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Correlation and path analysis for yield, oil and protein content of Soybean (*Glycine max* L.) genotypes under different levels of nitrogen starter and plant density

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Abstract. For investigation of correlation and path relations for soybean genotype under different levels of nitrogen starter and plant density an experiment was conducted in 2009-2010 growth season in Kermanshah, Iran. Results of correlation analysis showed that positive significant correlation was found for seed diameter and yield (r=1.00**) and for seed diameter and harvest index (r=0.54*). A negative significant correlation was found between oil and protein percent (r=-0.61**). Correlation coefficients between plant height and oil percent was negative and significant (r=-0.52*). Pod length correlated with protein content positively and significantly (r=0.70**) and correlated with oil content negatively and significantly (r=-0.61*). Path analysis for seed yield showed high positive direct effect of pod number per plant (0.51) and seed diameter (1.00) on seed yield. High positive indirect effects of characters on seed yield were found for pod number per plant through stem diameter (0.51) and 100-seed weight (0.51) and for seed diameter through harvest index (0.54). Based on path analysis results for oil percent of soybean genotypes high positive direct effects were found from seed diameter (1912.26), 100-seed weight (228.08), and number of pod per plant (121.57). Path analysis for protein percent showed that maximum positive direct effect was obtained from yield on protein percent (708.32).

Key words: *Glycine max*, Clark, Williams, Seed analyses, Seed diameter, Stepwise regression.

Introduction

Soybean (*Glycine max* L.) is the most important oilseed crop in all over the world. It serves as oil seed crop, feed for livestock and aquaculture, a good source of protein for the human diet and as a biofuel feedstock (Masuda & Goldsmith 2009). Soybean was grown on about 94.1 million ha with a seed production of 219.8 million metric tons annually (Masuda & Goldsmith 2008). World production of soybeans is predicted to increase by 2.1% annually to 371.3 million tons by 2030 (Masuda & Goldsmith 2009). FAO has elucidated the role of soybean in fighting world hunger (FAO 2004). More investigations to speed this world program are essential step. Increasing grain yield, oil and protein content of soybean are three goals of the program (FAO 2004). These characters are affected by growth conditions especially nitrogen starter and plant density are two essential factors (Osborne & Riedell 2006, Melakeberhan 2007, Lee et al. 2008, Oz 2008, Boroomandan et al. 2009, Peric et al. 2009). The highest yields were achieved at the 225000 and 275000 seeds/acre planting densities in soybean crop (Oplinger & Albaugh 1996). Also yield, oil and protein content of soybean are affected by other traits in the plant (Malik et al. 2006, Copur et al. 2009, Oz et al. 2009). Two of the statistical methods to indicate relations among traits are correlation and path analysis. This approach was conducted before (Dewey & Lu 1959). In soybean, Pandey and Torrie (1973), Wakankar et al. (1974), Akther and Sneller (1996), Qijian et al. (1996) Board et al. (1997), Taware et al. (1997), Shukla et al. (1998), Board et al. (1999), Bizeti et al. (2004), Arshad et al. (2006) and Qureshi and Ghafoor (2007) reported path analysis usages. Path coefficient analysis for seed yield at phenotypic level in sunflower showed that the direct effect was maximum value for oil yield followed by 100-seed weight (Kadevaiah et al. 2002). Malik et al. (2006) in soybean genotypes showed correlation coefficient of yield was significant and positive with number of pods per plant. Qureshi and Ghafoor (2007) reported in soybean number of nodes at maturity trait had a high direct effect on grain yield per plant. But correlation and path analysis of soybean characters under three factors (Starter nitrogen, plant density and genotypes) were not evaluated. This research goal was investigation of correlation and path analysis to identify main direct and indirect effects of characters on yield, oil and protein content in 4 genotypes of soybean under two levels of nitrogen starter and plant density.

Materials and methods

Plant material obtaining

Seeds of four soybean genotypes including M9, L17, Williams and Clark were received from Seed and Plant Improvement Institute, Karaj, Iran.

Experimental design

Experimental design was a split plot-factorial based on randomized complete block design with three replications. Nitrogen fertilizer with two levels (20 and 40 $kgha^{-1}$) was main factor. Two levels of plant density (20 and 40 plant m^{-2}) and four soybean genotypes were subjected to subsidiary plot as factorial. Area of each plot was 4×6 m^2 with 4 rows. Distance between two rows was 50 cm.

Location and time of research and agronomy activities

Location of the research was agriculture faculty of Razi University, Kermanshah, Iran (situated in 47° 3´ E long., 34° 19´ N lat., 1322 m a.s.l.). The research was lay out 2009-2010 growth season. Field was sowed in 25 cm depth and was flatten by leveler disc. Based on soil test no fertilizers were applied. Then furrows were made with 50 cm distance. Seeds mixed with *Rhizobium japonicum* as manufactory recommended and sowed in 5cm depth. Then irrigated planted seeds. Three weeks after planting, density treatments (20 and 40 plant m^2) and nitrogen starter treatment (20 and 40 $kgha^{-1}$) was executed. Weeding performed using mechanical methods. No pesticides were applied. Irrigation was carryout weekly.

Measurement traits

At physiologic maturity stage plant height, first pod height, pod length, pod width, number of pod per plant, number of seed per pod, stem diameter was recorded for 4 plants and calculated averages of them. Plant height measured from above soil to peak of plant. Stem diameter was measured right above soil surface. Total crop of 1 m^2 area was harvested (seed humidity was %12). Harvested crop was weighted as biological yield. Then seeds of harvested crop were weighted as seed yield and finally calculated harvest index using the following formula:

Harvest index= seed yield / biological yield

To measure 100-seed weight four sample of dried seed (humidity was %10) were applied. Dried seeds samples were applied to measured protein and oil content (seed analyses). Seed analyses for oil and protein content was conducted using near infrared reflectance spectroscopy (Inframatic 8620, Perten, Percon). Calibration equations used to determine oil concentration have a standard error of 0.05% (Cho et al. 1998).

Data analysis

Correlation and path analysis were conducted (based on Dewey and Lu 1959) using SAS software (Ver. 9.1). After correlation analysis, first stepwise regression was conducted to determine variables that applied to lay out path analysis. Then path analysis was conducted in three sections that seed yield, oil and protein content were dependent variable in every section of path analysis.

Results

Correlations

Correlation coefficients (Table 1) between plant height and first pod height (r=0.75**), number of seed per pod (r=0.56*) and biological yield (r=0.50*) was positive and significant. Oil percent (r=-0.52*) and harvest index (r=-0.62*) correlated plant height negatively and significantly.

A positive, significant correlation was found between first pod height and number of seed per pod (r=0.53*). Correlation of first pod height and harvest index was negative and significant (r=-0.63**).Correlation of pod length and pod width (r=0.59*) was positive and significant. Pod length correlated with protein content positively and significantly (r=0.70**) and correlated with oil content negatively and significantly (r=-0.61*). A significant and negative correlation was observed among the number of seeds per pod and pod width.

Number of pod per plant correlated with stem diameter (r= 1.00**), 100-seed weight (r= 1.00**) and number of sub branch per plant (r=0.70**) positively and significantly. Correlation of number of seed per pod and harvest index (r=-0.72**) was negative and significant. Correlation between stem diameter and 100-seed weight (r=1.0**) and between stem diameter and number of sub branch per plant (r=0.71**) were positively and significantly. Positive, significant correlation was found for 100-seed weight and number of sub branch per plant(r=0.70**). Negative, significant correlation was resulted for number of main branch number and harvest index (r=-0.51*) and main branch number with protein percent (r=-0.52*).Positive significant correlation was got for seed diameter and yield (r=1.00**) and for seed diameter and harvest index (r=0.54*). Seed diameter was affected by environmental factors and genotype in soybean.

Non-significant negative correlation between seed diameter and protein percent was found. Negative significant correlation was found between harvest index and biological yield (r=-0.57**). Harvest index correlated seed yield positively and significantly(r=0.54*). A negative significant correlation was found between oil and protein percent (r=-0.61**).

Path analysis

Path analysis for seed yield (Table 2) showed high positive direct effect of pod number per plant (0.51) and seed diameter (1.00) on seed yield. In soybean varied reports have been made about effects of traits on yield. Negative direct effect of 100-seed weight was chief (-0.45).Negative correlation between 100-seed weight and seed diameter was cause of this result (Table 1). High positive indirect effects of characters on seed yield were found for pod number per plant through stem diameter (0.51) and 100- seed weight (0.51)and for seed diameter through harvest index (0.54).Great negative indirect effects on yield were got by number of pod per plant (-0.45) and stem diameter (-0.45) through 100- seed weight. First pod height (-0.43) and number of main branch per plant (-0.42) had main negative indirect effect on seed yield through seed diameter.

Some research (Mirzaie-Nodoushan et al. 2001 in *Mentha* spp; Basalma 2008 in Rapeseed) showed that path analysis could do for other plant material exception yield. In soybean as mentioned above path analysis was performed for seed yield as dependent variable by previously researchers. In soybean oil and protein percent are determined after seed yield. These characters were correlated other traits. In this research we performed path analysis for oil and protein percent as dependent variables. Based on path analysis results for oil percent of soybean genotypes high positive direct effects were found from seed diameter (1912.26), 100-seed weight (228.08), and number of pod per plant (121.57) (Table 3). Negative direct effect of seed yield on oil percent was maximum value (-1912.29). Primarily oil percent was affected by plant height, first pod height, pod width, number of pod per plant, number of seed per pod, stem diameter, 100-seed weight, number of main branch and number of sub branch per plant through seed diameter negatively (Table 3). Seed diameter affected oil percent through yield, biological yield and harvest index positively. Mainly oil percent was affected by plant height, first pod height, pod width, number of pod per plant, number of seed per pod, stem diameter, 100-seed weight, number of main branch and number of sub branch per plant through seed yield positively (Table 3). Seed diameter and harvest index affected oil percent through yield negatively (Table 3). Path analysis for protein percent (Table 4) showed that maximum positive direct effect was got from yield on protein percent (708.32). Positive direct effect of stem diameter on protein content was high (433.90). Maximum negative direct effect was obtained from seed diameter (-705.08).

Discussion

As we concluded in this research, Iqbal et al. (2010) reported negative significant correlation for oil content in soybean. Maybe this correlation was due to nitrogen fertilizer that increased protein and plant height of soybean and decrease oil (Mekki & Ahmed 2005). Like as our findings, Shafii et al.

Table 1. Correlation coefficients of soybean genotype characters under different levels of nitrogen starter and plant density.

	Plant height	First pod height	Pod length	Pod width	No. pod per plant	No. seed per pod	Stem diameter	100seed weight	No. main branch per plant	No. sub branch per plant	Seed diameter	Harvest index	Yield	Biological Yield	%oil
First pod height	0.748**														
Pod length	0.127	-0.098													
Pod width	0.188	-0.091	0.587*												
No. pod per plant	-0.060	-0.095	-0.310	-0.128											
No. seed per pod	0.565*	0.530*	-0.009	0.167	0.167										
Stem diameter	-0.049	-0.096	-0.282	-0.089	0.999**	0.180									
100seed weight	-0.034	-0.083	-0.280	-0.084	0.999**	0.205	1.000**								
No. main branch per plant	0.128	0.281	0.279	0.423	0.348	0.403	0.369	0.378							
No. sub branch per plant	-0.310	-0.361	0.242	0.063	0.702**	-0.092	0.710**	0.704**	0.480						
Seed diameter	-0.181	-0.429	-0.144	-0.243	-0.165	-0.339	-0.177	-0.186	-0.422	-0.166					
Harvest index	-0.618*	-0.632**	-0.164	-0.221	-0.102	-0.722**	-0.116	-0.134	-0.511*	-0.026	0.541*				
Yield	-0.179	-0.426	-0.147	-0.244	-0.172	-0.340	-0.185	-0.193	-0.427	-0.176	1.000**	0.544*			
Biological Yield	0.497*	0.279	0.065	-0.027	-0.063	0.457	-0.060	-0.049	0.151	-0.115	0.381	-0.566*	0.379		
%Oil	-0.525*	-0.461	-0.606*	-0.356	-0.038	-0.353	-0.059	-0.068	-0.519*	-0.148	0.205	0.485	0.208	-0.359	
%Protein	-0.167	-0.096	0.704**	0.225	-0.085	-0.145	-0.071	-0.075	0.250	0.307	-0.069	0.040	-0.072	-0.096	-0.606*

*, ** Significant P> 0.05 P>0.01 level of probability, respectively

Table 2. Path analysis results (direct and indirect effects) of soybean genotype characters on seed yield under different levels of nitrogen starter and plant density.

		Indirect effects														
Variable	Direct effects	Plant height	First pod height	Pod length	Pod width	No. pod per plant	No. seed per pod	Stem diameter	100seed weight	No. main branch per plant	No. sub branch per plant	Seed diameter	Harvest index	Biological Yield	%Oil	%Protein	Total
Plant height	-0.0010	---------	0.0001	0.0011	0.0029	-0.0306	0.0083	0.0027	0.0155	0.0001	0.0040	-0.1808	0.0005	-0.0023	0.0002	0.0002	-0.1793
First pod height	0.0001	-0.0008	---------	-0.0008	-0.0014	-0.0489	0.0078	0.0053	0.0377	-0.0001	0.0046	-0.4286	0.0005	-0.0013	0.0002	0.0001	-0.4257
Pod length	0.0084	-0.0001	0.0001	---------	0.0090	-0.1590	-0.0001	0.0156	0.1275	-0.0001	-0.0031	-0.1438	0.0001	-0.0003	0.0002	-0.0010	-0.1467
Pod width	0.0153	-0.0002	0.0002	0.0050	-------	-0.0656	0.0025	0.0049	0.0383	-0.0001	-0.0008	-0.2433	0.0002	0.0001	0.0001	-0.0003	-0.2439
No. pod per plant	0.5134	0.0001	0.0001	-0.0026	-0.0020	--------	0.0025	-0.0553	-0.4546	-0.0001	-0.0090	-0.1653	0.0001	0.0003	0.0002	0.0001	-0.1724
No. seed per pod	0.0148	-0.0006	0.0002	-0.0001	0.0026	0.0858	-------	-0.0100	-0.0931	-0.0001	0.0012	-0.3391	0.0006	-0.0021	0.0001	0.0002	-0.3398
Stem diameter	-0.0554	0.0001	0.0002	-0.0024	-0.0014	0.5130	0.0027	-------	-0.4551	-0.0001	-0.0091	-0.1775	0.0001	0.0003	0.0001	0.0001	-0.1848
100seed weight	-0.4553	0.0002	0.0001	-0.0024	-0.0013	0.5127	0.0030	-0.0554	------	-0.0001	-0.0091	-0.1856	0.0001	0.0002	0.0003	0.0001	-0.1928
No. main branch per plant	-0.0002	-0.0001	0.0003	0.0024	0.0065	0.1788	0.0059	-0.0205	-0.1719	-----	-0.0062	-0.4216	0.0004	-0.0007	0.0002	-0.0004	-0.4273
No. sub branch per plant	-0.0129	0.0003	0.0002	0.0020	0.0010	0.3603	-0.0014	-0.0393	-0.3204	-0.0001	-------	-0.1656	0.0001	0.0005	0.0001	-0.0004	-0.1758
Seed diameter	1.0002	0.0002	0.0004	-0.0012	-0.0037	-0.0848	-0.0050	0.0098	0.0845	0.0001	0.0021	---------	-0.0004	-0.0018	-0.0001	0.0001	0.9999
Harvest index	-0.0008	0.0006	0.0002	-0.0014	-0.0034	-0.0524	-0.0107	0.0064	0.0610	0.0001	0.0003	0.5413	---------	0.0026	-0.0002	-0.0001	0.5436
Biological Yield	-0.0046	-0.0005	0.0001	0.0005	-0.0004	-0.0323	0.0067	0.0033	0.0222	0.0000	0.0015	0.3814	0.0005	---------	0.0001	0.0001	0.3785
%Oil	-0.0003	0.0005	0.0002	-0.0051	-0.0054	-0.0197	-0.0052	0.0033	0.0309	0.0001	0.0019	0.2052	-0.0004	0.0017	-------	0.0009	0.2082
%Protein	-0.0014	0.0002	0.0003	0.0059	0.0034	-0.0435	-0.0021	0.0039	0.0340	-0.0001	-0.0039	-0.0686	0.0002	0.0004	0.0002	--------	-0.0715

Residual: 0.0002

Table 3. Path analysis results (direct and indirect effects) of soybean genotype characters on oil content under different levels of nitrogen starter and plant density.

Variable	Indirect effects															
	Direct effects	Plant height	First pod height	Pod width	No. pod per plant	No. seed per pod	Stem diameter	100seed weight	No. main branch per plant	No. sub branch per plant	Seed diameter	Harvest index	Yield	Biological yield	%Protein	Total
Plant height	0.2669	----------	-0.1187	0.7158	-7.2351	-2.9446	16.9857	-7.7746	-0.1176	5.8557	-345.6354	1.4221	342.7061	-4.6629	0.0119	-0.5247
First pod height	-0.1587	0.1996	----------	-0.3451	-11.5874	-2.7626	33.6260	-18.8750	-0.2568	6.8101	-819.5526	1.4557	813.5931	-2.6145	0.0068	-0.4613
Pod width	3.8081	0.0502	0.0144	--------	-15.5345	-0.8705	31.1903	-19.1906	-0.3870	-1.1946	-465.1617	0.5086	466.1785	0.2492	-0.0161	-0.3558
No. pod per plant	121.5749	-0.0159	0.0151	-0.4866	----------	-0.8718	-348.8741	227.7489	-0.3189	-13.2368	-315.9766	0.2350	329.5726	0.5896	0.0061	-0.0385
No. seed per pod	-5.2140	0.1507	-0.0841	0.6358	20.3270	----------	-62.7441	46.6607	-0.3691	1.7426	-648.3214	1.6630	649.4736	-4.2845	0.0104	-0.3535
Stem diameter	-349.1541	-0.0130	0.0153	-0.3402	121.4774	-0.9370	----------	228.0086	-0.3381	-13.3883	-339.3974	0.2674	353.1709	0.5641	0.0051	-0.0593
100seed weight	228.0823	-0.0091	0.0131	-0.3204	121.3972	-1.0667	-349.0412	----------	-0.3457	-13.2722	-354.7992	0.3082	368.5243	0.4562	0.0053	-0.0678
No. main branch per plant	-0.9156	0.0343	-0.0445	1.6098	42.3414	-2.1018	-128.9374	86.1034	----------	-9.0510	-806.0848	1.1762	816.7835	-1.4145	-0.0179	-0.5191
No. sub branch per plant	-18.8614	-0.0829	0.0573	0.2412	85.3209	0.4817	-247.8387	160.4950	-0.4394	----------	-316.6801	0.0608	336.0367	1.0824	-0.0219	-0.1483
Seed diameter	1912.2593	-0.0482	0.0680	-0.9263	-20.0887	1.7677	61.9696	-42.3182	0.3860	3.1235	----------	-1.2460	-1911.1708	-3.5756	0.0049	0.2052
Harvest index	-2.3022	-0.1648	0.1004	-0.8412	-12.4107	3.7663	40.5611	-30.5361	0.4678	0.4978	1034.9908	----------	-1038.9499	5.3087	-0.0029	0.4851
Yield	-1911.2862	-0.0479	0.0676	-0.9288	-20.9638	1.7718	64.5173	-43.9776	0.3913	3.3161	1912.1437	-1.2514	----------	-3.5490	0.0051	0.2082
Biological Yield	-9.3758	0.1327	-0.0443	-0.1012	-7.6449	-2.3827	21.0065	-11.0979	-0.1381	2.1775	729.2619	1.3035	-723.4635	----------	0.0069	-0.3594
%Protein	-0.0715	-0.0446	0.0152	0.8562	-10.3098	0.7578	24.8420	-17.0451	-0.2292	-5.7826	-131.1314	-0.0925	136.7283	0.9013	----------	-0.6059

Residual: 0.1281

Table 4. Path analysis results (direct and indirect effects) of soybean genotype characters on protein content under different levels of nitrogen starter and plant density.

Variable	Indirect effects															
	Direct effects	Plant height	First pod height	Pod width	No. pod per plant	No. seed per pod	Stem diameter	100seed weight	No. main branch per plant	No. sub branch per plant	Seed diameter	Harvest index	Yield	Biological yield	%Oil	Total
Plant height	-0.79	--------	0.02	-1.03	9.42	3.55	-21.11	9.43	0.04	-1.97	127.44	1.95	-127.01	-0.22	0.10	-0.17
First pod height	0.03	-0.59	--------	0.50	15.09	3.33	-41.79	22.91	0.09	-2.30	302.18	2.00	-301.52	-0.12	0.08	-0.10
Pod width	-5.50	-0.15	0.00	----------	20.23	1.05	-38.76	23.29	0.14	0.40	171.51	0.70	-172.76	0.01	0.07	0.22
No. pod per plant	-158.36	0.05	0.00	0.70	----------	1.05	433.55	-276.38	0.12	4.46	116.51	0.32	-122.14	0.03	0.01	-0.08
No. seed per pod	6.29	-0.44	0.02	-0.92	-26.48	----------	77.97	-56.62	0.13	-0.59	239.05	2.28	-240.69	-0.20	0.06	-0.15
Stem diameter	433.90	0.04	0.00	0.49	-158.23	1.13	----------	-276.69	0.12	4.51	125.14	0.37	-130.88	0.03	0.01	-0.07
100seed weight	-276.78	0.03	0.00	0.46	-158.13	1.29	433.76	----------	0.12	4.47	130.82	0.42	-136.57	0.02	0.01	-0.07
No. main branch per plant	0.33	-0.10	0.01	-2.33	-55.15	2.53	160.23	-104.49	----------	3.05	297.22	1.61	-302.70	-0.07	0.10	0.25
No. sub branch per plant	6.36	0.24	-0.01	-0.35	-111.14	-0.58	307.99	-194.76	0.16	----------	116.76	0.08	-124.53	0.05	0.03	0.31
Seed diameter	-705.08	0.14	-0.01	1.34	26.17	-2.13	-77.01	51.35	-0.14	-1.05	----------	-1.71	708.27	-0.17	-0.04	-0.07
Harvest index	-3.16	0.49	-0.02	1.22	16.17	-4.54	-50.41	37.06	-0.17	-0.17	-381.62	----------	385.03	0.25	-0.09	0.04
Yield	708.32	0.14	-0.01	1.34	27.31	-2.14	-80.18	53.37	-0.14	-1.12	-705.04	-1.72	----------	-0.17	-0.04	-0.07
Biological Yield	-0.45	-0.39	0.01	0.15	9.96	2.87	-26.11	13.47	0.05	-0.73	-268.89	1.79	268.11	----------	0.07	-0.10
%Oil	-0.18	0.41	-0.01	1.96	6.09	-2.22	-25.73	18.76	-0.17	-0.94	-144.68	-1.53	147.48	0.16	----------	-0.61

Residual: 0.2053

(2011) reported positive correlation between seed per pod and biological yield in soybean under nitrogen treatments. Seed per pod is a part of biological yield. Therefore it is reasonable that it's correlation was positive. We found a significant relation for height of 1st pod and plant height identically to Oz et al. (2009). Maybe the reason of this relation was vegetative growth of plants. It's due to nitrogen fertilizer that affect height of 1st pod and plant height. Harvest index is concluded from seed yield and biological yield. This index has a direct relation with seed yield (Showkat & Tyagi 2010). Therefore it's reasonable that correlation of the HI index with all traits that decrease seed yield be negative. First pod height affected yield positively hence it's correlation with HI was negative. Length and width of pods were correlated. It is show that pod growth in soybean genotypes was two- dimentional. This was mentioned by previous studies. Altawaha (2010) reported significant positive correlation for pod length and pod width in soybean. He mentioned that oil and protein content of soybean were correlated with pod length inversely as we found in this research. As we found here Wang et al. (1986) reported negative correlation estimate of -0.45 between seed size and protein content of soybean plants. Oil and protein content of soybean response to nitrogen fertilizer diversely (Boroomandan et al. 2009, Hartwig et al.1997). Pod length also affected by nitrogen therefore correlation of pod length and oil and protein had different direction. Wang and Wang (2009) showed that in soybean significant correlation was found between every 2 traits of 100-pod weight, 100-fresh seed weight, 100-dry seed weight, pod length and pod width. Pod number per plant correlation with 100- seed weight and stem diameter were reported positively by Ojo (2003) as we found here. Whatever stem diameter is increased number of pod is increased because larger stem is lead to larger plant with more pod number. Our results showed that under favorite conditions (irrigation and suitable starter) seed diameter can affected yield chiefly because of positive correlation between 100-seed weight and seed diameter, 100- seed weight and number of sub branch per plant, seed diameter and seed yield.

Numbers of studies were performed about direct and indirect effects of soybean characters. Bizeti et al. (2004) reported same direct effect of seed diameter on grain yield in soybean. Iqbal et al. (2003) and Arahad et al. (2006) showed the highest direct effect of pod number per plant on seed yield in soybean. Ariyo (1995) showed high direct effect of flower number per plant on soybean yield. Oz et al. (2009) indicated that the number of seeds per pod gave the greatest direct positive effect on soybean yield (0.47). Showkat and Tyagi (2010) reported that path coefficient analysis revealed that biological yield and harvest index were major characters influencing seed yield of soybean directly and indirectly. These result showed that conditions of soybean genotypes growth had a major effect on trait interactions. Because in rainfed conditions pod number per plant had maximum direct effect on seed yield (Arahad et al. 2006). Therefore growth and filling of soybean seeds in the end of season under rainfed condition was decrease, this character had less direct effect as compare to irrigated condition (Arahad et al. 2006). Showkat and Tyagi (2010) reported same result. Bizeti et al. (2004) indicated indirect effects for all characters of soybean. Based on our results selection for seed yield of soybean genotypes must be create on seed diameter with the highest direct and indirect effects under our experimental conditions. Basalma (2008) in Rapeseed reported direct and positive effect of seed yield on oil yield was greater compared to other characters. With compare his findings and effects of seed diameter on seed yield in this experiment it's clear that characters correlated positively with yield or had high direct and indirect effect on seed yield are suitable for selection and development for oil content in soybean. Rai et al. (1993) in *Linum usitatissimum* L. show that negative indirect effects of characters on oil and protein content under low fertility conditions. Based on the correlation and path coefficient analysis, it could be concluded that positive significant correlation was found for seed diameter and yield. Maximum positive direct effect was resulted from seed diameter on seed yield. High positive indirect effects of characters on seed yield were found for seed diameter through harvest index. Maximum positive direct effect on oil percent were found from seed diameter. Because of these results seed diameter is recommended for selection of seed yield and oil percent in soybean genotypes under irrigation and starter nitrogen application.

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