T_{12}: 30 kg N ha^{-1} Basal + LCC ≤ 5 + 20 kg N ha^{-1}	4256^{d}	2.05^{ab}	0.48^{de}	87.25^{d}	33.26^{e}
T_{13}: Absolute control	1788^{g}	1.61^{d}	0.35^{f}	28.71^{g}	13.53^{g}
S. Em±	134	0.05	0.02	2.15	1.16

Note: Means followed by the same alphabet within a column are not significantly differed by DMRT (P=0.05)

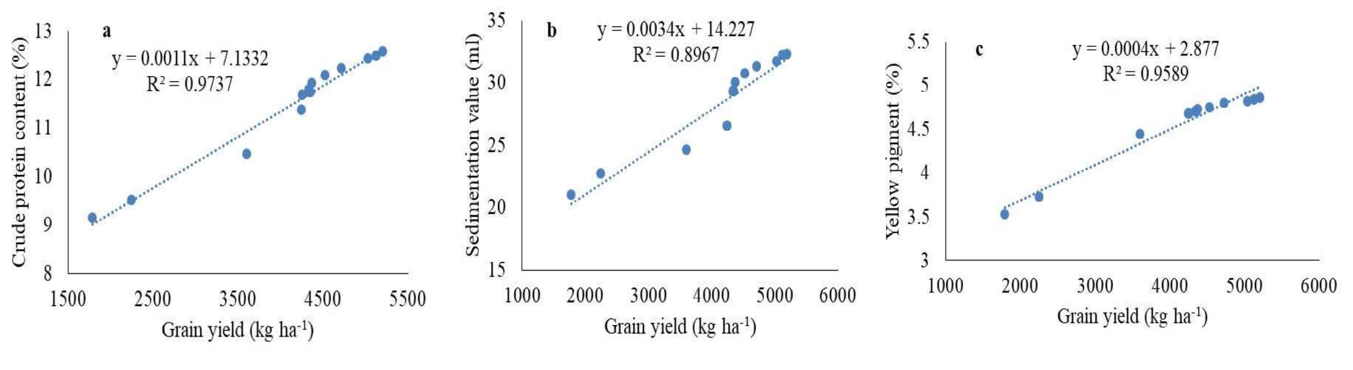

Fig.3. Relationship of grain yield with crude protein content (a), sedimentation value (b) and yellow pigment (c).

SSNM for targeted yield of 6.0 t ha^{-1}, 5.0 t ha^{-1}, Nutrient Expert for targeted yield of 6.0 t ha^{-1} and SSNM for targeted yield of 4.0 t ha^{-1} (32.19, 31.71, 31.27, 30.74 and 30.02 ml, respectively). However, significantly lower sedimentation value was observed in absolute control (20.98 ml). This might be due to increased accumulation of photosynthates from source to sink with increased levels of nitrogenous fertilizer (Singh and Agarwal, 2005).

The regression analysis between sedimentation value and crude protein content (Fig.1) shows that both quality parameters have significant positive relationship. Nearly 94 per cent variation in crude protein content.

β-Carotene content

β-Caroteneor yellow pigmentimparts attractive yellow colour to the wheat products. Significant difference was noticed with different precision nitrogen management practices for β-Carotene content (Table 1). Nitrogen application through STCR for targeted yield of 6.0 t ha^{-1} (4.86 ppm) recorded significantly higher β-Carotene content and was found on par with all other treatments except RDN, N omission and absolute control (4.45, 3.72 and 3.52 ppm, respectively). The regression analysis between yellow pigmentand crude protein content shows that both quality parameters have significant positive relationship. Nearly 92 per cent variation in yellow pigment (Fig.1). Improvement in grain quality traits like crude protein, sedimentation value and β-Carotene content of wheat crop due to better growth and development, better assimilation coupled with efficient usage of added nitrogen. These results are in conformity with Zhao *et al.* (2006), Kulkarni (2008), Dineshkumar (2011) and Nikhil Kumar (2019) in wheat crop.

Grain yield

Grain yield increased significantly with different precision nitrogen management practices (Table 2). Significantly higher grain was noticed in nitrogen management through STCR for targeted yield of 6.0 t ha^{-1}(5201 kg ha^{-1}).It was found on par with application of nitrogen through STCR for targeted yield of 5.0 t ha^{-1} (5125 kg ha^{-1}) and SSNM for targeted yield of 6.0 t ha^{-1} (5034 kg ha^{-1}). Significantly lower grain was recorded in absolute control (1788 kg ha^{-1}) followed by N omission (2252 kg ha^{-1}). The increment in the grain yield of emmer wheat with nitrogen management through STCR for targeted yield of 6.0 t ha^{-1} was to the tune of 31 and 65 per cent over RDN and absolute control, respectively. This was mainly due to application of nitrogen based on soil test value and site specific nutrient management at critical physiological phases of crop would have supported for better translocation of photosynthates from source to sink and higher yield attributing characters *viz*., number of productive tillers per meter square area, number of grains per spike, grain weight per spike, spike length and thousand grain weight in comparison to absolute control. The increased in the values of yield attributing characters in STCR based nitrogen management for targeted yield of 6.0 t ha^{-1} and 5.0 t ha^{-1} was due to tendency of nitrogen in accelerating growth, photosynthetic activity and translocation efficiency for photosynthates. These results are in conformity Kulkarni (2008), Dineshkumar (2011) and Nikhil Kumar (2019) who reported in emmer wheat.

The regression analysis of grain yield with crude protein content showed 97% contributed towards grain yield, sedimentation value contributed 89% and yellow pigment contributed 96% towards grain yield (Fig.3). These indicates that higher grain yield and better quality in terms of protein content, sedimentation value and β-Carotene content can be increased through proper management and timely application of nitrogen. Bushuk (1985) also reported that there is strong dependence of protein content on agronomic and environmental factors during the growing season of the crop. When the nitrogen applied in splits through precision nitrogen management practices, crop gets continuous supply of nitrogen throughout the crop season and results in higher grain yield along with better quality of grain.

Conclusion

It may be concluded that precision nitrogen management practices significantly influenced on the quality parameters of emmer wheat. However, the higher crude protein content, sedimentation value and β-Carotene content was significantly higher with nitrogen management through STCR for targeted yield of 6.0 t ha^{-1} and 65 per cent increase in grain yield of emmer wheat in this treatment compared tothe absolute control.

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