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Genetic Variations in Nutrient Contents by Wheat and its Substitution Lines

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Abstract: The different substitution lines and genotypes behaved differently in their biomass yield and nutrient uptake. Plant height, number of productive tillers, straw yield and number of earhead were more in substitution lines than the mother cultivars and check wheat genotypes. Yield of different substitution lines were lower than in check genotypes. The contents of N, P and K in plant parts of shoot, straw and grain were more in substitution lines than the check genotypes. No marked differences were observed in the contents of Ca, Na and Mn both in the lines and genotypes.

Key words: Genotype, genetic variation, *Triticum aestivum*, substitution lines, nutrients.

Introduction

Genetic improvement and development of bread wheat (*Triticum aestivum* L.) obtained by breeding techniques is due to the incorporation of characteristic growth enhancing factors or traits, which are comparatively easily recognized such as diseases resistance and logging phenomena. However, even when these limiting factors are eliminated from the growing environments, the different genotypes display varying response to mineral elements, presumably due to their different genetic make up, physiological and morphological superiority (Wright, 1976). In addition to these scenarioes, numerous soil and other environmental factors may considerably affect the absorption, translocation and utilization of nutrients and tolerance to high mineral concentration (Aoalsteinsson and Jensen, 1990; Gouis *et al.*, 1999; Guopang *et al.*, 1999; Mattsson *et al.*, 1991; Roderiguez *et al.*, 1999; Wissurwa, 1999). The mineral uptake capability of genotypes plays an important role in the growth performance of that particular genotype (Rasmusson *et al.*, 1971).

Studies of nutrient utilization by genotypes is important factor for the evaluation of the breeding value of varieties and crosses that yield the most for each unit of fertilizer applied (Akintoye *et al.*, 1999; Chaillou *et al.*, 1994). This phenomenon is important in view of the rising cost of inorganic fertilizers on global basis. The present study was therefore, undertaken to identify the genotypic differences in the uptake of nutrients contributing characters of 12 chromosome substitution lines, their parent and 2 locally grown wheat genotypes under post house condition at NIA, Tandojam.

Materials and Methods

Experiment was carried out using 12 Chinese spring substitution lines i.e.1A, 4A, 5A, 1B, 4B, 5B, 1D, 2D, 6D, 7D and mother cultivar (Cs-parent) and 2 locally grown genotypes (Sind-81 and Sarsabz) were used as control. The soil used was collected from the surface horizon (0-15 cm) of Nuclear Institute of Agriculture, farm, Tandojam. It was sandy clay loam in texture and alkaline in reaction. Some of the characteristics of soil are: N 0.079%, total P 0.094%, available P ($NaHCO_3$ pH 8.5) 3.5 ppm, organic matter 1.08%, $CaCO_3$ 9.4%, CEC 13.5 meq/100 g soil and pH 7.8. Soil sample was air-dried and then ground to pass through a 40 mesh screen. The bulk soil sample was mixed with 70 kg sterilized farm yard manure (FYM) and with 2 kg of fertilizer mixture containing all the essential plant nutrients. The ratios of fertilizer mixture was composed of ammonium sulphate 28 g, magnesium sulphate 98 g, potassium nitrate 140 g, calcium sulphate 112 g, ferrous sulphate 3.5 g, manganese sulphate1.28 g, boric acid 0.128 g, zinc sulphate 0.128 g, copper sulphate 0.128 g and molybdic oxide 0.02 g (Anon, 1971). Each plastic pot was filled with 9 kg of soil and then watered to field capacity. Eight healthy seeds of each line/variety were sown in each pot. After germination, the plants were thinned to four seedlings per pot. After 55 days of growth, two plants were harvested from each pot, dried in an oven at $70^{0}C$ and their dried weights were recorded. The plant samples were ground in a Wiley mill and retained for chemical analyses. The remaining two plants present in each pot were harvested at the time of maturity. Growth parameters and yield contributing characters were recorded. Straw and grain samples were ground and one-gram sample of each part was used for chemical analyses. The samples were digested with concentrated sulphuric acid (H_2SO_4) and 30% hydrogen peroxide (H_2O_2). Total plant nitrogen was determined by micro-Kjeldahl method. Phosphorus content was determined colorimetrically using phosphomolybdo- yellow colour method. Calcium, potassium and sodium contents were estimated by flame photometer and manganese was determined using potassium periodate (Jackson, 1958). The data were analyzed statistically to evaluate the treatment effects.

Results and Discussion

At 55 days of growth, the substitution line 4A was taller and had more number of tillers than the rest (Table 1). The locally grown check genotypes, (Sarsabz and Sind-81) had significantly less height and number of tillers than all the other lines. But the treatments did not differ significantly. Substitution line 5B yielded more dry biomass than other lines, mother cultivars and the checks. At maturity, the plant height was higher in the substitution lines than the parent and check genotypes. The differences in number of tillers, straw yield and number of earhead were not significantly different (Table 2). The check genotypes Sarsabz and Sindh-81 produced significantly higher weight of earhead, grain yield and 100 grain weight than the substitution lines and their parents. The chromosome lines 1A, 4A, 5A, 4B, 1D and 2D produced more 100 grain weight than their parents (CS-parent).

Chemical analyses of plant parts of the substitution lines and check genotypes for mineral uptake efficiency are given in Tables 3-5.Considerable variations were observed in different substitution lines and check genotypes in their nutrient uptake. The uptake of N was significantly higher in chromosome substitution lines 7D than all the other lines and checks in shoots (5.25%) and straw (1.86%). The N uptake in all A, B and D substitution lines was also significantly higher than mother cultivar and checks in shoots and straw (Table 3 and 4). Similarly, the N uptake in grain of

4B was higher (4.72%) than all the lines and checks (Table 5). These observations have indicated that the chromosome substitution lines are able to transfer the absorbed N from aerial parts to grain. The differential uptake of N by substitution lines suggests that they have greater uptake efficiency as a result of either a stronger root system or greater N absorption by substitution lines. Similar findings have also been reported by others (Clarelli *et al.*, 1998; Gouis *et al.*, 1999; Mattson *et al.*, 1991). The low N content by mother cultivars and checks in shoot and straw indicates the rapid translocation of N to grain material. Similar varietal differences in N uptake by grain of wheat have been reported (Akintoye *et al.*, 1999; Gouis *et al.*, 1999).

Table 1: Variation in mean plant height, number of tillers and shoot dry wt. of wheat genotypes at 55 days of growth

Genotypes	Plant height (cm)	Dry matter wt. (g)	tillers/pot
CS-Parent	46.8 a	10.6 NS	6.11 ab
CS-S-615/1A	48.2 a	9.04	3.79 bc
CS-S-615/4A	51.8 a	14.2	4.95 abc
CS-S-615/5A	43.5 ab	12.3	5.42 abc
CS-S-615/7A	45.4 ab	11.7	4.31 bc
CS-S-615/1B	44.5 ab	12.8	4.93 abc
CS-S-615/4B	48.5 a	10.4	5.83 ab
CS-S-615/5B	49.6 a	10.9	7.23 a
CS-S-615/1D	46.1 a	12.1	4.95 abc
CS-S-615/2D	48.5 a	13.8	4.59 bc
CS-S-615/6D	49.8 a	10.7	3.09 c
CS-S-615/7D	43.0 ab	13.3	3.33 c
Sind-81(Local)	35.8 b	10.9	3.86 bc
Sarsabz (Check)	38.5 b	7.5	4.52 bc

*Means followed by same letters do not differ significantly at 5% by DMRT.

Table 2: Growth parameters and yield contributing characters of wheat genotypes at maturity.

Genotypes	Plant height (cm)	Number of productive tillers/pot	Straw yield (g)	No.of earhed	Wt.of earhed (g)	Grain yield (g)	100-grain wt. (g)
CS-Parent	74.7	8.50	21.5	19.0	10.95	5.90	1.11
CS-S-615/1A	85.1	7.25	17.8	18.0	7.00	3.36	1.46
CS-S-615/4A	83.4	7.50	21.9	16.3	8.25	5.04	1.56
CS-S-615/5A	76.2	7.62	20.5	19.0	8.25	4.65	1.21
CS-S-615/7A	82.4	9.13	21.8	15.8	7.50	3.30	0.84
CS-S-615/1B	82.9	9.75	20.3	17.8	7.75	4.26	0.93
CS-S-615/4B	87.2	7.87	19.5	16.5	9.00	5.48	1.45
CS-S-615/5B	84.1	6.67	19.8	18.5	8.50	4.49	1.39
CS-S-615/1D	83.1	10.35	20.3	16.8	10.25	6.37	1.38
CS-S-615/2D	81.3	7.67	20.0	18.8	9.25	5.07	1.03
CS-S-615/6D	78.8	7.67	20.0	18.8	9.25	5.07	1.03
CS-S-615/7D	73.5	7.13	22.1	16.3	9.50	3.30	1.02
Sind-81(Local)	68.5	6.37	16.3	14.3	18.75	11.20	2.96
Sarsabz (Cheak)	70.6	5.63	14.9	11.5	17.25	10.20	3.12
S.E.	2.75	1.08	1.73	2.04	2.00	1.60	0.18
LSD 5%	NS	NS	NS	NS	NS	4.58	NS
LSD 1%	10.48	NS	NS	NS	7.65	NS	0.713

NS = Non significant

Table 3: Mineral content by wheat genotypes at 55 days of growth

Genotypes	Mineral content in percent of dry wt.:ug/g dry wt.					
	N	P	K	Ca	Na	Mn
CS-Parent	3.36	0.100	7.45	0.280	0.140	75
CS-S-615/1A	4.48	0.125	7.90	0.280	0.142	100
CS-S-615/4A	4.27	0.111	7.85	0.285	0.145	122
CS-S-615/5A	3.78	0.099	7.75	0.285	0.152	119
CS-S-615/7A	4.55	0.126	7.60	0.260	0.160	185
CS-S-615/1B	4.13	0.108	7.85	0.290	0.137	125
CS-S-615/4B	3.46	0.114	7.50	0.270	0.142	86
CS-S-615/5B	3.50	0.111	7.40	0.270	0.135	80
CS-S-615/1D	4.41	0.103	7.85	0.290	0.150	103
CS-S-615/2D	4.67	0.128	7.45	0.260	0.145	200
CS-S-615/6D	3.92	0.114	7.95	0.295	0.145	78
CS-S-615/7D	5.25	0.120	7.50	0.270	0.135	153
Sind-81(Local)	2.59	0.095	5.55	0.270	0.125	50
Sarsabz(Check)	3.29	0.072	5.90	0.295	0.150	48
S.E	0.262	0.0053	0.165	0.0065	0.0062	13.42
LSD at 5%	0.75	NS	NS	NS	NS	NS
LSD at 1%	1.00	0.020	0.63	0.025	NS	51

NS = Non significant

Table 4: Mineral content of wheat genotypes in straw at maturity.

Genotypes	Mineral content in percent of dry wt. : ug/g dry wt.					
	N	P	K	Ca	Na	Mn
CS-Parent	1.22	0.25	4.82	0.40	0.40	32.5
CS-S-615/1A	1.79	0.28	4.68	0.38	0.37	17.5
CS-S-615/4A	1.37	0.30	5.08	0.48	0.32	36.3
CS-S-615/5A	1.26	0.32	4.70	0.48	0.52	51.5
CS-S-615/7A	1.79	0.31	4.73	0.63	0.62	30.0
CS-S-615/1B	1.68	0.27	5.00	0.48	0.47	18.8
CS-S-615/4B	1.47	0.31	4.95	0.40	0.47	36.3
CS-S-615/5B	1.44	0.36	4.63	0.38	0.75	32.0
CS-S-615/1D	1.50	0.26	4.73	0.48	0.60	30.0
CS-S-615/2D	1.65	0.27	4.98	0.48	0.67	18.8
CS-S-615/6D	1.28	0.32	5.04	0.48	0.60	21.3
CS-S-615/7D	1.86	0.29	5.03	0.48	0.62	22.5
Sind-81(Local)	0.70	0.21	4.78	0.40	0.85	32.5
Sarsabz(Check)	0.65	0.14	5.08	0.50	0.85	30.0
S.E.	0.133	0.023	0.197	0.059	0.058	4.41
LSD at 5%	0.382	0.07	NS	NS	0.017	12.60
LSD at 1%	0.511	0.09	NS	NS	0.22	16.84

NS = Non significant

Table 5: Mineral content in wheat genotypes in grain.

Genotypes	Mineral content in percent of dry wt. : ug/g dry wt.					
	N	P	K	Ca	Na	Mn
CS-Parent	2.28	1.10	0.68	0.048	0.080	72.9
CS-S-615/1A	3.05	1.18	0.56	0.051	0.062	52.4
CS-S-615/4A	1.69	0.88	0.58	0.056	0.094	45.4
CS-S-615/5A	1.65	1.03	0.63	0.051	0.081	77.5
CS-S-615/7A	2.87	1.08	0.78	0.100	0.106	54.7
CS-S-615/1B	3.67	1.33	0.73	0.063	0.063	68.2
CS-S-615/4B	4.72	0.98	0.57	0.050	0.081	102.7
CS-S-615/5B	2.57	0.88	0.65	0.051	0.094	38.6
CS-S-615/1D	2.52	1.15	0.84	0.052	0.094	72.6
CS-S-615/2D	3.40	1.10	0.58	0.056	0.075	59.1
CS-S-615/6D	3.50	1.10	0.73	0.081	0.094	68.2
CS-S-615/7D	2.99	1.20	0.76	0.069	0.075	52.4
Sind-81(Local)	1.57	0.85	0.50	0.050	0.088	72.6
Sarsabz(Check)	1.62	0.80	0.54	0.048	0.080	72.6
S.E.	0.331	0.065	0.055	0.0039	0.0147	10.32
LSD at 5%	0.95	0.18	0.16	0.011	NS	29.5
LSD at 1%	1.27	0.25	0.21	0.048	NS	NS

NS = Non significant

The substitution lines with superior P uptake were also identified in the present work (Table 3-5). All the lines had significantly higher uptake of P in shoot, straw and grain than the parent and check genotypes. Substitution lines 2D, 5B and 1B showed higher P uptake than the other cultivars and checks in shoots(1.3%), straw (0.36%) and grain (1.33%), respectively. Phosphorus content in grains of genotypes was higher than shoot and straw. Phosphorus is an important constituent of grain of cereal crops and is the most necessary for seed development (Seng *et al.*, 1994). Therefore, these lines can be classified as P efficient genotypes, because of their high P uptake capabilities (Roderiguez *et al.*, 1999: Subbarao *et al.*, 1977 ; Wissurwa,1999).

The substitution lines and the mother cultivars (CS-parent) have shown significant difference in K uptake in shoot and grain, but non-significant in straw. These results point out the possible genotypic difference in K uptake (Guopang *et al.*, 1999 ; Walker and Schillinger,1975). The substitution lines showed higher Ca uptake in grains as compared to control and check genotypes. This indicates the possible and rapid translocation of Ca from portion of aerial parts to grain. Similar findings have been reported by Clark (1983). Sodium content in all the genotypes was insignificant in both shoot and grain. Locally grown check genotypes have shown higher uptake of Na compared to substitution lines. The substitution lines have significantly higher Mn content in shoot at 55 days of growth than the mother cultivar and check genotypes (Table 3). Manganese content in straw and grain also differed among each other in majority of the cases and its content was more in grain than straw. Differential uptake of Mn has also been reported for other crops (Yang, *et al.*, 1998).

The results clearly indicated that mineral uptake from soil by cereal crop plants is not only influenced by the environmental growth conditions, but to a greater extent by their hereditary potentialities. Similar conclusion about hereditary variations in plant nutrient uptake was drawn earlier (Harvey, 1939). Based on the findings of some elegant experimental results, Beadle and Tatum (1959) reported that many nutritional variations among plant varieties are the result of single gene mutation, which exerts and influence the absorption and utilization of mineral nutrients. It is evident from the present findings that there is a wide genetic variation among the substitution lines and checks in their absorption and translocation of mineral elements from the growing media under present experimental conditions. The genetic variations may reflect the difference in mechanism of ion transports which is considered to be under genetic control (Lauchli, 1976). Therefore, the genetic variants among the substitution lines are the possible factors affecting the uptake of mineral nutrients (Jensen and Patterson, 1980) in the present studies. It was concluded that mineral uptake studies provide guideline for the characteristics and breeding of nutritionally efficient substitution lines and wheat genotypes.

References

Akintoye, H.A., J.G. Kling and E.O.Lucas, 1999. N use efficiency of single , double and ynergetic maize lines grown at four N levels in three ecological zones of West Africa. Field Crops Res., 60: 189-199.

Anonymous, 1971. Kuwait Hydroponics Research Station, Ahmadi , Kuwait.

Aoalsteinsson, S. and P. Jensen, 1990. Influence of temperature on root development and phosphate influx in winter wheat grown at different P levels. Physiologia Plant, 80: 69-74..

Beadle, G.W and E.L Tatum, 1959. Genetic basis of selective ion transport. I. In. Annual Rev. Plant Physiol., 15. 169-184.

Chaillou,S., J.W. Rideout, C.D. Raper.jr and J.F.M. Goudry, 1994. Responses of soybean to ammonium and nitrate supplied in combination to the whole root system or separately in a split-root system. Physiologia plant, 90: 259-268.

Clarelli, D.M., A.M.C. Furland, A.R.Dechen and M. Lima, 1998. Genetic variation among maize genotypes for phosphorus uptake and phosphorus use efficiency in nutrient solution. J. Plant Nutr., 21: 2219-2229.

Clark, R.B., 1983. Plant genotype difference in the uptake, translocation, accumulation and use of mineral elements required for plant growth. Plant and Soil, 72, 175-196.

Gouis, L. J., O.Delebarre, D. Beghin, E.Heumez and P. Phechard, 1999. Nitrogen uptake and utilization efficiency of two row and six row winter barley cultivars grown at two N levels. Eu.J.Agron., 10: 73-79.

Guopang, Z., C. Jingxing and E.A. Tirore, 1999. Genotypic variation for potassium uptake and utilization efficiency in wheat, Nut. Cycle. Agroecoyst., 59: 41-48

Harvey, P.H., 1939. Hereditary variation in plant nutrition. Genetic, 34: 437-461.

Jackson, M.L., 1958. Soil chemical analysis. Prentice Hall Inc. N.J.,USA.

Jensen, P. and S. Pattersen, 1980. Varietal variation in uptake and utilization of potassium, rubidium in high salt seedling of barley. Plant Physiol., 48, 411-415.

Lauchli, A., 1976. Genotypic variation in transport. pp. 372-393. In. Transport in plants. II. Tissues and Organs. Vol. 2. Part. B. Eds. U. Luttage and M.G. Pitman. Ency. of Plant Physiol. New series. Springer, Berlin.

Mattson, M., E. Johanson, T. Lundbarg and C.M. Larson, 1991. Nitrogen utilization in N- limited barley during vegetative and generative growth. 1. Growth and nitrate uptake kinetics in vegetative cultures grown at different relative addition rates of nitrate-N. J. Expt. Bot., 42: 197-205.

Nyborg, M., 1970. Sensitivity in manganese deficiency of different cultivars of wheat, oats and barley. Can. J. Plant Sci., 4: 586-589.

Rasmusson, D.C., A.J. Hester, G.N. Pick and I. I. Byrne, 1971. Breeding for mineral content in wheat and barley. Crop Sci., 4: 586-598.

Roderiguez, F., H. Andrade and J. Gouriann, 1999. Effects of phosphorus nutrition on tiller emergence in wheat. Plant and Soil, 209: 1000-1009.

Seng,V., R.W. Bell, I.R.Willet and H.J.Nesbitt, 1994. Phosphorus nutrition of rice relation to floating and temporary loss of soil water saturation in lowland soils of Cambodia. Plant and Soil, 207: 121-132.

Subbarao, G.V., N. Ae and T.Otani, 1997. Genetic variation in acquisition and utilization of phosphorus from iron-bound phosphorus. Soil Sci. Plant Nutr., 43: 511-519

Walker, A.K. and J.A. Schillinger, 1975. Genotypic response to potassium in soybeans. Crop Sci., 15: 581-583.

Wissurwra, M. and N. Ae, 1999. Genotypic variation for phosphorus uptake from hardly soluble iron-phosphate in groundnut. Plant and Soil, 206: 163-171

Wright, M.J. (Eds). 1976. Plant adaptation to mineral stress in problem soils. Proc. Workshop at Beltsville. Md. Cornell Univ. Agric. Exp. Stn. Ithaca, N.Y., USA.

Yang, X., Z.Q. Ye, C.H. Shi, M.L. Zhu and R.D. Graham, 1998. Genotypic differences in concentrations of iron, manganese ,copper and zinc in polished rice . J. Plant. Nutr., 21: 1453-1462.