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Correlation coefficient and path analysis between grain yield and growth parameters, weed and yield attributes of cowpea (*Vigna unguiculata* L.) as influenced by weed management practices under rainfed condition

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Abstract
A field experiment was carried out in the rainy seasons of 2018, 2019 and 2020 in order to determine the correlation coefficient and path analysis between grain yield and growth parameters, weed and yield attributes of cowpea (*Vigna unguiculata*) as influenced by weed management practices under rainfed condition, in addition to the percent contribution for each independent variables on the variable that is dependent (yield). There are ten weed management practices used in the treatments. A randomize block design with three replications was used to set up the experiment. Grain yield correlated positively and significantly with growth and yield attributes while weed density, weed dry matter and weed index were highly negatively correlated. The direct and indirect contributions results indicated that number of seeds/pod and seed index had the highest direct contribution while plant height had the least direct effect in the study. The percent individual contribution to grain yield showed that number of seeds/pod (59.39%) made highest contribution followed by seed index (18.50%) while number of branches/plant (1.15%) made a least contribution. The combined contribution of number of seeds/pod via seed index (61.72%) was the highest positive contribution while number of branches/plant via number of pods/plant made the least negative contribution in combined study during 2018-2020.

Keywords: Cowpea, correlation, path analysis, yield attributes, weed management, contribution, direct, indirect

Introduction
Pulses are the primary supply of protein in Indian diet plan, containing huge amount of fibres, vitamins and minerals. India is the largest producer, consumer and importer of pulses in the world with a production of 25.46 mt from an area of 28.78 mha and cowpea shares 16% in world pluses production (GoI, 2021-22) [7]. Cowpea is mostly grown in *kharif* season in arid and semiarid area of the country. Globally, cowpea (*Vigna unguiculata* L.) is grown mostly for its seeds, although it is also used as a cover crop, as fodder, and as a vegetable (Andargie *et al.*, 2011) [3]. It is also known as vegetable meet due to its high protein content (19–26%; average: 22.5%), carbohydrate content (60.3%), mineral and vitamin content. Rajasthan's main pulse crop is the cowpea. It is highly sensitive to weed infection between 25 and 40 DAS, and depending on the area, season, and weed population, unchecked weeds can reduce the yield of cowpeas by up to 60% (Yadav *et al.*, 2017) [18].

Due to the scarcity and high cost of labour required for hand weeding, the majority of farmers are forced to use manual weed management techniques for pulses. Under various agro-climatic situations, the combined effects of each of these factors have a variable impact on the dynamics of cowpea composite weed culture and weed flora. Although the use of herbicides to control weeds is a well-established and efficient strategy, it has adverse impacts on the natural environment (Cheema *et al.*, 2003) [4]. A post-emergence spray must be applied because pre-emergence applications are insufficient to stop weeds from repeatedly coming out during the rainy season (Silva *et al.*, 2003) [15]. Yield is influenced by the interaction of several related characteristics. These basically consist of a plant's genetic makeup, the environment, agronomy, and other management factors. Genetic differences exist among different crops types and even within different crop varieties. The estimate of genetic parameters serves as a useful tool for its improvement. However, the results pointed out that, traits of agronomical importance can be correlated to each other at different magnitude in order to assess their

contributions to the yield of the crop. With an associated finding, Adekoya *et al.* (2014) [1] showed that the effective use of the right choosing indices might significantly increase the efficiency of crop improvement with the proper knowledge of the correlations between yield and their associated attributes. It is very important for a researcher to know the extent of the relationship between yield, growth parameters and weed attributes which will serve as a basic tool for selecting best crop types. It is also help to know about the relationship (positive & negative) between parameters and its impact on other parameter.

The assessment of the cause-effect relationship as well as successful selection are made possible via the use of path coefficient analysis, a standardized partial coefficient of regression that permits partitioning of a correlation coefficient into the direct and indirect impacts of different attributes towards the dependent variable. According to Nemati *et al.* (2009) [12], path analysis is crucial in assessing the magnitude of the relationship between yield and its various components.

The purpose of this study was to evaluate the nature and magnitude of the relationship between grain yield and growth, weed, and yield attributes of cowpea, as well as percentage contributions of all of the independent variables on dependent variable (grain yield).

Materials and Methods

The experiment was carried out on a cowpea crop during the rainy seasons of 2018, 2019, and 2020 at Agricultural Research Station, Fatehpur- Shekhawati, Sikar (Latitude 27˚56" N, Longitude 074˚59" E) in Rajasthan, India. This station is situated 430 meters above sea level in the city of Sikar. The experimental site was loamy sand to sandy loam in soil texture, alkaline in reaction (pH above 8.5), low in organic carbon (0.5%), low in available nitrogen (90.0 kg/ha), medium in terms of potassium availability (250 kg/ha) and availability of phosphorus (22.06 kg/ha). The experiment was laid out in randomized block design with ten treatments. The treatments were comprised *viz.*, T_1: Imazethapyr 100 g a.i/ha PE, T_2: Imazethapyr 150 g a.i/ha PE, T_3: Imazethapyr 40 g a.i/ha POE, T_4: Imazethapyr 60 g a.i/ha POE, T_5: Imazethapyr 80 g a.i/ha POE, T_6: Imazethapyr 100 g a.i/ha POE, T_7: Pendimethalin 1.0 kg a.i/ha PE, T_8: Pendimethalin + Imazethapyr 900 g a.i/ha PE, T_9: Hand weeding at 25 & 40 DAS and T_{10}: Weedy check (unwedded). Imazethapyr 10% SL and Pendimethalin 30% + Imazethapyr 2% EC were used in experiment which bought from market. The experiment was replicated thrice in three consecutive years. Imazethapyr and Pendimethalin + Imazethapyr were applied as PE, immediately after sowing, and Imazethapyr was also applied as POE at 25 DAS in 500 liters water/ha using flat fan nozzle during the year 2018, 2019 and 2020, respectively. The recommended dose of nitrogen, phosphorus and potash (15, 40 and 40 kg/ha) were applied through di-ammonium phosphate (DAP) and murate of potash (KCl) and drilled in the soil before sowing the crop. Cowpea variety RC-101' was sown in July and harvested in September during the year 2018, 2019 and 2020, respectively The crop was raised under rainfed conditions with recommended package of practices. Using 0.25 m^2 quadrants randomly placed at three different locations in a plot, weed data on total weed density and weed dry matter were obtained at 20 DAS, 40 DAS, and at harvest. Total number of weeds was counted from above three stages. Weed population converted into number of weed/m^2. While observations on grain yield, yield attributing and growth parameters *viz.*, number of branches/plant, number of pods/plant, number of seeds/pod, seed index and plant height were recorded at harvest. Weed control efficiency and weed index were calculated through weed dry matter and crop yield. All the data were subjected to analyses with standard statistical procedure. Since, similar trend was noticed during three years, pooling was done over the years.

Accordance with Little & Hill's (1978) [11] methodology of simple correlation analysis, the three-year mean data were obtained. Path analysis, as outlined by Dewey & Lu (1959) [6], was used to assess both direct and indirect effects on the individual and combined contributions of growth parameters and yield attributes to grain yield.

Results and Discussions

The three year combined (2018 - 2020) data showed that positive and highly significant correlation was found between grain yield and plant height, number of branches/plant, number of pods/plant, number of seeds/pod, Seed index, weed control efficiency at harvest. However, weed density, weed dry matter and weed index were highly negative correlated with grain yield (Table 1). The strongest significant correlation between growth parameters & yield attributes and seed yield in the combined data was that recorded between seed index and grain yield (r= 0.989**) followed by length of pod (r= 0.982**) and number of seeds/pod (r= 0.968**). While is the strongest growth relationship obtained in this study. The results revealed an inter–dependency between growth parameters and yield attributes as important yield determinants characters to be use for yield improvements in cowpea. These results confirmed the earlier findings of Sanjay *et al.* (2009) [13], Iqbal *et al*. (2003) [9] and Tesfaye *et al.* (2018) [16] who reported positive highly significant correlation between grain yield and seed index, seed per pod, pod length and number of pod per plant, plant height and number of branches. Weed density, weed dry matter and weed index was significantly highly negative correlated to grain yield indicating serious reduction in grain yield. The results are in concurrence to that of Daniya *et al.* (2013) [5] who reported significantly negatively correlations between weed components to the final seed yield of sesame crop.

The combined data indicated that, the direct contribution of the growth parameters and yield attributes to grain yield obtained were positive (Table 2), except that of number of branches/plant (-0.107) and number of pods/plant (-0.239) which have a negative contribution. Number of seeds/pod (0.771) made the greatest contribution to grain yield and was closely followed by seed index (0.430). While the weakest direct effect was from plant height (0.138). This probably meant that cowpea grain yield was dependent on number of seeds/pod, seed index (100-seed weight) and plant height. The highest direct and indirect contribution to grain yield was made by number of seeds/pod and seed index. The findings of this study also strongly emphasized that seeds/pod made the greatest direct percent contribution (59.39%) to grain yield. This could possibly be explained by the fact that the majority of the assimilates generated were translocated to the sink (pods), which produce the seeds (Haruna *et al.*, 2012) [8]. This probably meant that cowpea grain yield was dependent on number of seeds/pod and seed index. This finding agreed with Sharma *et al.* (2017) [14] who revealed that number of seeds/pod and seed index had the highest direct influence on grain yield of cowpea.

Table 1: Correlation matrix between grain yield and growth parameters, weed and yield attributes of cowpea as influenced by weed management practices in the combined (2018-2020) during rainy season.

	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	0.963**	1.000									
3	0.969**	0.985**	1.000								
4	0.859**	0.939**	0.953**	1.000							
5	0.982**	0.979**	0.991**	0.932**	1.000						
6	0.968**	0.977**	0.995**	0.950**	0.997**	1.000					
7	0.989**	0.936**	0.935**	0.797**	0.949**	0.931**	1.000				
8	-0.843**	-0.928**	-0.885**	-0.899**	-0.869**	-0.869**	-0.810**	1.000			
9	-0.845**	-0.933**	-0.901**	-0.933**	-0.884**	-0.887**	-0.800**	0.993**	1.000		
10	0.845**	0.933**	0.901**	0.933**	0.884**	0.887**	0.800**	-0.993**	-1.000**	1.000	
11	-1.000**	-0.963**	-0.969**	-0.859**	-0.982**	-0.968**	-0.989**	0.843**	0.845**	-0.845**	1.000

**: Significant at 1% level of probability *: Significant at 5% level of probability

1= Grain yield (kg/ha) 5= Pod length (cm) 9= Weed dry matter (g)
2= Plant height (cm) 6= Number of seeds/ pod 10= WCE (%)
3= Number of branches/plant 7= Seed index 11= WI (%)
4= Number of pods/plant 8=Weed density (No./m2)

Table 2: The direct and indirect contribution of growth parameters and yield attributes to grain yield (kg/ha) of cowpea as influenced by weed management practices in the combined (2018-2020) during rainy season.

	Effect through					
	Plant height	**Number of branches/plant**	**Number of pods/plant**	**Number of seeds/ pod**	**Seed index**	**Total**
Plant height	**0.138**	-0.106	-0.225	0.754	0.404	0.964
Number branches/plant	0.135	**-0.107**	-0.229	0.768	0.403	0.971
Number of pods/plant	0.129	-0.102	**-0.239**	0.732	0.345	0.864
Number of seeds/ pod	0.135	-0.107	-0.227	**0.771**	0.403	0.974
Seed index	0.129	-0.101	-0.192	0.722	**0.430**	0.988

Bold = Direct effect

Number of seeds/pod made a highest percent contribution to grain yield (59.39%) followed by seed index (18.50%) and number of pods/plant (5.74%). The lowest percent contribution to grain yield was recorded by number of branches/plant (1.15%) in the combined (2018 -2020) years (Table 3, Figure I). The greatest and positive combined contribution was obtained by number of seeds/pod via seed index (61.72%) followed by plant height via number of seeds/pod (20.17%) and plant height via seed index (11.07%) in the combined (2018 -2020) years. The individual or combined percent contribution of two parameters to cowpea grain yield showed that number of seeds/pod, seed index (100-seed weight), and number of seeds/pod via seed index (100-grain weight) and plant height via number of seeds/pod made the highest contribution to grain yield. This may be explained by the fact that the taller plants that were captured and transported more assimilate to the developing heavier seeds, which in turn resulted in increased grain yield. Higher yield attributes like number of seeds/pod, seed index (100-seed weight) and plant height helps to increase the grain yield.

Table 3: Percent contribution of different growth parameters & yield attributes to grain yield (kg/ha) of cowpea in the combined (2018-2020) during rainy season.

Parameters	% Contribution
Direct contribution	
Plant height	1.89
Number branches/plant	1.15
Number of pods/plant	5.74
Number of seeds/ pod	59.39
Seed index	18.50
Combined contribution	
Plant height via number branches/plant	-2.91
Plant height via number of pods/plant	-6.19
Plant height via number of seeds/ pod	20.71
Plant height via seed index	11.07
Number branches/plant via number of pods/plant	4.90
Number branches/plant via number of seeds/ pod	-16.47
Number branches/plant via seed index	-8.64
Number of pods/plant via number of seeds/ pod	-35.07
Number of pods/plant via seed index	-16.42
Number of seeds/ pod via seed index	61.72
Residual	0.61
Total	100.00

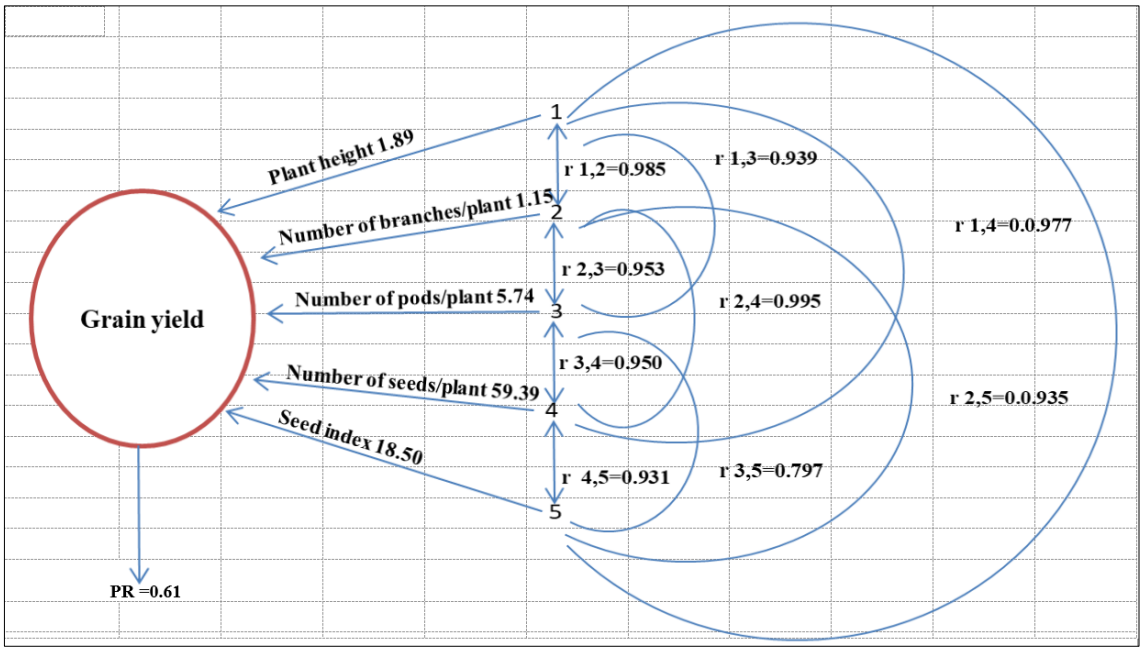

Fig 1: Path diagram indication the contribution and correlation of growth parameters & yield attributes to grain yield of cowpea as influenced by weed management practices in the combined (2018-2020) during rainy season.

The results were supported by earlier findings of Kalaiyarasi and Palanisamy (2001) [10], Vineeta *et al.* (2003) [17] and Anbumalarmathi *et al*. (2005) [2]. Through using the technique of path coefficient analysis, the indirect and direct effects of different variables on seed yield per plant were calculated. Seeds per pod, pods per plant, 100-seed weight, number of branches per plant, days to maturity, days to 50% blooming, and other factors among the various contributing factors showed highly beneficial direct effects on seed output per plant. The residual effects allow for a clear understanding of how other potential yield components interact. In order to determine the variance in cowpea yield, the residual impact of 0.61% was measured.

Conclusions and Recommendations

Based on the present investigation, it can be concluded that all the growth parameters and yield attributes made a positively contribution and significantly to grain yield, but negatively with weed density, weed dry matter and weed index. The highest direct effect to grain yield was by number of seeds/pod and seed index than any growth and yield attributes. The greatest direct effect and individual factor contribution were by number of seeds/pod and seed index (100-seeds weight). The highest indirect effect was by number of seeds/pod via seed index (100 seed weight) and plant height via number of seeds/pod. The overall finding indicated that these attributes should be used and evaluated in order to increase the cowpea grain yield.

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