Original Research Article

Response of different physiochemical parameters of wheat genotypes (*Triticum aestivum* L.) in nutrient stress condition

ABSTRACT

Nitrogen management strategies during plant growth period are based on chlorophyll content of plant photosynthesis efficiency. This study is aimed to determine the impact of different nitrogen and phosphorus fertilizer rates on the dynamics of chlorophyll content in winter wheat varieties during vegetative and flowering stage to determine the relationship between nitrogen and phosphorus on chlorophyll content in different winter wheat varieties. Field trial involving nine winter wheat (*Triticum aestivum* L.) varieties. The treatments were T1=Control, T2=100% (N+P+K) T3= 50% N+ 100% (P+K), T4 =50%P+100%N+K.The results of the trial shown that the maximum chlorophyll content in different wheat varieties was observed at the end of flowering stage. The chlorophyll content depended on the level of mineral fertilization. The highest chlorophyll content in leaves, stem and ears was obtained by using normal recommended doses. By using chlorophyll meter Yara N-tester recorded the highest chlorophyll content in all analyzed plant parts in one year trial. Nitrogen and phosphorus fertilization significantly affected chlorophyll content, SPAD value and photosynthesis rates in leaves. Nitrogen and phosphorus fertilization had an important effect on chlorophyll content, SPAD and leaf photosynthesis rates.

Aims: The genotypes with high photosynthetic rate and chlorophyll content characteristics identified in this study could be applied to conventional breeding efforts to more effectively exploit the constrained ecosystem which minimize environmental impacts.

Place and Duration of Study: This experiment was carried out during 2019-20 at subtropical region of India.

Methodology: In this experiment Photosynthetic rate was measured by Photosynthesis system (LICOR 6400) at 55 and 85 DAS. The measurement was taken in the morning hours (8 to 11 AM) in the leaf of wheat crop. The results were expressed in μmol m^{-2} s^{-1}. SPAD meter reading was measured at 90 DAS. SPAD reading was taken in the morning and evening hours on the leaf of wheat varieties in each plot. A method described by Richardson *et al*. (2002) was used for measuring leaf chlorophyll content at 65 and 85 DAS. Leaf samples were collected and washed with distilled water to eliminate dust. The leaf samples (0.25 g) were pulverised and centrifuged with 3 ml of DMSO. The absorbance of the supernatant was measured at 645 and 663 nm by the help of spectrophotometer to compute the total chlorophyll content.

Results: Among the nine wheat varieties At 55 DAS, G 366 had highest photosynthetic rate (33.50 μmol m^{-2} s^{-1}) followed by Narmada14 (33.45 μmol m^{-2} s^{-1}) and at 85 DAS, HI1531 had highest Ps rate (32.60 μmol m^{-2} s^{-1}). Under normal dose of N, SPAD readings were higher in variety narmada14 (48.40), followed by HI8713 (47.70).

Conclusion: Among all the wheat varieties tested, the variety HI 8713 had considerably higher dry weight, leaf area, biomass, grain yield, chlorophyll content, SPAD value and the maximum chlorophyll content was found in optimum dose on N and P plot. HI8737 shows optimum chlorophyll content in nutrient deficient condition.

Key words: Nutrient, Photosynthetic rate, chlorophyll content, SPAD, Vegetative growth

1. INTRODUCTION

The Triticeae tribe of the Poaceae family includes *Triticum aestivum* (2n = 6x = 42, AABBDD) and *Triticum durum* (2n=2x =14, AABB). It is referred to as the King of Cereals due to its supremacy in terms of high acreage, production, productivity, and a significant role in the global trade in food grains.

Proteins, Rubisco, nucleic acids, and chlorophyll all contain nitrogen as a structural component. N fertilization plays an important agronomic management strategy for increasing crop productivity (Karim *et al*., 2016). The supply of N in plants has a significant impact on the functional activity of the photosynthetic apparatus in leaves. Furthermore, it has been observed that effective N feeding can mitigate drought stress effects by maintaining metabolic processes even at low tissue water potential (Zhang *et al*., 2007). Excess nitrogen allows many plants to grow aggressively with dark green coloured lush growth, but it also causes developmental alterations and may alter the biology of plants such as a longer vegetative phase, delayed maturity, a longer plant life cycle, and enhanced succulence (Goyal *et al*., 2004).

De Saussure, who recognised nitrogen as a critical element of plants and that nitrogen were acquired mostly from the soil in 1804, is widely credited with discovering the essentiality of nitrogen (Barker and Bryson, 2006). One of the most extensively spread elements in nature is nitrogen. It can be found in the atmosphere, lithosphere, and hydrosphere, with the atmosphere serving as the primary source of nitrogen (Delwiche, 1983). One of the most critical elements for crop productivity is nitrogen (N). Increased growth and biomass yields arise from the application of nitrogen fertilizer. It has a direct impact on the protein amino acid content and, as a result, the nutritional quality of the economic produce (Maheswari, 2017). Nitrogen-deficient plants exhibit yellowing signs on older leaves, whereas cereals exhibit V-shaped yellowing at the lower leaf tip.

Nitrogen is the most critical nutrient that plants get from the soil in terms of quantity. (Lonhienne and colleagues, 2008) Plant roots have long been known to take up nitrogen molecules with a low molecular mass, such as ammonium, nitrate, and amino acids. In natural ecosystems, however, nitrogen is mostly found as proteins in the soil. This complex organic form of nitrogen is thought to be unavailable to plants directly.

Phosphorus is involved in a variety of biological functions, including membrane structure maintenance, biomolecule synthesis, and the production of high-energy molecules. Cell division, enzyme activation/inactivation, and glucose metabolism are all aided by it (Razaq *et al.,* 2017).

The photosynthetic capacity of leaves is normally linked to their nitrogen content because of the Calvin cycle proteins and thylakoids which account for the majority of leaf nitrogen, Thylakoid nitrogen is proportional to chlorophyll content (50 mol thylakoid N mol^{-1} Chl) and had a strong linear connection between nitrogen, RuBP carboxylase, and chlorophyll within species. The fraction of total leaf nitrogen in the thylakoids remains constant when nitrogen per unit leaf area increases, whereas the proportion of soluble protein increases (Evans, 1989).

The amount of nitrogen in a plant's tissues determines its growth. According to the N productivity idea, plants that develop in N-rich environments have higher internal N concentrations and a higher relative growth rate. Limited N supply causes low shoot growth, a high root–shoot ratio, and decreased leaf growth in plants. As the leaves age, more nitrogen is assigned to the highest leaves, where there is a greater demand for photosynthetic enzymes and chlorophyll, and it is mobilized to seeds (Pilbeam, 2018).

Phosphorus is the second most commonly limiting macronutrient for plant growth, behind N.P is a key plant macronutrient that accounts for around 0.2 percent of the dry weight of a plant. Phosphorus is a component of important compounds including nucleic acids, phospholipids, and ATP, plants cannot thrive without a consistent supply of this nutrient. The Pi is also involved in the regulation of metabolic pathways and the control of important enzyme processes (Reid,1998).

Kaur (2017) reported that the activities of nitrate reductase, nitrite reductase, glutamine synthetase, glutamate synthase, and glutamate dehydrogenase all increased as the nitrogen rate increased, resulting in a rise in protein and amino acid content in all wheat genotypes. The amount of nitrogen and chlorophyll in the leaves decreased as the leaves grew. It was also shown that nitrogen assimilatory enzymes (nitrate reductase and glutamine synthetase) have a positive association with NUE and nitrogen content, suggesting that these enzymes may be the rate limiting enzymes in nitrogen metabolism. The nitrogen-efficient genotypes could be used to boost wheat crop output while using less nitrogen, saving the environment and money.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The field study was carried out at the ICAR-IISS research farm in Bhopal and Madhya Pradesh during the rabi season of 2020–21. It is classified as semi-arid and subtropical and has scorching summers and frigid winters. Bhopal is in the agro climatic zone of the Vindhyan Plateau. About 1100 mm of precipitation falls on average each year, with the majority falling between July and September during the monsoon season. The typical maximum summer temperature is 35 to 40 degrees Celsius, while the average winter low is 2 to 9 degrees Celsius.

On November 25, 2020, the wheat varieties were manually planted at a rate of 100 kg/ha in lined furrows, approximately 3 cm deep, with a row-to-row distance of 22.5 cm and a plant-to-plant gap of 5 cm.

In the current study, nine different types of wheat (T. *aestivum* and T. *durum*) were chosen and planted as test crops. A split-plot design, duplicated three times, was used, with the nutrient dose serving as the main plot and the variety being the subplot treatment. There are 36 plots in a block (9 variety x 4 fertilizer N and P treatments). Each plot has a 2 m by 2 m space.

The experiment was set up in a split-plot design with three replications. Each replication contained three nitrogen levels, three P levels, and nine genotypes for a total of 36 treatments. All of the treatments were divided up independently in each replication.

Full-recommended doses of P and K fertilizers at 60 kg P_2O_5 and 40 kg K2O per acre were treated as a basal in SSP and MOP, respectively, in all treatments other than control. The control plots did not include N, P, or K. (T_1). T_3 received half of the recommended amount of N (60 kg/ha) and a full dose of P (60 kg/ha) whereas normal dose treatment (T_2) received the permitted amount of N (120 kg ha^{-1}) and P (60 kg/ha).

Fertilizers in full and half doses were given to the T_4 therapy. While the remaining N was top-dressed in equal portions at 25 and 45 DAS, respectively, 50% of the applied N is delivered as basal. Standard agronomic techniques were used to cultivate the wheat crops, and five irrigations (5 cm) and one manual weeding at 30 DAS were completed.

SPAD meter reading was measured at 90 DAS. SPAD reading was taken in the morning and evening hours on the leaf of wheat varieties in each plot.

A method described by Richardson *et al*. (2002) was used for measuring leaf chlorophyll content at 65 and 85 DAS. Leaf samples were collected and cleaned with distilled water to eliminate dust. The leaf samples (0.25 g) were pulverised and centrifuged with 3 ml of DMSO. The absorbance of the supernatant was measured at 645 and 663 nm and the following formulae were used to compute total chlorophyll content.

The reduction of nitrate to nitrite was assayed *in vitro* by incubating the enzyme extract with KNO_3 in the presence of an electron donor (NADH). Nitrite was diazotized with sulphanilamide and then reacted with N-(1- naphthyl) ethylene diamine dihydrochloride (NEDD) to produce an azo dye which was measured spectrophotometrically at 540nm (Nicholas and Nason, 1957). 0.2 g leaf sample was taken put it to 0.2 M phosphate buffer solution and 0.2M KNO_3 (3 ML). The samples were kept in dark chamber for 1 hour for incubation of reaction. The reaction was terminated at 100 °C boiling water. Aliquot (0.5 ml) was taken to which 1 ml of 1N sulphanimide and 1ml of 0.02% NEDD was added the volume was made up to 6 ml. The absorbance of the resultant solution (Pink colour) was measured against the blank at 540 nm wavelength. For the formation of standard curve potassium nitrite solution (0.01M) was formed with series of test tubes. The standard curve was prepared with diluted KNO2 solution with series of test tubes, make up the volume in each to 2 ml with water and proceeds it. The enzyme activity was expressed as µmole KNO_2 /h/g fresh weight. The sampling for NRA was done at 50, 65 and 85 DAS In the morning hours.

Photosynthetic rate was measured by Photosynthesis system (LICOR 6400) at 55 and 85 DAS. The measurement was taken in the morning hours (8 to 11 AM) in the leaf of wheat crop. The results were expressed in µmol m^{-2} s^{-1}.

3. RESULTS AND DISCUSSION

3.1 Chlorophyll content (mg g^{-1})

At 65 DAS, there were significant differences in chlorophyll content observed among the nine selected varieties of wheat and fertilizer treatments. The range of chlorophyll content was found in between 0.225(HI8713, HI1563, LOK1, NARMADA 14) to 0.65 mg g^{-1} (HI8663) (Table 1). Among all the treatments the mean chlorophyll content was higher in Normal dose treatment followed by reduced phosphatic fertilizer dose treatment, reduced nitrogen dose fertilizer treatment and lower in control plots. Among the varieties grown in full dose of N & P treatment, the highest chlorophyll content was found in HI8663(0.65mg g^{-1}) and the lowest chlorophyll content was found in Lok1(0.29 mg g^{-1}).Among the varieties grown in half dose of N fertilizer treatment higher chlorophyll content was observed in HI1544 (0.305 mg g^{-1}) followed by GW366 (0.285 mg g^{-1}) and among the varieties grown in half dose of P, higher chlorophyll content was found in HI1563 and HI1544 (0.54 mg g^{-1}) followed by HI8663 (0.535 mg g^{-1}). Among all the treatments, higher chlorophyll content was observed in HI8663 (0.65 mg g^{-1}) in normal dose fertilizer treatment and it was followed by HI8713 (0.63 mg g^{-1}) in normal Dose fertilizer treatment and lower chlorophyll content was observed in HI8713 (0.225 mg g^{-1}) in control plot. Across all nutrient treatment leaf area in selected wheat varieties followed the following trends:

HI8663> HI1544> HI1563= HI8737> HI8713=HI1531>GW366> LOK1> NARMADA 14 (Fig.1).

At 85 DAS, there were significant differences in chlorophyll content observed between varieties of wheat. The range of chlorophyll content was found in between 0.145 (HI1563) to 0.205 mg g^{-1}(HI8663, HI1563, Narmada 14) among all the treatments (Table 1). The mean chlorophyll content was higher in Normal dose treatment followed by reduced phosphatic fertilizer dose treatment and lower in control plots. Among the varieties grown in full dose of N & P treatment, the highest chlorophyll content was found in LOK1 (0.210mg g^{-1}) and the lowest chlorophyll content was found in HI8737 (0.175 mg g^{-1}).Among the varieties grown in half dose of N fertilizer treatment the highest chlorophyll content was observed in HI1563 and HI1544 (0.2 mg g^{-1}) followed by HI8737 and HI8663 (0.185mg g^{-1}) and among the varieties grown in half dose of P, the highest chlorophyll content was found in LOK1 (0.2 mg g^{-1}) followed by HI1544 and Narmada14(0.195 mg g^{-1}). Among all the treatments, the highest chlorophyll content was observed in Lok1 (0.21 mg g^{-1}) in normal dose fertilizer treatment and it was followed by HI1544, HI 1531 and Narmada 14 (0.205 mg g^{-1}) in normal Dose fertilizer treatment and lower chlorophyll content was observed in HI1563 (0.145 mg g^{-1}) in control plot (Table 1).

Table 1 Effect of N & P on total chlorophyll content of wheat genotypes

	Chlorophyll at 65 DAS					Chlorophyll at 85 DAS				
	T_1	T_2	T_3	T_4	Mean A	T_1	T_2	T_3	T_4	Mean A
HI8663	0.230	0.650	0.275	0.535	0.423	0.200	0.190	0.185	0.180	0.189
HI8737	0.260	0.625	0.250	0.530	0.416	0.155	0.175	0.185	0.165	0.170
HI8713	0.225	0.630	0.270	0.455	0.395	0.160	0.185	0.170	0.175	0.173
HI1563	0.255	0.615	0.255	0.540	0.416	0.145	0.195	0.200	0.185	0.181
HI1544	0.250	0.575	0.305	0.540	0.418	0.185	0.205	0.200	0.195	0.196
HI1531	0.235	0.590	0.255	0.500	0.395	0.175	0.205	0.175	0.185	0.185
GW366	0.280	0.445	0.285	0.470	0.370	0.160	0.200	0.180	0.190	0.183
LOK1	0.255	0.290	0.270	0.500	0.329	0.165	0.210	0.165	0.200	0.185
NARMADA14	0.255	0.295	0.255	0.460	0.316	0.170	0.205	0.180	0.195	0.188
Mean B	0.249	0.524	0.269	0.503		0.168	0.197	0.182	0.186	
Factors	**C.D.**		**SE(d)**		**SE(m)**	**C.D.**		**SE(d)**		**SE(m)**
Factor (A)	0.064		0.027		0.019	NS		0.011		0.008
Factor (B)	0.037		0.018		0.013	0.014		0.007		0.005
Factor (B) at same level of A	0.115		0.054		0.039	NS		0.021		0.016
Factor (A) at same level of B	0.115		0.054		0.038	NS		0.021		0.015

T_1=Control, T_2=100% (N+P+K) T_3= 50% N+ 100% (P+K), T_4 =50%P+100%N+K

Many researchers have revealed a strong relationship between chlorophyll and nitrogen levels (Evans, 1983; Field and Moony, 1986; Amaliotis *et al*., 2004). It's well known that nitrogen is a structural component of chlorophyll and protein molecules and thereby influences chloroplast development and chlorophyll accumulation (Tucker, 2004; Daughtry,2000). The amount of nitrogen in the leaf was related to the colour of the leaf (Cabrera, 2004). The cultivars with the highest nitrogen content (HI8663, HI8713, and HI1563) were dark green in this study. These cultivars also possessed higher chlorophyll content during 65 DAS. On the other hand, the leaves of LOK 1, Narmada14 cultivars were light green in colour, and their nitrogen concentration was lower. Significant increases in plant chlorophyll content were detected in wheat cultivated under graded nitrogen fertilizer doses (Nasri Reza *et al*., 2017) and (Singh *et al*. 2017).This was consistent with the current study's findings, which revealed that enhanced nitrogen fertilization resulted in higher chlorophyll content indicating that nitrogen and chlorophyll content are intrinsically related (Ameliotus *et al*., 2004).

3.2 Photosynthetic rate

At 55 DAS there were significant differences in photosynthetic rate observed between varieties of wheat and fertilizer treatments. The range of photosynthetic rate was found in between 20.35 (HI8713) to 33.50 µM m^{-2} s^{-1} (GW366) among all the treatments (Fig. 1). The mean photosynthetic rate was the highest in Normal dose treatment followed by reduced phosphatic fertilizer dose treatment, reduced nitrogen dose fertilizer treatment and lower in control plots. Among the varieties grown in full dose of N & P treatment, the highest Photosynthetic rate was found in GW366 (33.50µM m^{-2} s^{-1}) and the lowest rate was found in HI8713(25.20 µM m^{-2} s^{-1}).Among the varieties grown in half dose of N fertilizer treatment the highest photosynthetic rate was observed in HI8737 (31.80 µM m^{-2} s^{-1}) followed by HI1563 (31.50 µM m^{-2} s^{-1}) and among the varieties grown in half dose of P, the highest rate was found in HI1531 (32.25 µM m^{-2} s^{-1}) followed by HI1563(31.80µM m^{-2} s^{-1}). Among all the treatments, the highest photosynthetic rate was observed in GW366 (33.50 µM m^{-2} s^{-1}) followed by Narmada14(33.45 µM m^{-2} s^{-1}) in normal Dose fertilizer treatment and lowest Photosynthetic rate was observed in HI8737 (20.25 µM m^{-2} s^{-1}) in reduced phosphorus dose fertilizer followed by HI8713 (20.35 µM m^{-2} s^{-1}) Across all nutrient treatment leaf area in selected wheat varieties followed the following trends:
GW366>HI1563>NARMADA14>LOK1>HI1544>HI1531>HI8663>HI8737>HI8713 (Fig. 2).

At 75 DAS, the range of photosynthetic rate was found in between 17.10 (HI8737) to 32.60 µM m^{-2} s^{-1}(HI1531) among all the treatments. The mean photosynthetic rate was higher in Normal dose treatment followed by reduced nitrogen dose fertilizer treatment, reduced phosphatic fertilizer dose treatment and lower in control plots (Fig. 1). Among the varieties grown in full dose of N & P treatment, the highest photosynthetic rate was found in HI1531 (32.60 μM m^{-2} s^{-1}) and the lowest photosynthetic rate was found in HI8663 (22.60 mg g-1).Among the varieties grown in half dose of N fertilizer treatment the highest photosynthetic rate was observed in NARMADA14 (30.50 μM m^{-2} s^{-1}) followed by HI8737 (30.45 μM m^{-2} s^{-1}) and among the varieties grown in half dose of P, the highest rate was found in GW366 (28.20 μM m^{-2} s^{-1}) followed by Lok1 (27.50 μM m^{-2} s^{-1}). Among all the treatments, the highest photosynthetic rate was observed in HI1531 (32.60 μM m^{-2} s^{-1}) followed by HI1563 (31.95 μM m^{-2} s^{-1}) in normal dose fertilizer treatment and lower rate was observed in HI8737 (17.10 μM m^{-2} s^{-1}) in reduced phosphorus dose fertilizer followed by HI1531 (18.4 μM m^{-2} s^{-1}) (Fig. 2).

As discussed early on the influence of nitrogen and phosphorus on grain yield, these nutrients play a major role in photosynthesis, the amount of photo-assimilates produced by the plant, dry matter partitioning, and organ development. The influence of nitrogen on photosynthesis had a direct impact on the yield components (Dordas and Sioulas, 2009).

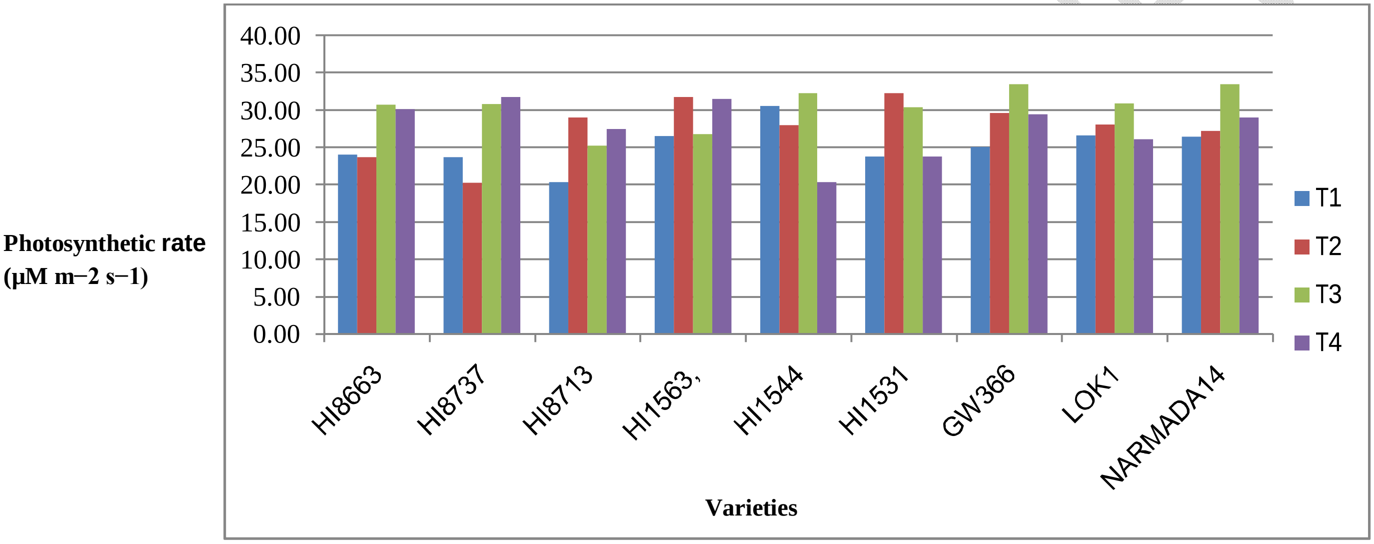

Fig. 1 Effect of N & P on photosynthetic rate of wheat genotype at 55 DAS.

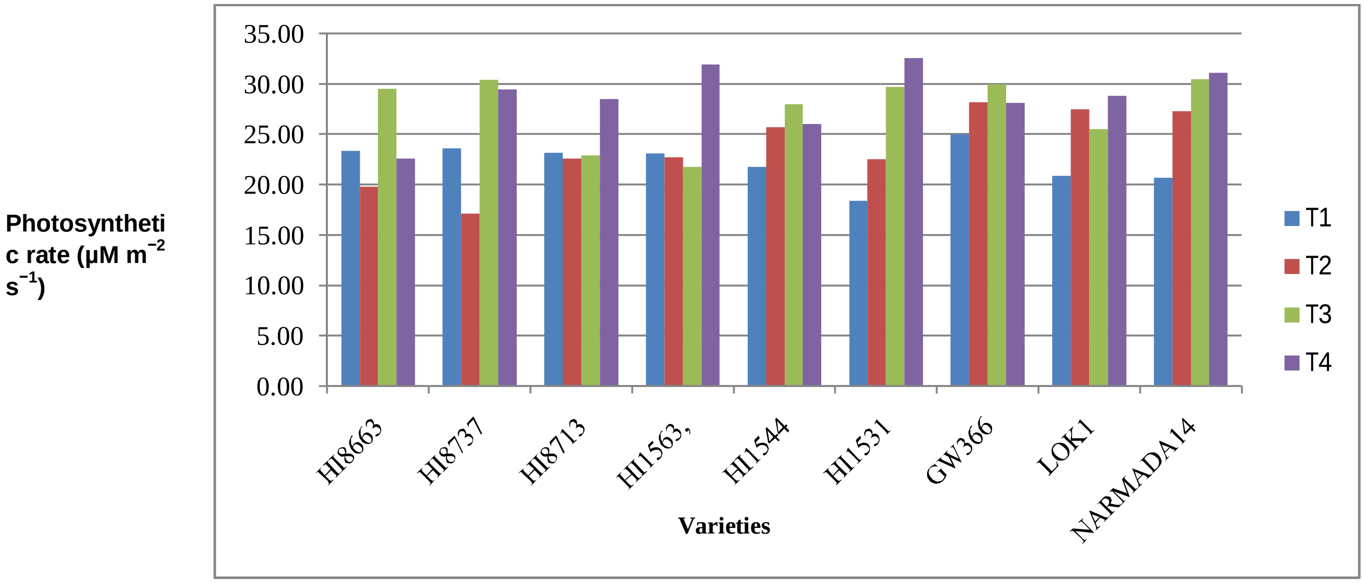

Fig. 2 Effect of N & P on photosynthetic rate of wheat genotype at 85 DAS.

3.3 SPAD reading at vegetative stage

There were significant differences in SPAD values observed among the nine selected varieties of wheat and fertilizer treatments. The range of SPAD value was found in between 37.20 (HI1531) to 48.40 (Narmada14) among all the treatments ((Fig.3). The mean SPAD value was higher in reduced phosphatic fertilizer dose treatment, followed by Normal dose treatment, reduced nitrogen dose fertilizer treatment, and lower in control plots. Among the varieties grown in full dose of N & P treatment, the highest SPAD value was found in HI8713 (47.70) followed by HI8663 (46.35).Among the varieties grown in half dose of N fertilizer treatment the highest SPAD value was observed in HI8713 (44.25) followed by Narmada14 (42.95) and among the varieties grown in half dose of P, the highest SPAD value was found in Narmada14 (48.40) followed by HI8713 (45.10). Among all the treatments, the highest SPAD value was observed in Narmada14 (48.40) in reduced dose P fertilizer treatment and it was followed by HI8713 (47.70) in normal Dose fertilizer treatment and lower SPAD value was observed in HI8663 (35) in reduced nitrogen dose fertilizer (Fig.3).

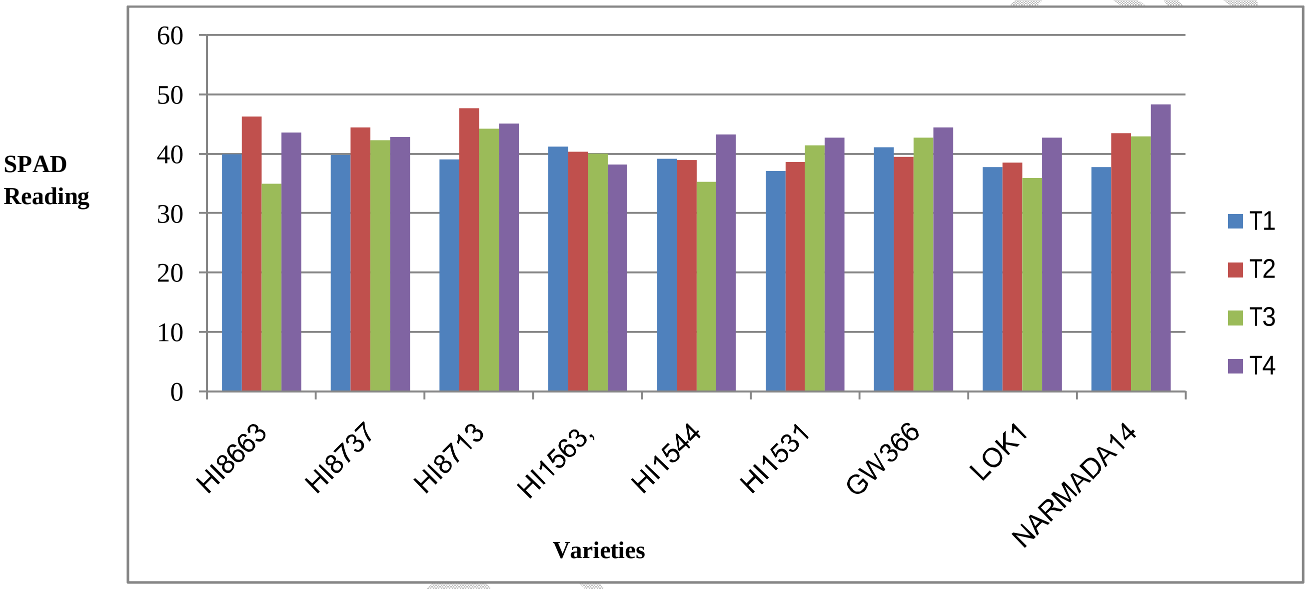

Fig. 3 Effect of N & P on SPAD Reading of wheat genotypes at flowering stage

Different N and P levels had a substantial impact on the chlorophyll content of leaves at the tillering stage (Fig.3). A considerable increase in chlorophyll content was seen with N levels up to 120N kg/ha, or 47.70% greater than control, when values were averaged across P levels. When the chlorophyll content was averaged across N levels, it exhibited considerable increases with P levels, i.e., 60 kg/ha P_2O_5, indicating that both N and P contributed significant green colour to leaves, proving chlorophyll production. According to them (Fig.3).The addition of nitrogen to chlorophyll could boost protein, amino acid, and enzyme production, all of which are important in photosynthetic production, grain formation, and other processes. While the interaction of nitrogen and phosphorus was determined to be statistically significant, the application of N varied depending on the P level. With a N:P ratio of 4:1 and 30 kg P_2O_5 and 120 kg N ha1, the greatest SPAD value of 48.50 percent was achieved. These findings are similar to those of Mussarat (2021), who reported a link between nitrogen and chlorophyll levels in wheat. Wheat crops respond well to nitrogen fertilizer, and the greenness factor, as measured by the SPAD value (Singh *et al*., 2002), increased when the amount of nitrogen fertilizer was increased. This was in line with the most of our findings.

4. SUMMARY AND CONCLUSIONS

During the rabi season of 2020–2021, researchers at the ICAR–Indian Institute of Soil Science in Bhopal (M.P.) examined the "Interactive effect of N and P in wheat cultivars in regulating nutrient utilisation efficiency and crop output. The major goal was to evaluate the characteristics of nitrogen and phosphorus utilization efficiency in wheat genotypes under various nutritional settings, as well as the agronomic and physiological responses of wheat genotypes to sub-optimal and optimal macro-nutrient fertilizer dose. The nine types of wheat that were chosen were planted in split plot designs with four levels of nutrient doses: no nutrient (control), 100% NPK, 50%N+100%PK, and 50%P+100%NK of recommended doses of fertilizer (RDF), or 120:60:40 N:P2O5:K2O. Under four levels of nutrient dosages, the performance of nine cultivars was assessed in terms includes physiological, metabolic, and morphological aspects, as well as yield characteristics. At 55 DAS, GW 366 had highest photosynthetic rate (33.50µmol m^{-2} s^{-1}) followed by Narmada14 (33.45 µmol m^{-2} s^{-1}) and at 85 DAS, HI1531had highest Ps rate (32.60 µmol m^{-2} s^{-1}). Under normal dose of N, SPAD readings were higher in variety narmada14 (48.40), followed by HI8713 (47.70).

Among all the wheat varieties tested, the variety HI 8713 had considerably higher dry weight, leaf area, biomass, grain yield, chlorophyll content, SPAD value, nitrogen content in grain and straw, total nitrogen uptake, agronomic use efficiency by N, nitrogen harvesting index, photosynthetic rate, total phosphorus uptake, apparent phosphorus recovery and phosphorus harvesting index and lower days to 50% flowering.

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APPENDICES

Source of Variation	DF	Photo synthetic rate	SPAD

		55 DAS	**75 DAS**	
Replication	1			
Factor A	3	81.87	175.47	66.76
Error(a)	3	5.82	22.86	10.34
Factor B	8	12.96	14.04	26.37
Intraction A X B	24	25.33	21.47	14.40
Error(b)	32	3.91	9.82	8.38
Total	71			

Factor A Main plot and Factor B is sub plot