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Performance, nutrient uptake and economics of rainfed rice varieties under different crop establishment techniques

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Abstract

A field experiment was conducted at the experimental farm of Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), during *kharif* 2017. The treatments consisted of three establishment methods (direct seeding of rice, puddled transplanting, unpuddled transplanting) and six varieties (Sahbhagi Dhan, Abhishek, Sabour Ardhjal, DRR-42, Swarna Shreya, and Rajendra Nilam). Results showed that maximum number of panicles (231.2/m^2), panicle length (28.1 cm), and number of grains per panicle (104.0) were achieved with puddled transplanting. Puddled transplanting showed 8.7% and 9.3% higher grain yields over unpuddled transplanting and direct seeding of rice, respectively. Sahbhagi Dhan recorded the highest number of panicles (230.5/m^2), panicle length (28.8 cm), and number of grains per panicle (104.5). Sahbhagi Dhan recorded significantly higher grain yield (41.5 q/ha) as compared to Abhishek (39.0 q/ha), DRR 42 (37.0 q/ha), and Rajendra Nilam (36.3 q/ha). Sabour Ardhjal, on the other hand, produced significantly higher straw yield (66.2 q/ha) than the others. Puddled transplanting registered significantly higher gross returns of ₹76170/ha with a B:C ratio of 1.22. Sahbhagi Dhan registered the highest net returns and B:C ratio, followed by Sabour Ardhjal. So, puddled transplantation of Sahbhagi Dhan proved beneficial for higher yield and profitability under rainfed conditions.

Key words: Puddled transplanting, profitability, rice, sahbhagi Dhan, yield

One of the main abiotic stress factors limiting rice productivity and yield stability is drought (Lanceras *et al*., 2004). Improved rice varieties with higher yield, better quality, and market value and tolerance to biotic and abiotic stress can increase rice farm productivity (drought, flood, extreme temperature, disease, and pest). Changing to crop varieties that are resistant to climate stress is one of the most frequently mentioned adaptation techniques for farm and non-farm life adaptation strategies (Dar *et al*., 2017).

In all rice-growing countries, there is an acute shortage of human labour during the transplanting period, and in many cases, this delays the transplanting, leading to reduced yield and lower profit (Singh *et al*., 2013). Agronomic manipulation, *viz*., planting geometry, may be advantageous for achieving the potential yield of rice varieties; however, the optimum planting geometry differed for rice varieties depending on their growth, duration, and plant structure (Huang *et al*., 2018).

Hence, determination of a suitable establishment method for harnessing the potential yield of different rice varieties needs critical investigation. Varieties play a unique role in the maximization of yield by improving input use efficiency. Thus, the selection of a suitable variety is of prime importance as the genetic potential of a variety

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limits the expression of its yield and affects plant growth in response to environmental conditions. Therefore, the present experiment was planned to evaluate the relative performance of rice varieties in terms of yield and profitability under different establishment methods in the rainfed conditions of Bihar.

Materials and Methods

The field experiments was carried out at research farm of Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar) during *kharif* season of 2017. The climate is sub-tropical, greatly influenced by hot-dry summer and too cold winter. It falls in the region of south-west monsoon and generally monsoon starts from mid-June and continue up to September. The total rainfall of 797.3 mm, maximum temperature ranging between 32.6 to 37.8^{o}C, mean minimum temperature ranged between 15.3 to 26.4^{o}C and maximum relative humidity varied between 91 to 77% was recorded during the cropping period of 2017. The soil was sandy loam with pH of 8.2, organic carbon content of 0.46%, available N of 285 kg/ha, available P_2O_5 of 22.6 kg/ha and available K_2O of 161.0 kg/ha at the start of the experiment in 0 to15 cm soil layer. The experiment was laid out in split plot design with three replications. Treatments consisted of three crop establishment methods in main plot viz. M_1-direct seeding rice, M_2-puddled transplanting, M_3-unpuddled transplanting and six varieties practiced in sub-plots viz. V_1-Sahbhagi Dhan, V_2-Abhishek, V_3-Sabour Ardhjal, V_4-DRR 42, V_5-Swarna Shreya and V_6-Rajendra Nilam. Sahbhagi Dhan is a dwarf variety with duration of 105-110 days. Abhishek is semi-dwarf variety resistance to bacterial blight. Sabour Ardhjal is suitable for upland and medium land condition. DRR 42 is high yielding variety. Swarna Shreya is suitable for rainfed low land condition with duration of 120-125 days. Rajendra Nilam is early maturing semi-dwarf variety with duration of 110-115 days. The treatments were randomized as per procedure given by Cochran and Cox (1962). The net plot size was 5.0 m x 2.6 m. The plot under direct seeded rice was cultivated twice using cultivator followed by harrowing with rotavator. In the treatment of puddled transplanted rice and unpuddled transplanted rice two ploughing operation was done by cultivator followed by crosswise harrowing using rotavator. For puddled transplanted rice, irrigation was applied before harrowing specially for puddling operation and it was not done for unpuddled transplanted rice. For the treatment unpuddled transplanted rice, irrigation was applied just after harrowing and kept the field for overnight soaking. In direct seeding of rice, seed was directly sown with seed rate of 80 kg/ ha and row to row distance of 20 cm in non pudlled and non-flooded soil; but in transplanted condition 25 days old seedlings were transplanted with 2-3 seedling/hill in the spacing of 20 × 15 cm. Recommended dose of fertilizer was 120:60:40 (N:P:K) and half of N along with full doses of phosphorus and potassium were applied at the time of sowing/transplanting. Remaining N was applied in two split *i.e.* tillering stage and panicle initiation stage. Pretilachlor @ 0.75 kg/ha at 3 DAT was applied in transplanted condition and bispyribac sodium @ 250 g/ha was applied at 20 DAT/S throughout the experimental plot. The crop was harvested on October 2017. Sampled plants were properly earmarked and tagged for field observation in situ. All data were recorded as per the standard procedure formula. The yield of clean and dry grains in the net plot area was recorded in kilogram/plot and was later converted in to q/ha to give the grain yield. The straw obtained after threshing from each net plot area was air dried and weighted. The weight of straw, thus obtained was converted into q/ha. Plant samples collected at harvest were dried in hot air oven at 60 ± 2 °C for 6 hours. The oven dried samples of straw and grain were taken for chemical analysis to determine N by modified microkjeldhal's method as outlined by Jackson (1973), P by vanadomolybdo phosphoric yellow colour method using spectrophotometer at 470 nm (Piper, 1966) and K by flame photometry (Piper, 1966). Statistical analysis was done by adopting appropriate method of Analysis of Variance (Gomez and Gomez, 1984).

Results and Discussion

Yield attributes

Number of panicles, panicle length, number of grains per panicle, and 1000-grain weight are important yield attributes that affect the yield of rice to a greater extent. Puddled transplanting recorded a significantly higher number of grains/panicle (104.0), which were 8.6 and 9.4% more than unpuddled transplanting and direct seeding of rice, respectively. Puddled transplanting resulted in an adequate supply of soil moisture throughout the crop growth period, particularly during the panicle initiation stage, which resulted in the maximum number of panicles. Sahu *et al*. (2015) and Baloch *et al*. (2006) also reported significantly higher panicles or hills under puddled transplanting than unpuddled transplanting. A favourable effect of puddled transplanting on the number of grains or panicle was also reported by Dileep *et al.* (2018). The higher number of grains/panicle with puddled transplanting was perhaps owing to better partitioning of photosynthates from source to sink as a result of lower crop weed competition (Sahu *et al*., 2015).

Different establishment methods did not show any significant effect on 1000-grain weight; however, it was comparatively higher under puddled transplanting. The varieties differed significantly in expressing their yield attributes. Among the varieties, Sahbhagi Dhan produced a significantly higher number of grains (104), which was statistically comparable to Sabour Ardhjal (101.6) and Swarna Shreya (100.9), which were significantly superior to other varieties. Similar findings were also reported by Manjunath *et al*. (2012) and Uddin *et al.* (2010). The varieties also differed significantly for 1000-grain weight. Maximum 1000-grain weight was recorded with the variety DRR-42 (23.5 g), which was followed by Rajendra Nilam (23.1 g) and Sahbhagi Dhan (22.4 g). Similar results were also reported by Sharma *et al*. (2016) and Suryavanshi *et al.* (2012).

Yield of rice

Methods of rice establishment had a marked effect on grain yield (Fig. 1). Puddled transplanting recorded a significantly higher grain yield (41.3 q/ha), followed by unpuddled transplanting (38.0 g/ha) and direct seeded rice (378 q/ha) (Fig 1). Puddling has great significance in rice culture. It increases the availability of nutrients, ensures better plant establishment, kills the weeds, and

Table 1. Effect of different establishment methods and varieties on yield attributes, straw yield and harvest index of rice

Treatment	Number of panicles/m^2	Panicle length (cm)	Number of grains/ panicle	1000-Grain weight (g)	Straw yield (q/ha)	Harvest index (%)
Establishment methods						
M_1	209.2	26.5	95.1	21.9	58.6	39.24
M_2	231.2	28.1	104.0	22.6	60.9	40.46
M_3	210.1	26.8	95.8	22.1	59.0	39.60
SEm±	3.62	0.32	1.43	0.17	1.04	0.76
CD (P=0.05)	14.6	1.3	5.8	NS	NS	NS
Varieties						
V_1	230.5	28.8	104.5	22.4	60.5	40.42
V_2	216.5	27.1	98.2	21.3	61.5	38.82
V_3	224.1	28.0	101.6	21.7	66.2	37.92
V_4	205.7	25.7	93.2	23.5	57.7	39.10
V_5	222.6	27.8	100.9	21.4	56.5	41.51
V_6	201.5	25.2	91.4	23.1	54.5	39.99
SEm±	4.58	0.46	1.87	0.26	1.32	1.01
CD (P=0.05)	13.3	1.4	5.4	0.7	3.8	NS
Intraction M×V						
SEm±	7.94	1.81	3.24	0.44	2.29	1.75
CD (P=0.05)	NS	NS	NS	NS	NS	NS

M_1-Direct seeding of rice; **M_2**-Puddled transplanting; **M_3**-Unpuddled transplanting; **V_1**-Sahbhagi Dhan; **V_2**-Abhishek; **V_3**-Sabour Ardhjal, **V_4**-DRR 42; **V_5**-Swarna Shreya; **V_6**-Rajendra Nilam; SEm(±) = Standard error of mean; CD: Critical difference helps the plants grow vigorously. Sahu *et al.* (2015) also reported that the highest yield under puddle transplanted conditions may be owing to better crop growth and yield-attributing characteristics because of efficient utilization of available resources, which has a direct impact on increasing the grain yield of rice. The straw yield of rice did not undergo significant changes due to different establishment methods (Table 1). Though a comparatively higher straw yield (60.9 g/ha) was obtained with puddled transplanting, which was followed in order by direct-seeded rice.

Moreover, there were significant variations in grain yield and straw yield among rice varieties. Variety Sahbhagi Dhan produced a higher grain yield (41.5 q/ha), which was statistically similar

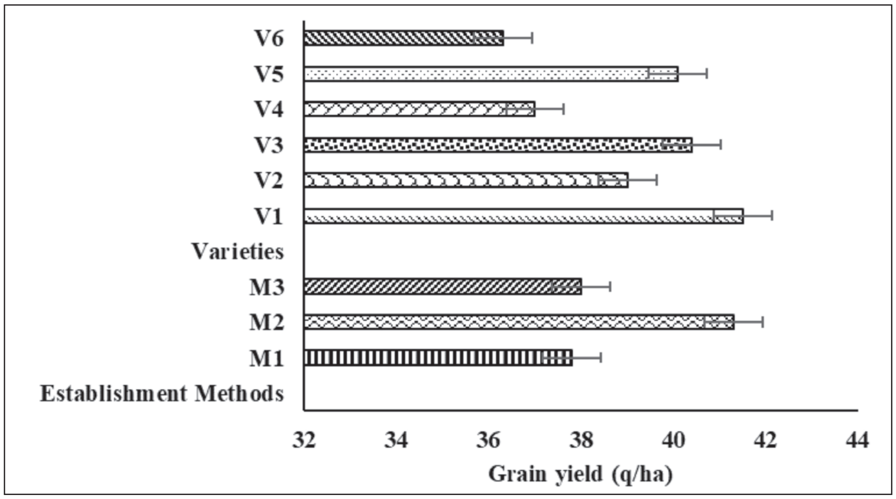

Fig. 1. Impact of different establishment methods and varieties on grain yield of rice (**M_1**-Direct seeding of rice; **M_2**-Puddled transplanting; **M_3**-Unpuddled transplanting; **V_1**-Sahbhagi Dhan; **V_2**-Abhishek; **V_3**-Sabour Ardhjal, **V_4**-DRR 42; **V_5**-Swarna Shreya; **V_6**-Rajendra Nilam)

Table 2. Effect of different establishment methods and varieties on N, P and K uptake by rice

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
M_1	41.0	30.6	71.6	9.8	8.0	17.8	8.2	67.8	75.9
M_2	45.7	33.9	79.6	11.7	9.2	20.9	9.5	73.2	82.8
M_3	41.7	31.3	73.0	10.1	8.2	18.3	8.5	69.5	78.0
SEm±	0.72	0.56	0.29	0.18	0.15	0.07	0.15	1.21	1.07
CD (P=0.05)	2.9	2.2	1.2	0.7	0.6	0.3	0.6	NS	4.3
Varieties									
V_1	45.0	32.1	77.1	11.1	8.5	19.6	9.2	70.5	79.7
V_2	43.0	32.2	75.1	10.6	8.6	19.1	8.8	70.8	79.5
V_3	43.9	33.5	77.4	10.8	9.0	19.8	9.0	73.7	82.7
V_4	40.9	31.8	72.7	10.0	8.4	18.5	8.3	69.9	78.2
V_5	43.7	31.4	75.1	10.8	8.3	19.1	8.9	68.9	77.8
V_6	40.3	30.6	70.9	9.9	8.1	18.0	8.2	67.2	75.4
SEm±	0.90	0.70	0.42	0.22	0.18	0.10	0.18	1.54	1.38
CD (P=0.05)	2.16	NS	1.2	0.6	0.5	0.3	0.5	NS	4.0
Intraction M×V									
SEm±	1.56	1.21	0.73	0.38	0.32	0.17	0.31	2.67	2.39
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

M_1-Direct seeding of rice; **M_2**-Puddled transplanting; **M_3**-Unpuddled transplanting; **V_1**-Sahbhagi Dhan; **V_2**-Abhishek; **V_3**-Sabour Ardhjal, **V_4**-DRR 42; **V_5**-Swarna Shreya; **V_6**-Rajendra Nilam; SEm(±) = Standard error of mean; CD: Critical difference to Sabour Ardhjal and Swarna Shreya and significantly superior to other varieties (Fig 1). Sabour Ardhjal produced significantly more straw yield (66.2 q/ha) than the other varieties. These findings are supported by Halder *et al*. (2009); Murthy *et al.* (2012); Veeresh *et al.* (2008); Kikon, and Gohain (2016).

Nutrient uptake of rice

N, P and K-uptake were significantly influenced by establishment methods (Table 2). Puddled transplanting recorded significantly higher total N (79.6 kg/ha), P (20.9 kg/ha) and K (82.8 kg/ha) which was followed by unpuddleed transplanting and direct seeded rice. It might be due to the submerged condition in transplanted rice facilitate availability of more mineralization form of N, P and K and therefore its uptake in transplanted rice is higher than that of direct sowing which encouraged tillers production in addition to higher dry matter production and grain yield. The findings confirm the results of Parameshwari and Shrinivas (2014) and Bhardwaj *et al*. (2018).

Among varieties, Sabour Ardhjal recorded higher total N-uptake (77.4 kg/ha) which was at par to Sahbhagi Dhan (77.1 kg/ha) and significantly superior over rest of the varieties. The P-uptake also showed the similar trend. Similarly, Sabour Ardhjal recorded higher total K-uptake which was statistically similar to Sahbhagi Dhan and Abhishek and significantly superior over other varieties. The higher N, P, K-uptake in Sabour Ardhjal may be attributed to higher mean grain and straw yield and nutrient concentration in yields. Such variable response to rice varieties was also observed by Dass and Chandra (2012).

Economics of rice

Puddled transplanting had a higher cost of cultivation due to the high cost of field preparation when compared to unpuddled transplanting and direct seeded rice. Among planting methods, puddled transplanting had the highest gross returns (₹76170/ha) followed by unpuddled transplanting and direct seeded rice (Table 3). This is may be due to higher biological yield obtained under puddled transplanted rice. Tripathi *et al.* (2004) and Gupta *et al*. (2006) also got similar results. However, direct seeding of rice recorded the maximum net returns (₹38700/ha) and B:C ratio (1.22). This is due to the lower cost of cultivation under direct seeded rice. Among varieties, the highest gross returns (₹76455/ha), net returns (₹40136/ha), and B:C ratio (1.12) were recorded with Sahbhagi Dhan. This might be due to the realisation of higher grain yields with the same input cost (Gangwar *et al*., 2008).

Table 3. Effect of different establishment methods and varieties on gross returns, net returns and B:C ratio of rice

Treatment	Gross returns (₹ /ha)	Net returns (₹/ha)	B:C ratio
Establishment methods			
M_1	70328	38700	1.22
M_2	76170	36405	0.92
M_3	70749	33184	0.88
SEm±	1209.3	825.0	0.02
CD (P=0.05)	4874	3326	0.09
Varieties			
V_1	76455	40136	1.12
V_2	72757	36438	1.02
V_3	75806	39487	1.10
V_4	68814	32494	0.91
V_5	73472	37153	1.04
V_6	67191	30872	0.87
SEm±	1533.5	1048.0	0.03
CD (P=0.05)	4448	3041	0.09
Interaction M×V			
SEm±	2656.0	1816.0	0.05
CD (P=0.05)	NS	NS	NS

M_1-Direct seeding of rice; **M_2**-Puddled transplanting; **M_3**-Unpuddled transplanting; **V_1**-Sahbhagi Dhan; **V_2**-Abhishek; **V_3**-Sabour Ardhjal, **V_4**-DRR 42; **V_5**-Swarna Shreya; **V_6**-Rajendra Nilam; SEm(±) = Standard error of mean; CD: Critical difference

Conclusions

Overall, it was observed in the present study that puddled transplanting recorded higher grain yield but higher net returns and B:C ratio were observed in direct seeding of rice as compared to puddled transplanting and unpuddled transplanting. Among different varieties, Sahbhagi Dhan recorded significantly higher yield attributes, nutrient uptake and economic yield as compared to other varieties. It can be concluded that drought tolerant variety Sahbhagi Dhan performed better under puddled transplanting under rainfed condition in terms of yield and economic point of view.

References

Bhardwaj, R., Singh, S., Singh, M.K., Singh, A.K and Tiwari, A.K. 2018. Soil fertility status and productivity of rice as influenced by different crop establishment methods under puddled condition. *Journal of Pharmacognosy and Phytochemistry.* SPI 7: 2943-2947.

Dar, M.H., Chakravorty, R., Waza, S.A., Sharma, M., Zaidi, N.W., Singh, A.N., Singh, U.S. and Ismail, A.M. 2017. Transforming rice cultivation in flood prone coastal Odisha to ensure food and economic security. *Food Security.* **9**: 711–722.

Dass, A. and Chandra, S. 2012. Effect of different components of SRI on yield, quality, nutrient accumulation and economics of rice (*Oryza sativa*) in tarai belt of northern India*. Journal of Agronomy.* **57**(3): 250-254.

Dileep, K., Pasupalak and Baliar, A.S. 2018. Effect of establishment methods and sowing time on growth and yield of rice varieties (*Oryza sativa*). *The Pharma Innovation Journal.* **7**(4): 904-907.

Gangwar, K.S., Gill, M.S., Tomar, O.K. and Pandey, D.K. 2008. Effect of crop establishment methods on growth, productivity and soil fertility of rice (O*ryza sativa*) based cropping systems. *Indian Journal of Agronomy.* **53**(2): 102-106.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* (2^{nd} Ed.). John Wiley and Sons, NewYork, USA.

Gupta, R.K., Jat, M.L., Singh, V.P. and Sharma, R.K. 2006. Resource conservation technologies. *Indian Farming.* **56**(7): 42-45.

Halder, J., Sahoo, K., Karmaker, S., and Nayak, R. 2014. Productivity and sustainability of different crop establishment methods for cultivation of rabi rice in Western Orissa. *Annals of Agricultural Research.* **30**(3&4): 82-86.

Huang, G., Qin, S., Zhang, S., Cai, X., Wu, S., Dao, J., Zhang, J., Huang, L. and Harnpichitvitaya, D. 2018. Performance, economics and potential impact of perennial rice PR23 relative to annual rice cultivars at multiple locations in Yunnan province of China. *Sustainability.* **10**(4): 1086.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, pp. 67-214.

Kikon, N. and Gohain, T. 2016. Growth and yield response of direct-seeded rice (*Oryza sativa* L.) cultivars under different sowing methods and weed management methods. *International Journal of Agricultural Sciences.* **8**(8): 1083-1086.

Lanceras, J.C., Pantuwan, G.P., Jongdee, B. and Toojinda, T. 2004. Quantitative trait loci associated with drought tolerance at reproductive stage in rice. *Plant Physiology.* **135**: 384-399.

Manjunath, B.L., Verma, R.R., Ramesh, R. and Singh, N.P. 2012. Evaluation of varieties and local manurial sources for organic rice (*Oryza sativa)* production. *Indian Journal of Agronomy.* **57**(3): 241-244.

Murthy, K.V.R., Reddy, D.S. and Reddy, G.P. 2012. Response of rice (*Oryza sativa*) varieties to graded levels of nitrogen under aerobic culture. *Indian Journal of Agronomy.* **57**(4): 367-372.

Parameshwari, Y.S. and Srinivas., A. 2014. Influence of weed management practices on nutrient uptake and productivity of rice under different method of crop establishment. *Journal of Rice Research* **7**(1&2): 403-405.

Piper, C.S. 1966. *Soil and Plant Analysis*, Academic Press, New York, pp. 236.

Sahu, R., Singh, M.K. and Yadav, L. 2015. Yield and economics as influenced by nitrogen scheduling, weed management and rice establishment methods in transplanted rice (*Oryza sativa*). *Indian Journal of Agronomy.* **60**(2): 261-266.

Sharma, V., Bali, A.S. and Kachroo. 2016. Effect of different establishment methods and sowing schedule on growth and yield of hybrid rice (*Oryza sativa*) and their after effect on succeeding wheat (*Triticum aestivum*) in rice-wheat cropping system. *Economic Affair.* **61**(13): 487-493.

Singh, R.K., Singh, A., Ram, H., Prasad, S.R. and Chauhan, R.K. 2013. Response of basmati (*Oryza sativa* L.) rice varieties to system of rice intensification (SRI) and conventional methods of rice cultivation. *Annals of Agricultural Research.* **34**(1): 50-56.

Suryavanshi, P., Singh, Y.V., Singh, K.K. and Shivay, Y.S. 2012. Relative efficiency of methods of crop establishment in rice (*Oryza sativa*). *Indian Journal of Agronomy.* **57**(3): 291-293.

Tripathi, J., Bhatta, M.R., Justice, S. and Shakya, N.K. 2004. Direct seeding: An emerging resource conserving technology for rice cultivation in the rice-wheat system. *In: Proc. 24th National Summer Crops Research Workshop*. July 8-10, 2004, Lalitput, Nepal. pp. 273-281.

Uddin, M.J., Hasan, M.M., Ahmed, S.M. and Hasan, M. 2010. Effect of spacing on morpho-physiological response of different Aman rice cultivars under coastal high land ecosystem. *Indian Journal Agricultural Research.* **44**(4): 251-258.

Veeresh, D.B.K., Vishwanath, S., Anilkumar., S.N, Rao, S and Halepyati, A.S. 2008. Growth and yield of Rice (*Oryza sativa* L.) varieties as influenced by different methods of planting under aerobic method of cultivation. *Research Jounal Agricultural Sciences*. **2**(2): 298-300.