The Pharma Innovation Journal 2022; SP-11(8): 2114-2117

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(8): 2114-2117

www.thepharmajournal.com
Received: 28-05-2022
Accepted: 30-06-2022

Anantha Reddy M
Department of Horticulture, Department of Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

P Vasudev Naik
Department of Horticulture, Department of Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

Jaiprakash Narayan RP
Department of Horticulture, Department of Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

Pampanna Y
Department of Horticulture, Department of Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

Govindappa MR
Department of Horticulture, Department of Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

Mahantesh Y Jogi
Department of Horticulture, Department of Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author
Anantha Reddy M
Department of Horticulture, Department of Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

Correlation and path analysis in onion genotypes under North-Eastern dry zone of Karnataka

Anantha Reddy M, P Vasudev Naik, Jaiprakash Narayan RP, Pampanna Y, Govindappa MR and Mahantesh Y Jogi

Abstract
An investigation was carried out on Correlation and path analysis in onion genotypes under North-Eastern dry zone of Karnataka at ICAR-KVK, Hagari, Benchikottal, Ballari, with thirty two onion genotypes in three replication. To determine correlation and path co-efficient analysis during *rabi* (2020-21). Correlation co-efficient analysis revealed that total yield per plot had positive and significant correlation with Plant height (cm), number of leaves per plant, leaf length (cm), leaf area (cm^2), average bulb weight (g), longitudinal diameter of bulb (cm), equatorial diameter of bulb (cm), number of rings per bulb, days to maturity, bulb neck thickness (cm), dry matter of onion (%), total yield per plot (kg/plot) at genotypic and phenotypic level. Path co-efficient analysis revealed that Plant height (cm), average bulb weight (g),equatorial diameter of bulb (cm), total soluble solids (^{0}B), bulb shape index and dry matter of onion percent exhibited positive and direct effect on total yield per plot, and could be utilized as selection criteria in onion improvement programme.

Keywords: Correlation, path, onion, genotypes

Introduction
Onion (*Allium cepa* L.) is a prime vegetable crop of the genus *Allium* belongs to the family Amaryallidaceae under order Asparagales having chromosome number 2n (2x) =16. It is confounded to be originated from Central Asia as center of origin and near East and Mediterranean regions are considered as secondary centers of origin (Vavilov, 1926 and McCollum, 1976) [14, 10]. Onions are used as raw in the form of salad, vegetable and spice all over the world (Katyal, 1985) [7]. The bulb and greens are rich in vitamin C, dietary fiber, mineral potassium, folic acid and it is richest source of mineral vanadium. It is also contains calcium, iron and high quality protein with low sodium without fat (Roshania and Agrawal, 1981) [12]. Onion bulb contains 86.80 per cent of moisture, 11.00 g of carbohydrates, 1.20 g of protein, 0.60 g of fiber, 0.08 mg of thiamine, 11.00 mg of vitamin C, 180.00 mg of calcium, 50.00 mg of phosphorus, 0.70 mg of iron, 0.40 mg of nicotinic acid and 0.01 mg of riboflavin per 100.00 g of edible portion (Nadkarni, 1993) [11]. The onion is significantly differed from other *Allium* species with shape, size, colour, flavor and other characters of bulbs and foliage. Onion has strong flavor due to presence of sulphur containing compound "allyl propyl disulphide" responsible for distinctive smell and pungency. Highly pungent red coloured onions are preferred in India, the yellow colour in onion is due to the presence of another pigment "quercetin" and red colour in onion is due to the presence of another pigment "anthocyanin". India is the second largest producer of onion in the world after china and occupies an area of 1,431.38 thousand hectares and production of 26,091.38 thousand metric tons with productivity of 18.23 t/ha. Maharashtra is the leading state in cultivation of onion and occupies an area of 618 thousand hectare with the production of 10,683 thousand metric tons, however the highest productivity is recorded from Sikkim with 56.11 ton/ha (Anonymous 2019-20) [1]. In Karnataka, onion is cultivated in an area of 160.00 thousand hectares and production of 2,275.00 thousand metric tons with a productivity of 14.22 t/ha. (Anonymous, 2019-20) [1]. Path coefficient analysis is the partitioning of total correlation into direct and indirect percentage contribution of various yield components to the final bulb yield in onion. The advantage of path-coefficient analysis is that it permits the partitioning of the correlation co-efficient into its components. In agriculture, path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield. In this study, attempt was made to study the direct and indirect influences of some important yield components among themselves and to yield through path analysis.

Materials and Methods

The experiment was conducted at ICAR-KVK, Hagari, Benchikottal, Ballari during *rabi* season (2020-2021) using thirty two onion genotypes collected at different places were taken for study (Table 1). Seedlings of 40 days old were transplanted to the main field during *rabi* season. The experiment was laid out by adopting Randomized Block Design with three replications with a spacing of 15 cm x 10 cm. One thirty three plants per genotype per replication were maintained. The correlation co-efficient were worked out to determine the degree of association of a character with yield and also among the yield components. Genotypic and phenotypic correlations were computed by using the formula given by Weber and Morthy (1952) [15]. Path analysis was carried out by using both phenotypic and genotypic correlation co-efficient to know the direct and indirect effects of the components on yield as suggested by Wright (1921) [16] and illustrated by Dewey and Lu (1959) [4].

Results and Discussion

Correlation coefficient analysis is a statistical measure which is used to find out the degree and direction of relationship between two or more variables. Association among different yield attributing characters with total yield was calculated in all possible phenotypic (P) and genotypic (G) level which is presented in Table 2 and 3. Character wise results of the correlation study were explained at genotypic and phenotypic levels. Estimates for phenotypic and genotypic correlation co-efficient imply that genotypic correlation was of a higher magnitude than the corresponding phenotypic correlation for most of the character combinations, thereby establishing a strong inherent relationship among the attributes studied.

Average bulb weight (0.968; 0.908) expressed highest positive and significant association with total yield per plot at genotypic and phenotypic correlation level followed by days to maturity (0.934; 0.822), plant height (0.928; 0.805), leaf length (0.919; 0.784), equatorial diameter of bulb (0.908; 0.811), leaf area (0.885; 0.784), dry matter of onion percent (0.754; 0.651); number of rings per bulb (0.626; 0.533), longitudinal diameter of bulb (0.552; 0.463), number of leaves per plant (0.509; 0.217), bulb neck thickness (0.357; 0.318). Total yield per plot expressed positive non-significant association on thickness of onion scale (0.1308; 0.1003) and total soluble solids (0.0733; 0.0700). Whereas, bulb shape index (-0.564; -0.463) expressed negative and significant association at genotypic and phenotypic correlation for total yield per plot. Similar result are in agreement with Basha and Lakshmi (2018) [2], Solanki *et al*. (2015) [13], Kale *et al*. (2015) [6], Lakshmi (2015) [8] and Chatto *et al*. (2015) [3].

The path coefficient analysis which splits total correlation coefficient of different characters into direct and indirect effects on total yield per plot in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation. The phenotypic correlation coefficient of total yield and its components were broken down into direct and indirect effect and taking total yield per plot as depended variables and rest of the characters were taken as independent variables. Direct and indirect effects of total yield contributing characters in onion are presented in Table 4 and 5.

Among all the characters studied total yield per plot had highest positive and direct effect on average bulb weight (1.1464; 0.6910), followed by plant height (0.4356; 0.4402), equatorial diameter of bulb (0.1293; 0.2840), bulb shape index (0.1140; 0.0755), total soluble solids (0.0274; 0.446), dry matter of onion percentage (0.0025; 0.0728) at genotypic and phenotypic level respectively. Total yield per plot had negative and direct effect on bulb neck thickness (-0.0159; -0.0474) followed by number of rings per bulb (-0.0870; -0.0043), number of leaves per plant (-0.1267; -0.0483), thickness of onion scale (-0.1294; -0.0762), longitudinal diameter of bulb (-0.1832; -0.1591), leaf length (-0.2833; -0.2447) at genotypic and phenotypic level. Whereas, leaf area (0.2511; -0.1119) had positive direct effect at genotypic level and negative with direct effect at phenotypic level. While, days to maturity (-0.3570; 0.0349) had negative direct effect at genotypic level and positive with direct effect at phenotypic level. Similar findings are in accordance with the work of Lakshmi (2015) [8], Kale *et al*. (2015) [6], Solanki *et al*. (2015) [13], Chatto *et al*. (2015) [3] and Haydar *et al*. (2007) [5].

Table 2: Genotypic correlation co-efficient of different characters on yield per plot in onion genotypes

Genotypic Correlation Matrix															
	PH	**NL**	**LL**	**LA**	**ABW**	**LDB**	**EDB**	**NR/B**	**ST**	**DM**	**TSS**	**BNT**	**BSI**	**DMP**	**TYPP**
PH	1	0.697**	0.922**	0.956**	0.936**	0.594**	0.803**	0.512**	0.002	0.984**	0.141	0.335**	-0.419**	0.915**	0.928**
NL		1	0.697**	0.591**	0.547**	0.1970	0.411**	0.1314	0.065	0.586**	-0.271*	0.100	-0.236*	0.984**	0.509**
LL			1	0.949**	0.920**	0.564**	0.782**	0.478**	-0.011	0.980**	0.135	0.335**	-0.427**	0.934**	0.919**
LA				1	0.914**	0.608**	0.860**	0.580**	0.202*	0.997**	0.116	0.262*	-0.481**	0.818**	0.885**
ABW					1	0.619**	0.946**	0.661**	0.234*	0.949**	0.005	0.356**	-0.562**	0.754**	0.968**
LDB						1	0.583**	0.403**	0.125	0.674**	-0.160	0.031	0.165	0.312*	0.552**
EDB							1	0.681**	0.331**	0.857**	-0.003	0.431**	-0.680**	0.577**	0.908**
NR/B								1	0.034	0.588**	0.223*	0.431**	-0.526**	0.307*	0.626**
ST									1	0.110	-0.084	-0.091	-0.284*	0.072	0.1308
DM										1	0.155	0.308*	-0.418**	0.749**	0.934**
TSS											1	0.116	-0.096	0.104	0.073
BNT												1	-0.503**	0.250*	0.357**
BSI													1	-0.358**	-0.564**
DMP														1	0.754**

Critical r value 5% = 0.200 1% = 0.330 * Significant at 5% level of significance ** Significant at 1% level of significance

PH- Plant height (cm) NL- Number of leaves per plant LL- Leaf length (cm)

LA- Leaf area (cm^2) ABW- Average bulb weight (g) LDB- Longitudinal diameter of bulb (cm)

EDB- Equatorial diameter of bulb (cm) NR- Number of rings per bulb ST-Thickness of onion scale (mm)

DM- Days to maturity TSS- Total soluble solids (^{0}B) BNT- Bulb neck thickness (cm)

BSI- Bulb shape index DMP- Dry matter of onion (%) TYPP- Total yield per plot (kg/plot)

Table 3: Phenotypic correlation co-efficient of different characters on bulb yield per plot in onion genotypes

Phenotypic Correlation Matrix														
	PH	**NL**	**LL**	**LA**	**ABW**	**LDB**	**EDB**	**NR/B**	**ST**	**DM**	**TSS**	**BNT**	**BSI**	**DMP**	**TYPP**
PH	1	0.278*	0.984**	0.831**	0.802**	0.553**	0.690**	0.475**	0.0470	0.869**	0.0784	0.267*	-0.262*	0.750**	0.805**
NL		1	0.284*	0.408**	0.289*	0.0855	0.234*	0.0333	0.0466	0.234*	-0.1020	0.0251	-0.1586	0.254*	0.217*
LL			1	0.832**	0.789**	0.539**	0.687**	0.431**	0.0561	0.859**	0.0574	0.263*	-0.272*	0.743**	0.784**
LA				1	0.855**	0.532**	0.799**	0.452**	0.1858	0.867**	0.0713	0.234*	-0.404**	0.619**	0.784**
ABW					1	0.563**	0.876**	0.552**	0.1950	0.868**	-0.0019	0.336**	-0.455**	0.618**	0.908**
LDB						1	0.518**	0.343**	0.1334	0.593**	-0.1039	0.0704	0.257*	0.239*	0.463**
EDB							1	0.560**	0.280*	0.747**	-0.0078	0.389**	-0.655**	0.477**	0.811**
NR/B								1	0.0503	0.539**	0.1856	0.359**	-0.343**	0.259*	0.533**
ST									1	0.1188	-0.0099	-0.1201	-0.1829	0.0560	0.1003
DM										1	0.1189	0.260*	-0.310*	0.645**	0.822**
TSS											1	0.1479	-0.0339	0.0082	0.0700
BNT												1	-0.368**	0.1737	0.318*
BSI													1	-0.292*	-0.463**
DMP														1	0.651**

Critical r value 5% = 0.200 1% = 0.330 * Significant at 5% level of significance ** Significant at 1% level of significance
PH- Plant height (cm) NL- Number of leaves per plant LL- Leaf length (cm)
LA- Leaf area (cm^2) ABW- Average bulb weight (g) LDB- Longitudinal diameter of bulb (cm)
EDB- Equatorial diameter of bulb (cm) NR- Number of rings per bulb ST-Thickness of onion scale (mm)
DM- Days to maturity TSS- Total soluble solids (^{0}B) BNT- Bulb neck thickness (cm)
BSI- Bulb shape index DMP- Dry matter of onion (%) TYPP- Total yield per plot (kg/plot)

Table 4: Genotypic path coefficients showing direct and indirect effects of different parameters on yield per plot in onion genotypes

Genotypic PATH matrix of Total yield per plot														
	PH	**NL**	**LL**	**LA**	**ABW**	**LDB**	**EDB**	**NR/B**	**ST**	**DM**	**TSS**	**BNT**	**BSI**	**DMP**
PH	0.4356	0.3036	0.4376	0.4162	0.4078	0.2588	0.3496	0.2228	0.0012	0.4286	0.0617	0.146	-0.1824	0.3986
NL	-0.0883	-0.1267	-0.0884	-0.0749	-0.0693	-0.0250	-0.0521	-0.0166	-0.0082	-0.0742	0.0343	-0.0128	0.0299	-0.1246
LL	-0.2846	-0.1976	-0.2833	-0.2688	-0.2606	-0.1599	-0.2215	-0.1355	0.0032	-0.2776	-0.0382	-0.0950	0.1210	-0.2646
LA	0.2399	0.1484	0.2382	0.2511	0.2295	0.1525	0.2158	0.1456	0.0508	0.2504	0.0292	0.0659	-0.1207	0.2055
ABW	1.0733	0.6271	1.0547	1.0480	1.1464	0.7098	1.0849	0.7572	0.2687	1.0882	0.0065	0.4081	-0.6438	0.8644
LDB	-0.1088	-0.0361	-0.1034	-0.1113	-0.1134	-0.1832	-0.1068	-0.0738	-0.0229	-0.1234	0.0294	-0.0057	-0.0302	-0.0571
EDB	0.1037	0.0531	0.1011	0.1111	0.1223	0.0754	0.1293	0.0880	0.0428	0.1108	-0.0004	0.0557	-0.0879	0.0746
NR/B	-0.0445	-0.0114	-0.0416	-0.0505	-0.0575	-0.0350	-0.0593	-0.0870	-0.0030	-0.0512	-0.0194	-0.0375	0.0458	-0.0267
ST	-0.0003	-0.0084	0.0015	-0.0262	-0.0303	-0.0162	-0.0429	-0.0044	-0.1294	-0.0143	0.0110	0.0119	0.0368	-0.0094
DM	-0.3512	-0.2091	-0.3498	-0.3560	-0.3388	-0.2405	-0.3059	-0.2100	-0.0393	-0.3570	-0.0555	-0.1101	0.1490	-0.2672
TSS	0.0039	-0.0074	0.0037	0.0032	0.0002	-0.0044	-0.0001	0.0061	-0.0023	0.0043	0.0274	0.0032	-0.0026	0.0028
BNT	-0.0053	-0.0016	-0.0053	-0.0042	-0.0057	-0.0005	-0.0069	-0.0069	0.0015	-0.0049	-0.0018	-0.0159	0.0080	-0.0040
BSI	-0.0477	-0.0269	-0.0487	-0.0548	-0.0640	0.0188	-0.0776	-0.0600	-0.0324	-0.0476	-0.0110	-0.0574	0.1140	-0.0408
DMP	0.0023	0.0025	0.0023	0.0021	0.0019	0.0008	0.0014	0.0008	0.0002	0.0019	0.0003	0.0006	-0.0009	0.0025
TYPP	0.928**	0.509**	0.919**	0.885**	0.968**	0.552**	0.908**	0.626**	0.1308	0.934**	0.0733	0.357**	-0.564**	0.754**

Residual effect = 0.207* Significant at 5% level of significance ** Significant at 1% level of significance
Diagonal vales indicates direct effect
PH- Plant height (cm) NL- Number of leaves per plant LL- Leaf length (cm)
LA- Leaf area (cm^2) ABW- Average bulb weight (g) LDB- Longitudinal diameter of bulb (cm)
EDB- Equatorial diameter of bulb (cm) NR- Number of rings per bulb ST-Thickness of onion scale (mm)
DM- Days to maturity TSS- Total soluble solids (^{0}B) BNT- Bulb neck thickness (cm)
BSI- Bulb shape index DMP- Dry matter of onion (%) TYPP- Total yield per plot (kg/plot)

Table 5: Phenotypic path coefficients showing direct and indirect effects of different parameters on yield per plot in onion genotypes

Phenotypic PATH matrix of Total yield per plot														
	PH	**NL**	**LL**	**LA**	**ABW**	**LDB**	**EDB**	**NR/B**	**ST**	**DM**	**TSS**	**BNT**	**BSI**	**DMP**
PH	0.4402	0.1223	0.4332	0.3657	0.3528	0.2434	0.3037	0.2093	0.0207	0.3827	0.0345	0.1176	-0.1155	0.3303
NL	-0.0134	-0.0483	-0.0137	-0.0197	-0.0139	-0.0041	-0.0113	-0.0016	-0.0023	-0.0113	0.0049	-0.0012	0.0077	-0.0123
LL	-0.2408	-0.0694	-0.2447	-0.2036	-0.1930	-0.1319	-0.1682	-0.1053	-0.0137	-0.2102	-0.0140	-0.0643	0.0666	-0.1819
LA	-0.0929	-0.0456	-0.0931	-0.1119	-0.0956	-0.0595	-0.0894	-0.0506	-0.0208	-0.0969	-0.0080	-0.0261	0.0452	-0.0692
ABW	0.5539	0.1997	0.5450	0.5905	0.6910	0.3893	0.6055	0.3816	0.1348	0.5995	-0.0013	0.2322	-0.3145	0.4269
LDB	-0.0880	-0.0136	-0.0858	-0.0846	-0.0897	-0.1591	-0.0824	-0.0546	-0.0212	-0.0943	0.0165	-0.0112	-0.0410	-0.0380
EDB	0.1959	0.0665	0.1952	0.2269	0.2488	0.1471	0.2840	0.1590	0.0796	0.2120	-0.0022	0.1104	-0.1861	0.1353
NR/B	-0.0021	-0.0001	-0.0019	-0.0020	-0.0024	-0.0015	-0.0024	-0.0043	-0.0002	-0.0023	-0.0008	-0.0016	0.0015	-0.0011
ST	-0.0036	-0.0036	-0.0043	-0.0142	-0.0149	-0.0102	-0.0213	-0.0038	-0.0762	-0.0091	0.0008	0.0092	0.0139	-0.0043
DM	0.0303	0.0082	0.0300	0.0302	0.0303	0.0207	0.0261	0.0188	0.0041	0.0349	0.0041	0.0091	-0.0108	0.0225
TSS	0.0035	-0.0045	0.0026	0.0032	-0.0001	-0.0046	-0.0003	0.0083	-0.0004	0.0053	0.0446	0.0066	-0.0015	0.0004
BNT	-0.0127	-0.0012	-0.0124	-0.0111	-0.0159	-0.0033	-0.0184	-0.0170	0.0057	-0.0123	-0.0070	-0.0474	0.0174	-0.0082
BSI	-0.0198	-0.0120	-0.0206	-0.0305	-0.0344	0.0194	-0.0495	-0.0259	-0.0138	-0.0234	-0.0026	-0.0278	0.0755	-0.0220
DMP	0.0546	0.0185	0.0541	0.0451	0.0450	0.0174	0.0347	0.0188	0.0041	0.0469	0.0006	0.0126	-0.0212	0.0728

TYPP	0.805**	0.217*	0.784**	0.784**	0.908**	0.463**	0.811**	0.533**	0.1003	0.822**	0.0700	0.318*	-0.463**	0.651**

Residual effect = 0.364 * Significant at 5% level of significance ** Significant at 1s% level of significance
Diagonal values indicates direct effect
PH- Plant height (cm) NL- Number of leaves per plant LL- Leaf length (cm)
LA- Leaf area (cm^2) ABW- Average bulb weight (g) LDB- Longitudinal diameter of bulb (cm)
EDB- Equatorial diameter of bulb (cm) NR- Number of rings per bulb ST-Thickness of onion scale (mm)
DM- Days to maturity TSS- Total soluble solids (^{0}B) BNT- Bulb neck thickness (cm)
BSI- Bulb shape index DMP- Dry matter of onion (%) TYPP- Total yield per plot (kg/plot)

Conclusion

Average bulb weight is the superior character which resulted from multiple interaction of several other components thus, identification of important yield components and information about their inter relationship with each other will be very useful for developing breeding strategy. Direct selection of the traits would improve breeding efficiency, leading to increase in the production. As a result, the characters might be considered as the most relevant component traits for total yield per plot.

References

1. Anonymous, National Horticulture Research and Development Federation. Government of India; c2019.
2. Basha DR, Lakshmi LM. Correlation and Path Coefficient Analysis for Some Yield and Related Traits in onion (*Allium cepa* L.) Genotypes. Int. J Pure App. Bio sci. 2018;6(5):1249-1254.
3. Chattoo MA, Angrej, Kamaluddin. Genetic Variability, Interrelationship and path analysis for yield and yield related traits in onion (*Allium cepa* L.) under temperate condition in Kashmir valley. Pl. Archives. 2015;15(2):1161-1165.
4. Dewey DR, Lu KH. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 1959 Sep;51(9):515-518.
5. Haydar A, Sharker N, Ahmed MB, Hannan MM, Razvy MA, Hossain M, *et al*., Genetic variability and interrelationship in onion (*Allium cepa* L.), Middle-East J Sci. Res. 2007;2(3-4):132-134.
6. Kale O, Rangare SB, Yadav V, Chandravanshi D, Banjare C. Assessment of post-harvest losses in different treatments of onion (*Allium cepa* L.) bulbs during storage at room condition. Acta Hortic. 2015;29(2):555-558.
7. Katyal SL. Vegetable growing in India, Oxford and IBH pub Co. New Delhi; c1985.
8. Lakshmi R. Studies on genetic variability, correlation and path analysis of yield and yield components in onion. J Hortl. Sci. 2015;10(2):237-241.
9. Mahalanobis PC. On the generalized distance in Statistics. Proc. Nation. Academy Sci. India. 1936;2(9):49-55.
10. McCollum GD. Evaluation of crop plants, ed. N.W. Simmonds, Longman, London and New York; c1976. p. 186-190.
11. Nadkarni KM. Indian Material Media. Nadkarni and Co., Bombay; c1993.
12. Roshania BD, Agrawal YK. Chemical Analysis, (Warsaw). 1981;26:191.
13. Solanki P, Jain PK, Sunil P, Namrata R, Khandait RN, Patil S. Genetic Analysis and Character Association in Different Genotypes of Onion (*Allium cepa* L.). Int. J Agric. Envi. Bio tech. 2015;8(4):783-793.
14. Vavilov NI. Centres of the origin of cultivated plants, Trudy Prikl. Bot. Genet. 1926;1: 20.
15. Weber, Morthy BR. Heritable and non-heritable relationship and variability of oil content and agronomic characteristics in the F2 generation of soybean crosses. Agron. J. 1952;44:202-209.
16. Wright TS. Correlation and causation. J Agric. Res. 1921;20:557-587.