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RESEARCH PAPER

Effects of nutrients and compaction levels on amino acids and protein content in wheat (*Triticum aestivum* L.) grain

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Abstract : A field experiment was conducted during the winter season on loamy sand soils of Rajasthan, India to study the effect of different levels of nitrogen, potassium and compaction on total amino acids (TAA), proline, lysine, methionine and total protein (TP) concentration in wheat grain. The experiment was laid out in Split Plot Design with three levels of nitrogen (40, 80 and 120 kg N ha^{-1}), three of potassium (20, 40 and 60 kg K_2O ha^{-1}) and four levels of compaction (0, 4, 8 and 12 passing of 500 kg manually driven iron roller). The results showed significant increases in total grain amino acid, lysine, methionine, and total protein concentration with increase in compaction levels, while proline content decreased. Increasing levels of nitrogen and potassium significantly increased in total amino acids, proline, lysine, methionine, and total protein content in wheat grain and improved the nutritional quality by increasing the protein and amino acids content.

Key Words : Sandy soils, Nutrients, Compaction, Amino acids, Protein

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INTRODUCTION

Cereals serves as the main crops for providing energy in feed and food and also they are major supplier of protein consumed by humans. Wheat grain contains protein and amino acids with high biological value. The protein is required for maintaining, repairing the body and for energy (Young and Pellet, 1985). The building blocks of proptein are known as amino acids. Lysine, methionine and proline are considered to be important amino acids for the nutritional quality of wheat protein. The nutrition quality of wheat (*Triticum aestivum* L.) can be improved by increasing the protein content and maintaining the balance between the essential amino acids. Application of appropriate fertilizer doses of nitrogen (Moss, 1981) and potassium (Pettigrew *et al.*, 2008) with conservation tillage practices affects the quality and quantity of wheat grain protein (Hussain *et al.*, 1980). The extent of sandy soils are wide in arid and semi-arid regions of India. The property of such soils are extremely permeable because of their coarse texture, looseness and poor organic matter content. Their moisture retention capacity is very low and more than one third of the applied water or rainwater is lost as deep percolation (Mann and Singh, 1975). These soils are prone to heavy losses of soluble nutrients (Mann and Singh, 1977). The extent of nutrient loss is highest with nitrogen (N) followed by potash (K) and least with phosphorus (P) (Gupta and Majumdar, 1994). Potassium maintains the permeability of cell membranes, keeping protoplasm in a proper degree of hydration which favours increased tolerance in plants against moisture stress, heat, frost and diseases (Singh, 2000). All amino acids, significantly increased with increased N and K treatments (Kandi *et al.*, 2012 and Tababtabaei and Ranjba, 2012) except proline. The role of soil surface compaction is indirect in facilitating crop development. Compaction that results in soil

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retention of N and K in highly permeable soils can enhance wheat grain quality. Potassium application increases the lysine and methionine concentration in wheat grain (Hojjati and Maleki, 1972). Koch and Mangel (1977) reported that K increased the concentrations of prolamine, glutelin and soluble amino acids in grain for protein synthesis. Ghildyal and Satyanarayana (1965) explored the possibility of increasing micropores at the expense of macropores by soil compaction. Compaction of such soils at procter (optimal moisture content, Day Robert, 2001) moisture creates a barrier of relatively high bulk density in the subsurface layer, which helps in minimizing percolation losses of nutrients and improves its capacity to store more moisture. Majumdar *et al.* (2000) and Majumdar and Meena (2003) advocated compaction of sandy soil as a convenient and economic method of decreasing permeability and nutrient loss. Singh *et al.* (2011) suggested the application of compaction to decrease the mobility of nitrogen and potassium in light textured soils for their efficient utilization. Therefore, a field experiment was undertaken to study the effect of compaction and nutrients on protein and amino acids in wheat grain grown in a highly permeable soils.

MATERIAL AND METHODS

The field experiment was conducted at the Agronomy Farm, College of Agriculture, Jobner, located at 75.28^0E longitude and 26.06^0N latitude at MSL 427 m. The climate is semi-arid having maximum temperature up to 46^0C in summer and minimum occasionally falls below 0^0C. The average rainfall is 400 mm. Wheat (var. Raj 3077) was the test crop. The soil was a loamy sand, low in available nitrogen (127.3 kg ha^{-1}, alkaline permanganate method, Subbiah and Asija, 1956), available phosphorus (15.8 kg ha^{-1}, 0.5 N $NaHCO_3$ extraction, Olsen *et al.*, 1954) and available K_2O (174.7 kg ha^{-1}, Metson, 1956). The soil was non saline with a pH value 8.1 (Table A). The experiment was a Split Plot Design consistedof four levels of compaction (zero, 4, 8 and 12 passings of a 500 kg manually driven iron roller) as main plot treatments and three levels of nitrogen (40, 80 and 120 kg N ha^{-1} as urea) and three levels of potassium (20, 40 and 60 kg K_2O ha^{-1} using potassium chloride) as sub-plot treatments. The 36 factorial treatment combinations were replicated four times. The soil was thoroughly prepared and leveled before sowing. A half dose of nitrogen (urea) and full dose of potassium (potassium chloride) was applied as basal dose and remaining half dose of nitrogen was applied as top dressing 30 days after sowing in plot size of 4×3m. The grain samples of about 1.5 - 2.0 kg from individual plot was collected, prepared, grinded and analyzed as per standard methods (Table B) in the laboratory. The variance ratio was calculated by the Fisher (1950) variance technique.

Table A : Physico-chemical properties of experimental soils

Physical properties		Chemical properties	
Mechanical composition			
Course sand (%)	19.9	Available N (kg ha^{-1})	127.3
Fine sand (%)	64.0	Available P_2O_5 (kg ha^{-1})	15.8
Silt (%)	8.7	Available K_2O (kg ha^{-1})	174.7
Clay (%)	7.4	CEC [cmol (p+) kg^{-1}]	6.2
Textural class	Ls	$CaCO_3$ (%)	0.2
Particle density (Mgm^{-1})	2.7	Organic carbon (%)	0.2
Bulk density (Mgm^{-1})	1.5	Total nitrogen (%)	0.02
Hydraulic conductivity ($cmhr^{-1}$)	9.3	ECe (dSm^{-1} at 250C)	1.20
Infiltration rate($cmhr^{-1}$)	20.1	pH (1:2 soil water suspension)	8.1
Moisture retention at 1/3 bar (%)	10.3		

Table B : Effect of levels of compaction on bulk density and per cent moisture content at various stages of crop growth

Compaction levels	Depth (cm)	Bulk density (Mgm^{-3})		Moisture (%)	
		JAC	AH	JAC	AH
C_0	0-15	1.50	1.48	8.34	4.26
	15-30	1.53	1.52	8.68	4.49
C_4	0-15	1.54	1.51	11.04	5.33
	15-30	1.58	1.56	11.82	5.89
C_8	0-15	1.56	1.54	12.50	6.24
	15-30	1.62	1.56	13.20	6.86
C_{12}	0-15	1.60	1.56	13.20	7.00
	15-30	1.66	1.57	13.96	7.68

JAC: Just after compaction, AH: At harvest

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Total amino acids (TAA) and total protein (TP) :

Compaction :

The maximum concentrations of TAA and TP occurred with the maximum compaction, C_{12}. The C_{12} level had 8.96 to 18.29 and 10.92 to 12.73 per cent higher TAA and TP concentrations, respectively over the control, C_0. Significant positive effects (Table 1) of compaction on TAA and TP were likely due to the increased N availability, and more favorable soil physical properties *i.e*. bulk density, moisture storage capacity and non capillary porosity of soil, decrease in hydraulic conductivity and infiltration rate reported by Kirda *et al.* (1973); Ghuman *et al.* (1975), Gupta and Majumdar (1994) and Mathur *et al*. (2006).

Nutrients :

Maximum TAA and TP of wheat occurred (Table 2) with the maximum rate of N, 120 kg N ha^{-1}. The N significantly increased TAA (79.12 to 70.97 %) and TP (13.13 to 12.35 %). Increased TAA and TP with increased N is due to higher N content (Singh and Anderson, 1973). Increasing potassium increased the TAA and TP of wheat grain with 60 kg ha^{-1} (K_{60}). Treatment K_{60} maintains higher values of TAA (14.79 to 12.23 %) and TP (4.36 to 3.96 %) as compared to K at 20 kg ha^{-1}. Sub-surface compaction and levels of potassium has significantly increased nitrogen and potassium utilization efficiency (Majumdar *et al.*, 2000).

Lysine, methionine and proline content :

Compaction :

Increasing compaction increased wheat grain lysine and

Table 1 : Methods used for analysis

Parameter	Procedure	Reference
Total amino acids	By modified ninhydrin method, colour measured using colorimeter	Yemmand Cocking (1955)
Total proteins	Using folin-ciocalteau reagent	Lowry *et al.* (1957)
Lysine	Amino group of lysine form dinitropyridyal derivative with 2 chloro-3, 5 dinitropyridine, a coloured product so formed , estimated colorimetrically	Theymoli and Sadasivam (1987)
Methionine	Methionine gives yellow colour with nitropruside solution under alkaline condition and turns red on acidification. This colour is estimated colorimetrically.	Hern *et al.* (1946)
Proline	Extraction with aqueous sulphosali cyclic acid and reaction with ninhydrin in acid medium the pink colour so obtained is measured colorimetrically	Bates *et al.* (1993)

Table 2 : Effect of compaction, nitrogen and potassium levels on tatal amino acids (TAA) and total protein (TP) content

Treatments	TAA (mg g^{-1})		TP (mg g^{-1})	
	1st year	2nd year	1st year	2nd year
Compaction				
C_0	3.4	3.1	91.5	89.5
C_4	3.5	3.4	94.0	93.2
C_8	3.6	3.5	98.1	98.0
C_{12}	3.7	3.7	101.5	100.9
S.E. ±	0.03	0.12	0.78	0.36
C.D. (P=0.05)	0.11	0.38	2.52	1.14
Nitrogen				
N_{40}	2.5	2.5	89.9	89.9
N_{80}	3.6	3.5	97.3	96.4
N_{120}	4.5	4.2	101.7	101.0
S.E. ±	0.02	0.06	0.56	0.31
C.D. (P=0.05)	0.06	0.17	1.56	0.86
Potassium				
K_{20}	3.3	3.2	94.1	93.4
K_{40}	3.6	3.5	96.6	95.8
K_{60}	3.7	3.6	98.2	97.1
S.E. ±	0.02	0.06	0.56	0.31
C.D. (P=0.05)	0.06	0.17	1.56	0.86

Table 3 : Effect of compaction, nitrogen and potassium levels on lysine, methionine and proline content

Treatments	Lysine (mg g^{-1})		Methionine (mg g^{-1})		Proline (mg g^{-1})	
	1^{st} year	2^{nd} year	1^{st} year	2^{nd} year	1^{st} year	2^{nd} year
Compaction						
C_0	3.24	3.18	3.00	2.98	0.23	0.24
C_4	3.39	3.34	3.22	3.17	0.21	0.20
C_8	3.59	3.49	3.35	3.29	0.19	0.17
C_{12}	3.74	3.65	3.38	3.34	0.16	0.15
S.E. ±	0.039	0.089	0.082	0.054	0.02	0.018
C.D. (P=0.05)	0.126	0.284	0.263	0.176	0.06	0.058
Nitrogen						
N_{40}	3.21	3.19	2.90	2.89	0.19	0.18
N_{80}	3.50	3.40	3.35	3.24	0.20	0.19
N_{120}	3.76	3.66	3.46	3.44	0.23	0.21
S.E. ±	0.021	0.042	0.056	0.029	0.003	0.004
C.D. (P=0.05)	0.059	0.119	0.157	0.083	0.008	0.013
Potassium						
K_{20}	3.24	3.22	2.96	2.92	0.19	0.18
K_{40}	3.50	3.37	3.23	3.19	0.21	0.20
K_{60}	3.74	3.66	3.51	3.47	0.22	0.21
S.E. ±	0.021	0.042	0.056	0.029	0.003	0.004
C.D. (P=0.05)	0.059	0.119	0.157	0.083	0.008	0.013

methionine concentrations, but proline decreased (Table 3). The C_{12} level had 14.75 to 14.07 and 11.80 to 11.36 per cent higher lysine and methionine concentration, and 39.72 to 42.16 per cent lower proline over the control C_0. Positive effects of compaction on lysine and methionine may be due to better moisture availability and root growth in compacted plots. Compaction increased wheat grain protein (Raath and Agenbag, 1997). Proline content decreased with increased compaction in our study, due likely to more optimum moisture and reduced stress conditions that otherwise increase proline.

Nutrients :

Nitrogen significantly increased wheat lysine, methionine and proline content of wheat with 120 kg ha^{-1}, lysine increased 17.13 to 14.73 per cent, methionine 19.31 to 19.03 per cent and proline 20.32 to 19.66 per cent content over the N_{40} treatment. Increased lysine, methionine and protein with increased N were reported by Ahmed and Arain (1999). Higher values for protein and methionine content were also reported with maximal N fertilizers (Crista *et al*., 2012). Higher K levels (K_{60}) also showed increased lysine, methione and proline content of wheat grain. Potassium increased the rate of amino acid translocation into the grain as well as the conversion of amino acids into grain proteins (Mengel *et al*., 1981). Kehui *et al*. (1996) reported increased in amino acids concentration with K fertilizer. Hojjati and Maleki (1972) conducted an experiment to study the effects of N and K fertilization on the lysine, methionine, and total protein contents of wheat and reported that K significantly increased the lysine percentage in the protein.

Conclusion :

On the basis of this study, it is suggested that compaction and nutrients increased TAA, TP, lysine, and methionine likely as a result of improved soil physical properties for better root growth and higher moisture and nutrient availability. The light textured soils are prone to quick nutrient losses were improved and resulted in enhancement of the better nutritive value of wheat grain.

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