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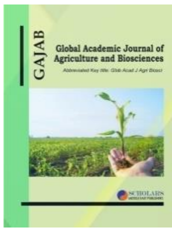

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Research Article

Path Coefficient analysis and Polynominal Model Studies on Upland rice Characters

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Abstract: This study on path coefficient and polynomial model assessed the direct and indirect contributions of upland rice characters. A mixed of stepwise regression procedure in SAS Insti-tute with a probability to enter and remove variables was set at 0.05, and was used to select the 13 yield-related traits. The results revealed that there were direct effects on paddy yield in which number of grains contributed the highest, followed by percent filled grains and 1000 grain weight while indirect contribution of growth and yield components via number of tillers, leave area index and 1000 grain weight were negative.The individual percent contribution showed that 1000 grain weight contributed to the yield more than any other parameters followed by number grains per panicle while the least individual percent contribution was made by panicle weight. The highest indirect percent contribution to yield via one another were observed through number of filled grains per panicle via number of grains per panicle, followed by number of grains per panicle via 1000 grain weight and the least was plant height via number of tillers. The unaccounted residual effect constitutes 9.13% and 5.55%. The polynomial response showed that optimum seed rate of 85.7 kg ha^{-1} was observed with quadratic function of $Y=-0.2765X^2 + 47.409X-36.4$ while in 2012, the optimum seed rate of 81.3 kg ha^{-1} was recorded with quadratic function of $Y=- 0.3044X^2 +49.491X + 2252.8$. The optimum seed rate of 83.4 kg ha^{-1} with quadratic function of $Y=- 0.2905X^2 +48.451X +1108.1$ was recorded for the combined.

Keywords: polynomial -model, rice characters, direct and indirect contributions.

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the family poacae and is an important crop which supplies staple food for nearly 50% of the global population (FAO 2011; Garris *et al.,* 2005). Among the most cultivated cereals in the world, rice ranks second to wheat (Abodolereza and Racionzer, 2009). Optimizing yield is one of the most important goals for most rice growers and consequently, most rice research programs. In general, increased number of fertile panicles is the single most important yield component associated with rice yield /panicle, percent filled grains/panicle are also of secondary and tertiary importance (Rachana *et al.,* 2018). Another trait directly related to panicle is panicle density which chiefly affects the yield potential. The degree of relationship and association of these components with yield can be measured by correlation coefficients but selection based on correlation without taking into consideration the interactions between the component characters may sometimes proven misleading (Sarawagi *et al.,* 2016). Moreover, it does not give an exact position of the relative importance of direct and indirect effect of the various characters on yield but in path analysis, the correlation coefficient between two traits is separated into the components which measure the direct and indirect effects (Ahmadizadeh *et al.,* 2011). Path coefficient analysis also provides an exact picture of the relative importance of direct and indirect effects of each of the component character towards yield. It has been used to organize and present the causal relationship between predictor variables and response variables through a path diagram that is based on experimental results. The advantage of path analysis is that it permits the partitioning of the correlation coefficient into its components, one component being the path coefficient (or standardized partial regression coefficient) that measures the direct effect of a predictor variable upon its response variable; the second component being the indirect effect(s) of a predictor variable on the response variable through other predictor variables (Tewachew, 2018). 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 (Gour, *et al.,* 2017, Ezeaku & Mohammed 2006). Path coefficients have been used to develop selection criteria for complex traits in several crop species of economic importance such as rice (Aminpanah and Sharifi, 2011). Majumder *et al.,* (2008) obtained in a path analysis grains per spike followed by 100-grain weight, spikes per plant and harvest index had positive direct effects on grain yield of bread wheat. In a breeding programme direct estimation of yield which has low heritability is difficult to obtain. Plant breeders commonly select for yield components that indirectly increase yield (Harsha *et al.,* 2017). Yield component breeding would be most effective if the components involved were highly heritable and positively correlated. Grain yield has been reported to be influenced by productive tillers, panicle length and flowering time(Kalyan *et al.,* 2017), plant height and the number of panicle per plant (Kumar and Ravindrababu 2016) the number of effective tillers per plant, grains per panicle and 1000-grain weight (Rashmi *et al*., 2017), grains per panicle and productive tillers (Solomon and Wegary 2016), the number of filled grains per panicle and 1000-grain weight (Chouhan *et al*., (2014), Islam *et al*., (2015) and biological yield, harvest index and 1000-grain weight (Rai *et al*., (2014), Patel *et al*., (2014**).** However, simple correlation does not provide the adquate information about the contribution of each factor toward yield. Therefore, the objective of this study was to determine direct and indirect effects in terms of path coefficient analysis as well as optium grain yield using polynominal model.

MATERIALS AND METHODS

The field trials were conducted on the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University Samaru, Zaria and on the Research Farm of the Kaduna State Agricultural Development Programme, Maigana in 2011 and 2012 cropping seasons. Samaru is on the Latitude 11°11¹ N and Longitude 7 °38¹ E and is 686 m above sea level while Maigana is located on Latitude 11°11.06¹ N and Longitude 7.54° 7.58¹ E. Random samples of soils were taken at depth of 0-30cm from the experimental sites using an auger of 10 cm diameter before land preparation and were analysed for physical and chemical properties.

The treatments were laid out in a split plot design with the combination of sowing methods and seed rates in the main plots and three rice varieties in the sub plots measuring 3 m x 3 m with a net plot of 2 m x 2 m and were replicated three times. The main plots were separated by a distance of 1 m and the sub plots by 0.5 m. Pre-planting herbicides, glyphosate (round up) was applied to the experimental sites at the rate 2 kg active ingredents ha^{-1} two weeks before land preparation in each year of the study in order to control the prevalent weeds on the field. Thereafter, the field was harrowed twice to ensure fine tilth of the soil and the soil levelled manually.

Seeds of each variety were treated with Apron star as seed dressing chemical at the rate of 1.0 g of metalaxy to 3.0 kg seed to prevent pest attack. Also hand pulling methods of weed control was used to control the weeds that later emerged at four and eight weeks after sowing. Fertilizers were applied at the recommended rate of 100 kg N ha^{-1}, 50 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1}. The nitrogen fertilizer were applied as split, half of the nitrogen fertilizer together with 50 kg P_2O_5 and 50 kg K_2O ha^{-1} were applied once at two weeks after planting using NPK (15:15:15) while the second half of the nitrogen were applied at panicle initiation stage using urea (46% N).

A mixed stepwise regression procedure (SAS Insti-tute 1995) with a probability to enter and remove variables was set at 0.05, and was used to select the initial 13 yield-related traits. The stepwise regression was necessary because of multicollinearity between predictor variable.

RESULTS AND DISCUSSION

The direct and indirect effects of the different growth and yield components on paddy yield for 2011, 2012 and the combined at Samaru and Maigana are presented in Tables 1, 2 and 3. In 2011 at Samaru, all the direct effects on growth and yield characters to paddy yield were positive. The greatest direct effect on paddy yield was from number of grains per panicle (0.48988). All the indirect effects of other characters to paddy yield via number of tillers were small while the indirect effect of other parameters to paddy were positive. The greatest indirect effect to paddy yield was number of grains per panicle (0.44885) via percent filled grain while the weakest indirect effect on paddy yield was 1000 grain weight via panicle weight (-0.00978). In 2012, The greatest direct effect on paddy yield was also from number of grains per panicle (0.44047) while the weakest direct effect was 1000 grain weight (-0.09860). The greatest indirect effect to paddy yield was number of grains per panicle (0.44885) via percent filled grain while the weakest indirect effect on paddy yield was plant height via panicle weight (0.00227). All the parameters had their greatest effect on paddy yield via number of grains per panicle in all cases and weakest effect via plant height.

In the combined analysis, all the direct effect on growth and yield characters to paddy yield was positive. (0.04683). The greatest direct effect on paddy yield was from number of grains per panicle (1.05641). This was followed by leaf area index (0.79016), then number of filled grains per panicle (0.56086) while the weakest direct effect was number of tillers (-0.10736). All the indirect effect of other characters to paddy yield via number of tillers was negative and small. While the indirect effect of other parameters to paddy were positive. The greatest indirect effect to paddy yield was number of grains per panicle (0.51893) via leaf area while the weakest indirect effect on paddy yield was number of tillers via panicle weight (-0.05474). In 2012. The greatest direct effect on paddy yield was also from number of grains per panicle (0.56653) while the weakest direct effect was number of tillers (-0.10736). The greatest indirect effect to paddy yield was number of grains per panicle (0.51893) via leaf area while the weakest indirect effect on paddy yield was number of tillers via panicle weight (-0.05474) The importance of number of grains per panicle in enhancing grain yield in rice was reported by Zahid *et al*., (2006) who reported that number of grains per panicle has highest positive effect followed by 1000 grain weight. Number of grains per panicle has high indirect effect through number of filled grains but they were negatively correlated in this experiment in 2011 due to drought. The highest percent individual contribution to paddy yield was made by or via number of grains per panicle could be due to the fact that cooler evening temperatures observed during the trials might have restricted respiration as it results in more assimilate being deposited in the grain leading to increase in yield of the crop hence factors limiting growth and yield may be different for different fields due to dynamic nature of soils, crop variety, weather and field management as reported by Robert and John (2012). Analysis showing partitions into direct and indirect matrix presenting correlation in a more meaningful way (Mohsin *et al*., 2009).

At Maigana in both years, all the direct contribution of growth and yield characters to paddy yield were positive. The greatest direct effect on paddy yield was from number of grains per panicle (0.26790) and (0.44047) while the weakest direct effect were number of tillers (0.24973) and 1000 grain weight (0.00978). The greatest indirect effect to paddy yield was leaf area index (0.23091) via percent filled grain while the weakest indirect effect on paddy yield was 1000 grain weight via plant height (-0.00894). In combined analysis, all the direct effect on growth and yield characters to paddy yield were positive. The greatest direct effect on paddy yield was from number of grains per panicle (0.67402). This was followed by percentage filled grains per panicle (0.42885), then plant height (0.17024) while the weakest direct effect on paddy yield was from number of tillers (0.02078). Some of the indirect and panicle weight via number of tillers, number of grains per panicle as well as 1000 grain weight to paddy yield were negative and small. While the indirect effect of other parameters to paddy was postive. The greatest indirect effect to paddy was leaf area index via plant height (0.23153) and the weakest effect on paddy was 1000 grain weight via plant height (-0.00414). This is in conformity with the works of (Ramya *et al.,* 2017 and Naseem *et al*., (2014).

Table 1: Direct and indirect effects of some growth and yield components of three upland rice varieties in 2011 and 2012 wet seasons at Samaru..

			Samaru	2011				
Parameters	**PHT9**	**NTILL9**	**LAI 9**	**PFGP**	**NGP**	**1000GW**	**PW**	**Total corr**
PHT9	**0.03522**	-0.10684	0.12559	0.15852	0.24606	0.10125	0.03748	0.20979
NTILL9	0.01507	**0.24973**	0.22488	0.25079	0.37111	0.12040	0.03552	0.23632
LAI9	0.01670	-0.21205	**0.26484**	0.26943	0.37579	0.11869	0.03181	0.29295
PFGP	0.01512	0.16965	0.19329	**0.36917**	0.44885	0.16570	0.04336	0.29725
NGP	0.01769	0.18918	0.20316	0.33825	**0.48988**	0.16875	0.04910	0.36576
1000GW	0.01383	0.11656	0.12186	0.23715	0.32048	**0.25795**	0.03195	0.36470
PW	0.00815	-0.05474	0.05199	0.09880	0.14844	0.05087	**0.16203**	0.25165
Samaru 2012								
PHT9	**0.05712**	0.00052	-0.05625	0.05574	0.15155	0.02365	-0.00894	-0.08074
NTILL9	-0.00015	**0.20290**	0.16062	0.05441	0.05333	-0.02850	0.03720	0.26434
LAI9	0.00612	0.06204	**0.52532**	0.07477	0.14314	-0.02735	0.06077	0.68303
PFGP	0.01661	0.05759	-0.20491	**0.19169**	0.41605	0.07487	-0.14901	0.54439
NGP	0.01528	0.01910	-0.13273	0.14077	**0.56653**	0.05559	-0.13580	0.60431
1000GW	0.01370	0.05864	0.14570	0.14556	0.31944	**-0.09860**	0.13813	0.40405
PW	0.00227	0.03361	0.14216	0.12719	0.34259	-0.06065	**0.22457**	0.55283

Figures heighted represent direct effects.
PHT9= Plant height at 9WAS NITLL= Number of tillers at 9WAS LAI= Leaf area index PFGP= Percent filled grains NGP= Number of grains per panicle 1000GW =1000 grain weight PW= panicle weight.

Table 2 :Direct and indirect effects of some growth and yield components of three upland rice varieties in2011 and 2012 wet seasons at Maigana.

			Maigana 2011					
Parameters	**PHT9**	**NTILL9**	**LAI 9**	**PFGP**	**NGP**	**1000GW**	**PW**	**Total corr**
PHT9	**0.1169**	0.04134	0.00062	-0.02769	0.07813	-0.00611	-0.02044	0.00705
NTILL9	0.08503	**0.13024**	-0.00542	-0.05043	0.14534	-0.00940	-0.04430	0.08099
LAI9	-0.00297	0.01275	**-0.05540**	-0.03574	0.01303	-0.00512	-0.00144	-0.01040
PFGP	0.06344	-0.05618	-0.01694	**0.26790**	0.13790	0.01633	0.00727	0.20205
NGP	0.08962	0.08104	0.00309	-0.06904	**0.23355**	-0.00886	-0.02970	0.12047
1000GW	-0.07873	0.05888	0.01366	-0.09186	0.09956	**0.02078**	-0.01310	0.03236
PW	-0.06686	0.07046	0.00098	-0.01038	0.08471	-0.00333	**0.08188**	0.00631
Maigana 2012								
PHT9	**0.05334**	0.03525	0.23091	0.08796	0.00248	0.00197	0.01612	0.14543
NTILL9	0.01717	**0.10946**	-0.21239	0.08322	0.00544	0.00363	0.00763	-0.21564
LAI	0.02796	0.05278	**0.02006**	0.09047	0.00549	0.00598	0.01060	-0.11534
PFGP	0.02915	0.05660	0.24760	**0.16095**	0.00571	-0.00881	0.00433	0.11534
NGP	0.00660	-0.02968	-0.12045	0.04581	**0.44047**	-0.00492	0.00558	0.39688
1000GW	0.00253	-0.00961	0.06359	0.03425	0.00239	**0.04139**	0.00444	0.13392
PW	0.01612	-0.01566	0.08753	0.01308	0.00210	0.00345	**0.05333**	0.09735

Figures heighted represent direct effects.
PHT9= Plant height at 9WAS NITLL= Number of tillers at 9WAS LAI= Leaf area index PFGP= Percent filled grains NGP= Number of grains per panicle 1000GW =1000 grain weight PW= panicle weight.

Table 3: Combined analysis of direct and indirect effects of some growth and yield components of three upland rice varieties in 2011 and 2012 wet seasons at Samaru and Maigana.

			Samaru					
Parameters	**PHT9**	**NTILL9**	**LAI 9**	**PFGP**	**NGP**	**1000GW**	**PW**	**Total corr**
PHT9	**0.09234**	-0.10736	0.06934	0.21426	0.39761	0.1249	0.02854	0.12905
NTILL9	0.01492	**0.04683**	0.3855	0.3052	0.42444	0.0919	0.07272	0.50066
LAI 9	0.01058	0.15001	**0.79016**	0.3442	0.51893	0.09134	0.09258	0.97598
PFGP	0.03173	0.22724	0.01162	**0.56086**	0.8649	0.24057	-0.10565	0.29725
NGP	0.03297	0.17008	0.07043	0.47902	**1.05641**	0.22434	-0.0867	0.97007
1000GW	0.02753	0.05792	0.26756	0.38271	0.63992	**0.15935**	0.17008	0.76875
PW	0.01042	-0.02113	0.19415	0.22599	0.49103	-0.00978	**0.3866**	0.80448
Maigana								
PHT9	**0.17024**	0.07659	0.23153	0.11565	0.08061	-0.00414	0.00432	0.15248
NTILL9	0.1022	**0.02078**	0.21781	0.03279	0.15078	-0.00577	-0.03667	0.13465
LAI 9	0.02499	0.06553	**0.03534**	0.12621	0.01852	0.00086	0.00916	0.12574
PFGP	0.09259	0.00042	0.23066	**0.42885**	0.14361	0.00752	0.0116	0.31739
NGP	0.09622	0.05136	0.11736	0.02323	**0.67402**	-0.01378	-0.02412	0.51735
1000GW	-0.0762	0.04927	0.07725	0.05761	0.10195	**0.06217**	-0.00866	0.16628
PW	0.05074	0.0548	0.08851	0.02346	0.08681	0.00012	**0.13521**	0.10366

Figures heighted represent direct effects.
PHT9= Plant height at 9WAS NITLL= Number of tillers at 9WAS LAI= Leaf area index PFGP= Percent filled grains NGP= Number of grains per panicle 1000GW =1000 grain weight PW= panicle weight.

The individual percentage contributions of growth and yield components are presented in Table 4. At Samaru, when the individual percent contribution to paddy yield was computed, it was found that 1000 grain weight contributed to the yield more than any other parameters with the highest in 2012. Number grains per panicle recorded the next higher individual percent contribution to yield while the least individual percent contribution to yield was made by panicle weight in 2011. The highest indirect percent contribution to yield via one another were observed through number of filled grains per panicle via number of grains per panicle in 2012, followed by number of grains per panicle via 1000 grain weight in 2011 and the least was plant height via number of tillers. The unaccounted residual effect constitutes 9.13% and 5.55% in 2011 and 2012 respectively.

At Maigana, when the individual percent contribution to paddy yield was computed, it was found that number of filled grains per panicle contributed to the yield more than any other parameters with the highest in 2012, 1000 grain weight recorded the next higher individual percent contribution to yield while the least individual percent contribution to yield was made by leaf area index. The highest indirect percent contribution to yield via one another were observed through number of tilers via leaf area index in 2012, followed by plant height via number of grains per panicle in 2011 and the least was number of tillers via 1000 grain weight.The unaccounted residual effect constitutes 16.03% and 11.55% in 2011 and 2012 respectively.

The result of direct and indirect percentage contributions of growth and yield components to paddy yield for combined analysis revealed that at both locations, it was 1000 grain weight that contributed to the yield more than any other parameters with the highest value in Samaru (28.05%), than Maigana (16.83%), followed by number of grains per panicle (13.81%) and percent filled grains at Samaru and Maigana respectively while leaf area index contributed the least direct percentage to yield at both location. The highest indirect percent contribution to yield via one another were observed through percent filled grains via panicle weight (4.45%) and number of tillers via leaf area index (2.25%) at Samaru and Maigana respectively while the least indirect percentage contribution was number of tillers via panicle weight (-0.13%) and number of tillers via 1000 grain weight (-0.08%) at Maigana. The unaccounted residual effect constitutes 7.34% at Samaru while that of Maigana was 13.79%.

Table 4: Direct and indirect percent contribution of some growth and yield components to paddy yield and residual effect in 2011 and 2012 at Samaru

	Contribution (%)					
	Samaru			**Maigana**		
Growth and yield components	2011	2012	Combined	2011	2012	Combined
Direct contribution (Pi)2*100						
Plant height	14.12	3.67	8.89	7.18	9.28	8.23
Number of tillers 9WAS	7.01	7.60	7.30	10.65	9.40	10.02
Leave area index 9WAS	6.24	4.12	5.18	5.33	4.20	4.76
Number of filled grains per panicle	13.63	10.33	11.98	11.00	22.59	16.79
Number of grains per panicle	16.65	10.97	13.81	15.08	10.17	12.62
1000 grain weight	24.00	32.10	28.05	13.63	20.04	16.83
Panicle weight	2.63	9.04	5.83	6.18	7.28	6.73
Sub total	84.28	77.83	81.05	69.04	82.96	76.03
Indirect contribution (2PJRIJ)*100						
Plant height 9 WAS and Number of tillers 9WAS	0.75	-0.01	0.37	2.21	0.38	1.29
Plant height 9WAS and Leave area index 9WAS	-0.88	-0.64	-0.76	0.03	2.46	1.24
Plant height 9WAS and Number of filled grain per panicle	1.12	0.64	0.88	1.43	0.94	1.18
Plant height 9WAS and Number of grains per panicle	1.73	-1.72	0.01	4.19	0.03	2.11
Plant height 9WAS and 1000 grain weight	-0.71	0.28	-0.22	0.33	0.02	0.17
Plant height 9WAS and Panicle weight.	-0.26	-0.10	-0.18	1.09	0.17	0.63
Number of tillers 9WAS and Leave area index 9WAS	-1.23	6.52	2.64	-0.14	4.65	2.25
Number of tillers 9WAS and Number of filled grains per Panicle	2.53	2.21	2.37	1.31	1.82	1.56
Number of tillers 9WAS and Number of grains per panicle	-1.53	-2.16	-1.84	3.79	0.12	1.95
Number of tillers 9WAS and 1000 grain weight	-6.01	-1.16	-3.58	-0.24	0.08	-0.08
Number of tillers 9WAS and panicle weight	-1.77	1.51	-0.13	1.15	0.17	0.66
Leave area index 9WAS and Number of filled grains per panicle	4.27	-7.86	-1.79	0.4	-7.97	-3.78
Leave area index 9WAS and Number of grains per panicle	1.91	-15.04	-6.56	0.14	0.48	0.31
Leave area index 9WAS and 1000 grain weight	-6.29	-2.87	-4.58	0.06	0.53	0.29
Leave area index 9WASand Panicle weight.	1.68	-6.39	-2.35	0.02	0.93	0.47
Number of filled grains per panicle and Number of grains	-7.14	15.95	4.40	-3.22	0.18	-1.52
Number of filled grains per panicle and 1000 grain weight	2.23	2.87	2.55	0.38	0.28	0.33
Number of filled grains per panicle and Panicle weight	3.20	5.71	4.45	0.17	0.14	0.15
Number of grains per panicle and 1000 grain weight	6.53	-6.3	0.11	0.41	0.02	0.21
Number of grains per panicle and Panicle weight	4.81	-15.39	-5.29	1.39	0.02	0.70
1000 grain weight and Panicle weight.	1.65	-2.72	-0.53	0.05	0.04	0.04
Sub total	6.59	16.62	11.60	14.93	5.49	10.21
Residual	9.13	5.55	7.34	16.03	11.55	13.79
Total	100	100	100	100	100	100

POLYNOMIAL RESPONSES

The polynomial response of paddy yield to seed rate in 2011 and 2012 and the combined at Samaru and Maigana respectively are presented in figures 1 and 2. At Samaru in 2011, the optimum seed rate of 85.7 kg ha^{-1} was observed with quadratic function of $Y=-0.2765X^2 + 47.409X-36.4$ while in 2012, the optimum seed rate of 81.3 kg ha^{-1} was recorded the quadratic function of $Y=- 0.3044X^2 +49.491X + 2252.8$. The optimum seed rate of 83.4 kg ha^{-1} with quadratic function of $Y=- 0.2905X^2 +48.451X +1108.1$ was recorded for the combined.

At Maigana in 2011, the optimum seed rate of 78.3 kg ha^{-1} was recorded the quadratic function of Y=-0.4247X^2 + 66.466X-1057. Also in 2012, the optimum seed rate of 114.9 kg ha^{-1} recorded the quadratic function of Y=-0.2541X^2 +58.382X + 204.5 while the optimum seed rate for the combined was 92.0 kg ha^{-1} with quadratic function of Y= -0.3393X^2 +62.421X -426.1. The quadratic responses to paddy yield by seed rates showed that the rice varieties were responsive to seed rate of 81.3kg ha^{-1} in 2011 and 85.7 kg ha^{-1} in 2012 at Samaru while at Maigana, the optimum seed rate was 78.3 in 2011 and 114.9 kg ha^{-1} 2012 wet seaon. The differences in optimum seed rates and optimum yield at different locations in the two years of the study may be due to differences in soil and climatic conditions of the experimental site especially rainfall and temperature. The combined quadratic responses to paddy yield by seed rates proved that the rice varieties were responsive to seed rate of 83.4 and 92 kg ha^{-1} with the corresponding yield of 3128.3 and 2444.8 kg ha^{-1} at Samaru and Maigana, respectively. This proved that further increase of seed rate to 120 kg ha^{-1} will not significantly increase paddy yield. It is therefore necessary to conclude that, there was no need to increase the yield by a way of increasing the seed rate since the optimum yield were reached in the two years of the study and the combined at both locations. However, there was contrast to the quadratic response in 2012 only at Maigana, when the crops experienced more distribution of rainfall.

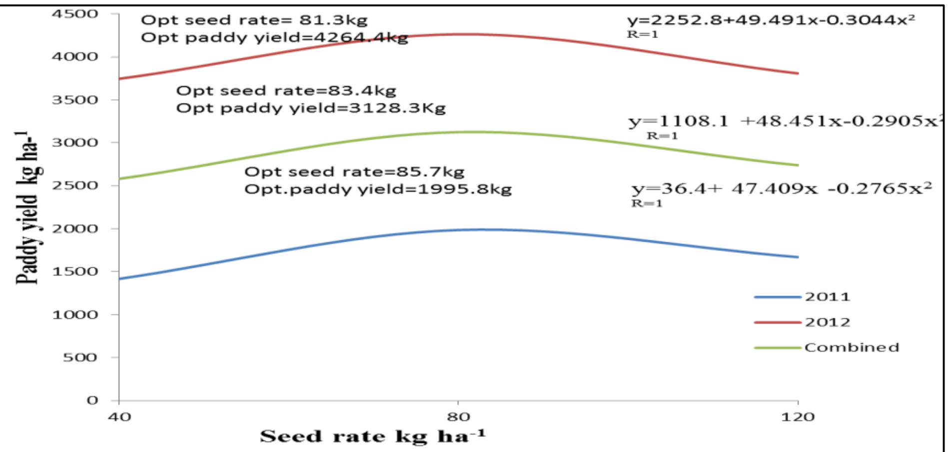

Fig 1: Polynominal response of rice seed rates to paddy yield 2011, 2012 and the combined at Samaru

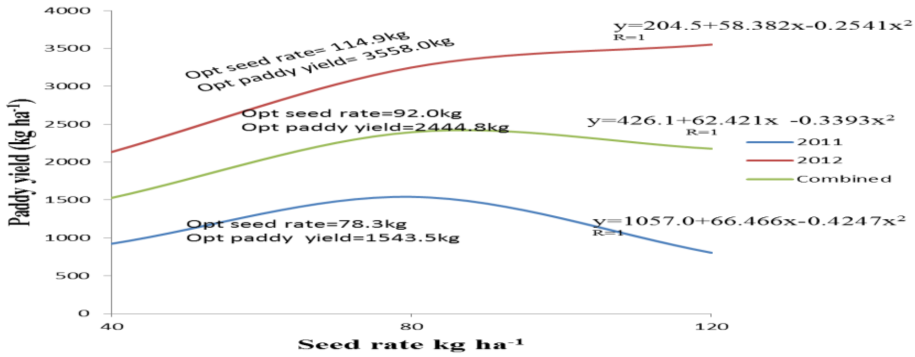

Fig 2: Polynominal response of rice seed rates to paddy yield in 2011, 2012 and the combined at Maigana

CONCULUSION

It could be concluded from the present study that number of grains consisentlycontributed the largest direct effect in grain yield. This was followed by percent filled grains per panicle except the years 1000 grain weight ranked next to number of grains per panicle. On the other hand, the indirect contributions of the growth characters via one another were less than those obtained through yield components.

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