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Research Article

Genetic Variability and Association Analysis in Different Rice Genotypes in Mid-Hill of Western Nepal

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Abstract

An experiment has been carried out in Sundar bazar Municipality of Lamjung district using 7 rice genotypes with a local check variety (Biji) to get information on genetic variability of different traits and interrelationship of yield and yield attributing characters. The experiment conducted in a Randomized Complete Block Design with 3 replications. Among the studied genotypes, days to booting, days to heading, days to anthesis, plant height, effective tillers per m^2, thousand grain weight, straw yield, harvest index was found significantly varied. The genotype NR11130-B-B-B-8-3 was the earliest in flowering whereas, Local-Check Biji was late flowering type. The highest plant height was recorded in the variety NR11289-B-16-3 but the variety LPNBR-1628 was the shortest in plant height. LPNBR 1628 produced the highest 1000 grains weight on the other hand the variety Khumal-4, produced the lowest 1000 grains weight. The highest yield per m^2 was produced by the LPNBR 1628, whereas the lowest yield per m^2 was produced by the variety NR11130-B-B-B-8-3. Genotypic correlation coefficients were lower than the corresponding phenotypic correlation coefficients of all the traits. The highest GCV (30.675) was found in case of Grain yield. Heritability was quite high for all the characters except panicle length (0.02), flag leaf area (0.14). The highest heritability was found against the character of anthesis days (0.97), Genetic advance was found highest for effective tillers per m^2 (33.80). Grain yield per plant showed significant and positive correlation with spikelet fertility indicating the importance of filled grain per panicle for yield improvement in this population.

Keywords: Correlation; GCV; Heritability; PCV; Rice

Introduction

Rice (*Oryza sativa*) is a plant belonging to family Gramineae. Rice is the staple food crop of almost 50% of the world population i.e. 3 billion people. Asian region has 90% global production of rice (IRRI, 2016). It is grown from sea level (Indonesia) to more than 3050m elevation (Nepal) and from 50^0N latitude to 40^0S latitude from equator. In 2014, world production of paddy rice was 741.5 million tons, led by China and India with a combined 49% of this total. Other major producers were Indonesia, Bangladesh and Vietnam [1]. In Nepal Rice is cultivated in all agroecological regions (mountains, hills and terai) covering mountain slopes, hill terraces, intermountain basins, river valleys and flat lowland plains bordering India [2] i.e. 71.57% area in Terai, 24.81% in Hill and 3.62% in Mountain. It contributes approximately 21% to Agricultural Gross Domestic Product (GDP) of the country [3]. It occupies about 1.42 million ha of land with annual production of 4.5 million tons and productivity of 3.36 tons per ha during fiscal year 2014/015 [4]. 40% of the food calorie intake for the people of Nepal with an average per capita annual consumption of 122 kg [4]. Rice grain contains 75 to 80% starch, 12% water and 7% protein [5,6].

The area of paddy cultivated in Nepal in the year 2013/14 was 1,486,951 ha with production of 5,047,047 Metric ton. However, the production area and the production decreased in the following years 2014/15 and 2015/16. In the year 2015/16 the production area and production of rice in Nepal was 1,362,908 ha and 4,299,079 Metric Ton. Once an exporter of rice, Now Nepal has a food deficit. The productivity of rice is decreasing as a result the condition of food security is worsening. Also the gross profit gained from rice is approximately INR 5,994 per ha which is quite lower than vegetables and fruits due to higher rate of cultivation [7]. Therefore, transformation of conventional rice cultivation practice is an urgent need to address the issue of food security. The most effective and economic way is crop improvement through suitable breeding programme. For the improvement of grain yield, the knowledge on the association between grain yield and its component characters will be helpful. Once genetic variability has been ascertained, crop improvement is possible through the use of appropriate selection method So to break yield barriers in rice breeding, this research can act as important study as an initiation as well as reference for further researches on rice in mid-hill of Nepal.

Materials and Methods

Location of experiment and cropping history

A total of seven promising lines from NARC were evaluated together with a local check variety (Biji) in field of IAAS at an altitude of 725 meter above sea level with Latitude of 28º7´ to 28º10´ North and longitude of 84º24´ to 84º 28´ East on Randomized Complete Block Design which were replicated 3 times. Seed sowing was done on 8th June at the rate of 400 gram/plot (3m^2). 27 days seedling were transplanted. Land preparation were done by using tractor and indigenous plough. Plots were randomly assigned within each main plot. The sub-plot size was 3m × 2m, where two seedlings per hill were planted in a line with a hill spacing of 0.2m × 0.2m. There was no practice of agriculture in the research site. The land was left fallow all around the year. No FYM, 100:60:40 kg N: P_2O_5: K_2O ha^{-1} urea, DAP and MOP were applied. Only half dose of Urea was applied as basal dose and remaining (1/4) of each were applied at 1st and 2nd top dressing on 30 and 60 days after transplanting (DAT). First weeding was done in 28th July (23 DAT). Second weeding was done in 20th August (48 DAT). No chemical weedicide was applied. Rice bug was the serious problem in the field. So, the field was sprayed with Cypermethrin 2 ml/L on the date 11th September. Water was applied most of the time in the field. Field was drained one week before harvesting. Harvesting was done when more than 50% plant turned yellow on 30th October. Harvesting was done by using sickle and allowed for sun drying on the same field. Threshing was done manually.

Data collection and recording

Different Phenological, biometric observations and yield attributing characters were taken and Harvest index, Spikelet fertility and relative water content were computed using following formulae.

i) Spikelet fertility = $\frac{Filled\ grain}{Total\ grain} \times 100$

ii) Harvest index = $\frac{Grain\ Yield\ (Kg)}{Grain\ Yield\ (Kg) + Straw\ Yield\ (Kg)} \times 100$

iii) Relative water content =

$$\frac{Fresh\ leaf\ weight\ (gm) - Oven\ dry\ leaf\ weight\ (gm)}{Leaf\ weight\ after\ dipping\ in\ water (gm) - Oven\ dry\ leaf\ weight\ (gm)} \times 100$$

Statistical analysis

Data entry and processing was carried out using Microsoft Excel 2016 and Microsoft Word 2016 software. Mean and Standard deviations, Analysis of variance (ANOVA), mean performance and DMRT was calculated by using RStudio version 3.1.1. Pearson's correlation co-efficient was computed by using IBM SPSS Statistics 21.

Result and Discussion

Yield and Yield Attributes

Significant variation was found among the studied genotypes for days to booting, days to heading, days to anthesis, plant height, effective tillers per m^2, thousand grain weight, straw yield, harvest index. But non-significant for panicle length, days to anthesis, yield per plant, panicle exertion, panicle length, spikelet fertility, straw yield, grain yield, flag leaf area. Mean performance of genotypes for these traits is presented in table 1.

The mean number of days to booting was 88.291 days. The minimum days to booting was 81 days, which was exhibited by NR11130-B-B-B-8-3, whereas the maximum number of days to booting was 106 days, exhibited by Local Check BG. The mean number of days to heading was 94.5 days. The minimum days to heading was 85.667 days which was exhibited by NR1196-B-25-3, whereas the maximum number of days to heading was 122.33 days, exhibited by Local Check BG. The mean number of days to anthesis was 97.5833days. The minimum days to anthesis was 88.667 days which was exhibited by NR11130-B-B-B-8-3, whereas the maximum number of days to 121.333 days which was exhibited by Local Check BG. The mean plant height was 137.1917. The minimum plant height was 102.0467 cm which was exhibited by LPNBR 1628, whereas the maximum plant height was 156.9133

Treatments	NR11289-B-16-3	NR1196-B-25-3	NR11130-B-B-B-8-3	NR11130-B-B-B-8	LPNBR 1628	LPNBR 1632	Khumal-4	Biji (Local Check)	Grand Mean	F- Test	CV
Bd	91b	81c	81c	82c	90b	84c	90b	106a	88.29	0.00***	3.17
Hd	95.66b	85.66c	85.66c	85.66c	95.33 b	91.66 bc	94b	122.33a	94.5	0.00***	4.35
Ad	98.33bc	89.66d	88.66d	89.66d	99.66 b	96.33 c	97bc	121.33a	97.58	0.00***	1.74
Ph (cm)	156.91a	147.94abc	156.30a	148.86ab	102.04 e	125.04 d	132.97 bcd	126.91cd	137.19	.0004***	8.22
Pl (cm)	30.027a	26.68a	26.68a	27.127a	27.127 a	28.067 a	28.30a	29.867a	27.99	0.4	8
Etpm	110.00ab	88.00bc	139.00a	63.00c	106.33 ab	85.33 bc	97.667 bc	135.667a	103.12	.009**	20.50
Sf	83.02 a	72.82ab	46.89b	62.04ab	77.92 a	86.39 a	63.44ab	78.82a	71.41	0.08	20.86
Tgw	20.1e	22.5de	23.99cd	21.55de	34.36 a	31.31 b	20.33e	26.1c	25.03	.00***	5.8
Sy (kg)	0.58bc	0.88a	0.80ab	0.53c	0.57 bc	0.73 abc	0.55bc	0.62bc	0.65	.04*	19.74
Gy	0.30ab	0.23ab	0.14b	0.16b	0.45a	0.38 ab	0.19b	0.37ab	0.28	0.1	49.64
Hi	0.34ab	0.21bc	0.14c	0.20bc	0.42a	0.33 abc	0.24abc	0.38ab	0.283	.0449*	35.79
Fla (cm^2)	43.60ab	44.88ab	43.05	40.13a	59.64 ab	64.85 a	42.05ab	52.96ab	48.89	0.242	26.43
Rwc	56bc	51.79bc	39.57d	47.22cd	59.74 b	56.14 bc	62.46ab	73.07a	55.75	.0009***	11.75

Table 1: Bd: 50% Booting Days; Hd:50% Heading Days; Ad: 50% Anthesis Days; Ph: Plant Height; Pl: Panicle Length; Etpm: Effective Tillers Per Meter Square; Sf: Spikelet Fertility; Tgw: Thousand Grain Weight; Sy: Straw Yield; Gy: Grain Yield; Hi: Harvest Index; Fla: Flag Leaf Area; Rwc: Relative Water Content

cm which was exhibited by NR11289-B-16-3. The mean panicle length was 27.997 cm. The minimum panicle length was 26.68 cm which was exhibited by NR1196-B-25-3, whereas the maximum panicle length was 30.026 cm which was exhibited NR11289-B-16-3. The mean effective tillers per meter square were 103.125. The minimum effective tillers per meter square were 63 which was exhibited by NR11130-B-B-B-8, whereas the maximum effective tillers per meter square were 139 which was exhibited by NR11130-B-B-B-8-3. The mean spikelet fertility was 71.4196. The minimum spikelet fertility was 46.887 which was exhibited by NR11130-B-B-B-8-3, whereas the maximum spikelet fertility was 86.39039 which was exhibited by LPNBR1632. The mean thousand weight was 25.030 gram. The minimum thousand grain weight was 20.326 gram which was exhibited by Khumal-4, whereas the maximum thousand grain weight was 34.36 gram exhibited by LPNBR 1628 followed by LPNBR1632 (31.307 gram). The mean straw yield was 0.658 kg. The minimum straw yield was 0.533 kg which was exhibited by NR11130-B-B-B-8, whereas the maximum straw yield was 0.883 kg which was exhibited by NR1196-B-25-3. The mean grain yield was 0.278 kg per m^2. The minimum grain yield was 0.137 kg per m2 which was exhibited by NR11130-B-B-B-8-3, whereas the maximum grain yield was 0.453 kg per m2 exhibited by LPNBR 1628 followed by LPNBR1632 (0.383 kg per m^2). The mean harvest index was 0.28. The minimum harvest index was 0.14 which was exhibited by NR11130-B-B-B-8-3, whereas the maximum harvest index was 0.43 exhibited by LPNBR 1628 followed by Local Check BG (0.38). The mean flag leaf area was 48.89 cm^2. The minimum flag leaf area was 40.13 cm^2 which was exhibited by NR11130-B-B-B-8, whereas the maximum flag leaf area was 64.85 cm2 exhibited by LPNBR1632. The mean relative water content was 55.748. The minimum relative water content was 39.574 which was exhibited by NR11130-B-B-B-8-3, whereas the maximum relative water content was 73.067 exhibited by Local Check BG.

Variability, heritability and genetic advances

Estimates of genotypic (V_g) and phenotypic variances (V_p), genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), broad sense heritability (H^2), genetic advance (GA) are shown in table 2.

	TrMss	EMSS	Mean	Vg	Ve	Vp	$\sqrt{v_g}$	$\sqrt{v_p}$	GCV	PCV	Heritability	GA
Bd	205.85	7.83	88.22	66.01	7.83	73.84	8.12	8.59	9.21	9.74	0.89	15.82
Hd	436.8	16.9	94.50	139.97	16.9	156.87	11.83	12.52	12.52	13.25	0.89	23.02
Ad	332.5	2.9	97.58	109.87	2.9	112.77	10.48	10.62	10.74	10.88	0.97	21.31
Ph	1071.5	127.4	137.19	314.70	127.4	442.10	17.74	21.03	12.93	15.33	0.71	30.83
Pl	5.33	5.02	28.00	0.10	5.02	5.12	0.32	2.26	1.15	8.08	0.02	0.09
Etpm	1967	447	103.13	506.67	447	953.67	22.51	30.88	21.83	29.95	0.53	33.80
Sf	519.1	222.1	71.42	99.00	222.1	321.10	9.95	17.92	13.93	25.09	0.31	11.38
Tgw	82.95	2.11	25.03	26.95	2.11	29.06	5.19	5.39	20.74	21.54	0.93	10.30
Sy	0.05	0.02	0.66	0.01	0.02	0.03	0.11	0.17	16.25	25.58	0.40	0.14
Gy	0.04	0.02	0.28	0.01	0.02	0.03	0.09	0.16	30.68	58.24	0.28	0.09
Hi	0.03	0.01	0.28	0.01	0.01	0.02	0.08	0.13	28.14	45.53	0.38	0.10
Fla	252.3	167.1	48.90	28.40	167.1	195.50	5.33	13.98	10.90	28.60	0.15	4.18
Rwc	304.76	42.98	55.75	87.26	42.98	130.24	9.34	11.41	16.76	20.47	0.67	15.75

Table 2: Bd: 50% Booting Days; Hd:50% Heading Days; Ad: 50% Anthesis Days; Ph: Plant Height; Pl: Panicle Length; Etpm: Effective Tillers Per Meter Square; Sf: Spikelet Fertility; Tgw: Thousand Grain Weight; Sy: Straw Yield; Gy: Grain Yield; Hi: Harvest Index; Fla: Flag Leaf Area; Rwc: Relative Water Content; TrMss: Treatment Mean Sum of Square; EMSS: Error Mean Sum of Square; v_g: Genotypic Variance; v_e: Error Variance; v_p: Phenotypic Variance; GCV: Genotypic Coefficient of Variance; PCV: Phenotypic Coefficient of Variance; GA: Genetic Advance.

Vg, Vp, GCV and PCV

Genotypic coefficients of variation ranged from 1.153 (Panicle length) to 30.675 (Grain yield) whereas phenotypic coefficient of variation ranged from 8.084 (Panicle length) to 58.224 (Grain yield) among various parameters studied. PCV and GCV values more than 20% are regarded as high, whereas values less than 10% are low and values between 10 and 20% to be moderate [8]. Based on this delineation, GCV and PCV high for effective tillers per m^2, thousand grain weight, grain yield, harvest index. Moderate GCV and high PCV for spikelet fertility, straw yield, flag leaf area and relative water content. Similarly, moderate GCV and PCV for Heading days, anthesis days and plant height. Low GCV and PCV for booting days and panicle length. In addition, PCV values were higher than theirs corresponding GCV values for all the characters considered. However, this difference was low for all the characters except the effective tillers per meter square, spikelet fertility, grain yield, flag leaf area, harvest index. Results of present study closely agree with the earlier reports of Ramalingam., *et al*. [9], Suman., *et al*. [10] and Panwar., *et al* [11]. Findings of Prasad., *et al*. [12] and Zahid., *et al*. [13] reported maximum variation for grain yield.

Heritability in broad sense (H^2)

Heritability is an important concept in quantitative genetics, particularly in selective breeding. The heritability in broad sense (H^2) estimate varied from 0.02 to 0.974 respectively for panicle length and anthesis days. Traits with heritability less than 0.2 are considered as low heritable traits, between 0.2 - 0.4 are considered as moderate traits and > 0.4 are high heritable traits. Booting days (0.89), heading days (0.89), anthesis days (0.97), plant height (0.71), effective tillers per meter square (0.53), thousand grain weight (0.92), relative water content (0.67) are highly heritable traits. Spikelet fertility (0.31), straw yield (0.40), grain yield (0.28) are moderately heritable traits whereas panicle length (0.02), flag leaf area (0.14) are low heritable traits. Similar results were reported by Kaul and Kumar [14], Mehetre., *et al.* [15] and Sarma., *et al.* [16], Ehdaie and Waines [17], Ayciecek and Yildirim [18] and Mohsin., *et al.* [19] for anthesis days, thousand grain weight, plant height, effective tillers per meter square. Low heritability might be due to the variation of environmental component involved in this trait. The moderate heritability estimate for grain yield may possibly be due to the influence of the environment on the polygenic nature of this trait.

Correlation

Degree of correlation between the traits is important in plant breeding as it can be used as tools for indirect selection. Paddy yield revealed positive correlation with booting days, heading days, anthesis days, panicle length, effective tillers per m2, spikelet fertility, harvest index, flag leaf area, relative water content whereas negative correlation with plant height and straw yield. Correlation Between grain yield and yield component of eight rice genotypes is presented in table 3.

	Bd	Hd	Ad	Ph	Pl	Etpm	Sf	Tgw	Sy	Bi	Gy	Hi	Fla	Rwc
Bd	1	.981**	.980**	-0.407	.778*	0.508	0.435	0.124	-0.442	0.03	0.536	0.68	0.243	.895**
Hd		1	.997**	-0.391	.741*	0.528	0.426	0.177	-0.328	0.125	0.536	0.638	0.308	.863**
Ad			1	-0.455	.733*	0.492	0.481	0.24	-0.345	0.156	0.597	0.691	0.373	.887**
Ph				1	0.01	-0.008	-0.448	-0.829*	0.314	-0.316	-.778*	-0.726*	-.773*	-0.598
Pl					1	0.336	0.542	-0.194	-0.441	-0.098	0.361	0.549	0.077	0.678
Etpm						1	-0.172	0.091	0.162	0.235	0.137	0.154	0.053	0.197
Sf							1	0.408	-0.148	0.491	.830*	.819*	0.654	0.625
Tgw								1	0.035	0.608	.784*	0.611	.918**	0.22
Sy									1	0.688	-0.188	-0.439	0.065	-0.425
Bi										1	0.584	0.339	0.691	0.119
Gy											1	0.951**	0.863**	0.637
Hi												1	0.698	.744*
Fla													1	0.398
Rwc														1

Table 3: Bd: 50% Booting Days; Hd:50% Heading Days; Ad: 50% Anthesis Days; Ph: Plant Height; Pl: Panicle Length; Etpm: Effective Tillers Per Meter Square; Sf: Spikelet Fertility; Tgw: Thousand Grain Weight; Sy: Straw Yield; Gy: Grain Yield; Hi: Harvest Index; Fla: Flag Leaf Area; Rwc: Relative Water Content.

**: Correlation is significant at the 0.01 level (2-tailed).

*: Correlation is significant at the 0.05 level (2-tailed).

Plant height showed significant negative correlation with grain yield per meter square indicating yield could be improved by decreasing plant height. This character also had significant negative correlation with thousand grain weight, harvest index and flag leaf area, whereas non-significant negative correlation with effective tiller per meter square, total grain per panicle, filled grain per panicle, spikelet fertility and relative water content.

Panicle length was found to display significant positive correlation with booting, heading and anthesis days and positive correlation with total grain per panicle, filled grain per panicle, spikelet fertility and grain yield. However, panicle length with thousand grain weight, straw yield and biological yield was negatively correlated.

Highly positive significant association was obtained between filled grain per panicle with spikelet fertility, grain yield, harvest index and flag leaf area. Whereas, negative correlation was obtained for plant height, effective tillers per meter square and straw yield. Positive correlation was found for thousand grain weight, biological yield, relative water content, anthesis days, booting days, heading days, panicle length with filled grain per panicle.

Positive significant correlation was obtained for total grain per panicle, filled grain per panicle, grain yield, harvest index with spikelet fertility. Significant correlation was obtained between total grain per panicle, filled grain per panicle, grain yield, harvest index and spikelet fertility, however plant height, effective tillers per meter square, straw yield showed negative correlation with spikelet fertility.

Positive significant correlation was obtained for grain yield, flag leaf area with 1000 grain weight. Therefore, selection based on this trait would be effective for increasing grain yield. Positive correlation was obtained for booting days, anthesis days, heading days, total grain per panicle, filled grain per panicle, spikelet fertility, biological yield and harvest index, whereas negative significant correlation for panicle length. Similarly, low positive correlation was obtained for effective tillers per meter square, straw yield, relative water content.

Grain yield, spikelet fertility, filled grain per panicle, total grain per panicle, relative water content showed highly positive correlation with harvest index. This result implies that grain yield could be increased by increasing harvest index. Significant negative correlation was obtained for plant height. Also, positive correlation was obtained for booting days, heading days, anthesis days, panicle length, effective tillers per meter square, thousand grain weight, biological yield, flag leaf area. Negative correlation was obtained for straw yield.

Booting days, heading days, anthesis days, panicle length thousand grain weight, biological yield, grain yield, harvest index, flag leaf area, relative water content showed positive correlation with effective tillers per meter square whereas plant height, total grain per panicle, filled grain per panicle, spikelet fertility, straw yield showed negative correlation with effective tillers per meter square.

Anis., *et al*. [20], Khan., *et al*. [21] and Moosavi., *et al*. [22] also reported negative correlation of plant height for grain yield. However positive significant correlation was obtained by Yadav., et al. [23], Akhtar., *et al*. [24], Yadav., *et al*. [25], Seyoum., *et al*. [26] for plant height with grain yield. Chaubey and Singh [27] gave similar finding for anthesis days and panicle length. Ramakrishnan., *et al*. (2006) found positive and non-significant correlation of panicle length with yield. However, Chaubey and Richharia [28], Ullah., *et al*. [29], Tomar., *et al*. [30], Ghosal., *et al*. (2010), Yadav., *et al*. [23], Vange [31], Sadeghi., *et al*. [32], Sankar., *et al*. [33], Selvaraj., et al. [34] and Rangare., et al. [35] reported positive and significant correlation between grain yield and panicle length. Panicle length has lowest correlated value with flag leaf area (0.077), whereas Anis., *et al*. [20] reported highest value between panicle length and flag leaf area. Chakraborty., *et al*. [36], Rajeshwari and Nandrajan [37] reported similar result for filled grain per panicle and grain yield. Silitonga [38] observed significant positive correlation between number of filled grains and grain yield. Paul and Sharma [39] reported similar types of observation for harvest index, grain yield, filled grain per panicle with spikelet fertility. Ray., *et al*. (1993), Paul and Sharma [39] and Balan., *et al*. [40], Chakraborty., *et al*. [36] reported highly significant positive correlation between 1000-grain weight and grain yield. Iftekharuddaula., *et al*. [41] reported similar finding for grain yield and harvest index. Positive association of grain yield with productive tillers [37].

Conclusion

In this study, Genotype LPNBR-1628 gave the highest grain yield followed by LPNBR-1632. LPNBR-1628 also showed highest thousand grain weight, maximum harvest index, and minimum height among the genotypes. LPNBR-1632 showed maximum spikelet fertility, flag leaf area. So, these two genotypes are best adaptive in mid-hill of western Nepal. These two genotypes can be used in selection for high yield rice genotypes and/ or hybridization between them or with any other high yield rice genotypes.

Highest GCV and PCV was for grain yield and lowest GCV and PCV for panicle length. Highest variation between GCV and PCV was for grain yield. Heritability in broad sense was maximum for anthesis days and minimum for panicle length. Booting days, anthesis days, heading days, plant height, effective tiller per meter square, thousand grain weight, relative water content are highly heritable traits and spikelet fertility, straw yield, grain yield are moderately heritable traits. These characters could be successfully transferred to off-springs if their selection is performed in hybridization programme Thus, these plant traits deserve greater attention in further breeding programs for developing high yielding rice. Panicle length and flag leaf area are low heritable traits.

Spikelet fertility (Number of filled grains/panicle) is the most important character for selection to improve grain yield as suggested by correlation analysis.

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Volume 2 Issue 9 September 2018