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Short Communication

Growth analysis of rice (*Oryza sativa* L.) hybrids as influenced by fertility levels under mid hills of Himachal Pradesh

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Abstract

A field experiment was conducted at the Experimental Farm of Department of Agronomy of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (H.P.) during *kharif* 2019 to study the growth and performance of rice hybrids under varying fertility levels. The treatments consisted of four rice varieties (three hybrids viz., Arize 6129, Arize Swift, AZ 6508 and inbred HPR 2143) which were tested under five fertility levels viz., 50% recommended dose of fertilizer (RDF), 100% RDF (90:40:40), 150% RDF, 150% RDF + $ZnSO_4$ @ 25 kg ha^{-1} and natural farming treatment. The trial was laid out in split plot design with fertility levels in main plot and rice varieties in sub plot and was replicated thrice. Plant height and dry matter accumulation were significantly influenced by fertility levels with highest values recorded with the application of highest dose of fertilizers along with zinc while significantly lower values recorded in natural farming treatment. Significantly higher values of crop growth rate (CGR) and relative growth rate (RGR) at both the stages (between 30-60 days and 60 – 90 days after transplanting, DAT) were recorded with the application of 150% RDF + $ZnSO_4$ though this treatment was at par with the application of 150% RDF alone. Significantly lowest values of both these parameters at both the stages were recorded with the natural farming treatment. Varieties also differed significantly with HPR 2143 producing significantly taller plants while Arize Swift producing shorter plants. Hybrids accumulated more dry matter as compared to inbred HPR 2143 with AZ 6508 recording significantly higher value of this parameter. Among the varieties tested AZ 6508 recorded significantly higher values of CGR, RGR and NAR at both the stages of observation indicating higher potential of this hybrid.

Key words: Growth, CGR, RGR, NAR, fertility levels, hybrids.

Rice (*Oryza sativa* L.) is the staple food for half of the world's population and plays an important role in food and nutritional security of the world's poorest and undernourished people. This is also the most important food crop of our country and occupies the top place in terms of area as well as total production. It is one of the major *kharif* crops of the state of Himachal Pradesh being cultivated on an area of 73.7 thousand hectare with the production and productivity of 129.9 thousand tonnes and 17.6 q ha^{-1}, respectively (Anonymous 2017).The average productivity of this crop is quiet low in our state (17.6 q ha^{-1}) and there is immense scope of increasing this so as to achieve the food security of our state as well as improving the financial well-being of the farming community. Hybrid rice is one such technology that can help increase the productivity of this crop.The hybrids have a higher yield potential and hence also have a higher nutritional requirement.

Yield is a dynamic feature that depends on a number of physiological and biochemical processes taking place within the plant system. To completely understand the effect of various factors affecting yield attributes and yield, it is important to study the effect of these factors on different growth indices during the crop growing period.These indices are measured on the basis of the leaf area developed and dry matter accumulated at periodic interval (Gardner *et al*., 1985). Hence the present study was undertaken to study the impact of various levels of fertilizers on different growth indices so as to enable better understanding of the effect of these graded doses on the productivity of rice hybrids.

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The present investigation was carried out during *kharif* 2019 at the Experimental Farm of Department of Agronomy, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur (32°09' N latitude, 76°54' E longitude and altitude of 1290 m above mean sea level). The soil of the experimental site was silty clay loam in texture, acidic in reaction, medium in available nitrogen, phosphorus, potassium and zinc.The experiment consisted of twenty treatment combinations which included five fertility levels viz., 50% recommended dose of fertilizer (RDF), 100% RDF (90:40:40), 150% RDF, 150% RDF + $ZnSO_4$ @ 25 kg ha^{-1} and natural farming and four varieties which included three hybrids namely Arize 6129, Arize Swift & AZ 6508 and one inbred check variety HPR 2143. The experiment was laid out in split plot design, replicated thrice, with fertility levels in main plot and varieties in sub plot.

The nursery of all the varieties was sown on 6th June 2019 and the transplanting was done on 2nd July 2019. In natural farming treatment no chemical (herbicide, fungicide and chemical fertilizers) was used and the practices given by natural farming expert, Mr. Subhash Palekar were adopted (Palekar 2011).The data was recorded on the plant height, dry matter accumulation and leaf area at periodic interval (30, 60 and 90 days after transplanting, DAT) and at harvest and was used to calculate the different indices using standard procedures. The data so recorded was subjected to statistical analysis as per procedure given by Gomez and Gomez (1984). For parameters where the effects exhibited significance at 5 per cent probability level, critical difference (CD) was calculated.

The data on effect of fertility levels on plant height and dry matter accumulation at periodic intervals has been given in Table 1 while the data on various growth indices viz., absolute growth rate (AGR), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) has been presented in Table 2. Plant height of rice increased with increasing fertilizer application from 50% RDF to 150% RDF though the differences between successive levels (50 and 100% & 100 and 150%) were significant only at 90 DAT. Addition of zinc further increased the plant height though the increase could not breach the level of significance. Significantly lowest plant height at all stages was recorded in natural farming treatment which was due to the inability of the practices adopted in this treatment to meet the nutritional requirement of the rice crop. Varieties also behaved differently with respect to plant height with the check variety HPR 2143 producing significantly taller plants at all stages of observation. Amongst the hybrids tested AZ 6508 produced significantly taller plants while lowest plant height was recorded in Arize Swift at all the stages of observation. The differences between the varieties are due to the genetic makeup of these varieties. Similar results have also been reported by Kumar (2019).

Fertility levels had a pronounced effect on the dry matter accumulation by rice at all the stages of observation. Significantly higher dry matter accumulation at all the stages was recorded with the application of 150% RDF along with $ZnSO_4$ though this treatment was at par with the application of 150% RDF which in turn was at par with 100 % RDF. Significantly lowest dry matter accumulation was recorded in natural farming treatment. Dry matter accumulation at periodic interval was significantly influenced by varieties. Rice hybrid AZ 6508 accumulated significantly higher dry matter at all the stages of observation (30, 60 and 90 DAT) though this variety was at par with Arize 6129 at 30 and 60 DAT. Significantly lowest dry matter at all the stages was produced by the inbred check variety HPR 2143 though this variety was also at par with Arize Swift at the first two stages of observation (30 and 60 DAT). The results so obtained can be attributed to the growth habit of hybrids which produce vigorous root system, more tillering and remain green for a longer period of time thus accumulating more dry matter.

In general higher values of AGR were recorded between 30–60 days after transplanting (DAT) as compared to 60-90 DAT as the height of rice usually increases till the initiation of flowering after which there is only a slight increase in height. During 30–60 DAT the significantly lowest value of AGR was recorded in natural farming treatment while all the fertility levels were at par with each other. However between 60–90 DAT application of 150% RDF either alone or along with zinc resulted in significantly higher AGR. Amongst the varieties HPR 2143 recorded significantly higher value of AGR between 30-60 DAT followed by AZ 6508 while between 60–90 DAT AZ 6508 and Arize Swift recorded higher values of AGR. The variety HPR 2143 is an inbred variety and is medium statured while all the three hybrids tested are short statured ones. Lower AGR of HPR 2143 during 60–90 DAT can be attributed to early flowering as this variety takes about 15 days less for reaching flowering as well as physiological maturity.

The Crop Growth Rate (CGR) of rice increased with increasing fertility levels with significantly higher

Table 1. Effect of varying fertility level and varieties on plant height and dry matter accumulation at periodic intervals

Treatment	Plant height (cm)			Dry matter accumulation (g m^{-2})		
	30 DAT*	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Fertility level						
F_1: 50% RDF#	54.7	79.2	98.8	92.6	412.8	988.2
F_2: 100% RDF	56.8	80.8	101.2	97.5	440.3	1080.3
F_3: 150% RDF	58.9	82.0	104.7	101.4	464.8	1142.3
F_4: 150% RDF + $ZnSO_4$	59.2	83.3	105.2	104.2	480.6	1204.1
F_5: Natural farming	54.4	76.0	93.2	90.0	378.8	818.3
SEm±	0.7	0.7	0.6	1.6	10.0	21.6
CD (P=0.05)	2.2	2.1	1.9	5.1	32.5	70.3
Varieties						
V_1: Arize 6129	57.3	75.1	93.8	97.6	445.3	1055.0
V_2: Arize Swift	52.3	68.9	89.8	96.4	425.4	1035.7
V_3: AZ 6508	58.2	79.2	99.9	99.2	464.3	1160.3
V_4: HPR 2143	59.3	100.3	119.2	95.4	406.8	935.6
SEm±	0.6	0.9	1.1	0.8	8.2	23.0
CD (P=0.05)	1.8	2.7	3.2	2.4	23.8	66.4

*DAT: Days after transplanting, #RDF: Recommended dose of fertilizer (90:40:40)

CGR values recorded with the application of 150% RDF + $ZnSO_4$ though this treatment was at par with the application of 150% RDF. Natural farming treatment resulted in significantly lower values of CGR at both the stages. Since the CGR depends on the dry matter accumulation, higher doses of fertilizers applied at transplanting could have ensured adequate supply of the primary nutrients to the crop which could have resulted in better photosynthetic activity and hence higher CGR. Further higher quantity of nitrogen applied as topdressing at maximum tillering and flowering resulted in higher CGR between 60–90 DAT as nitrogen plays an important role in translocation of cytokinin resulting in increase in cell division thereby more growth (Timothy and Joe, 2003). Zinc plays an important role in various physiological and biochemical processes in plant system and increased availability as a result of its application resulted in higher photosynthetic activity and dry matter production and hence higher CGR (Rawat *et al*., 2019). In natural farming chemical fertilizers were not used and only limited quantity of FYM along with *Jeewamrit* were applied which could not meet the nutrient requirement of rice and hence lower values of CGR were recorded. Among varieties AZ 6508 recorded significantly higher values of CGR during both the stages while lowest values were recorded with the check variety HPR 2143 which may be due to the higher photosynthetic efficiency of hybrids. Kumar (2019) have also reported higher crop growth rate of hybrids as compared to the inbred varieties.

A close perusal of the data in Table 2 revealed that RGR increased with increasing fertility levels with significantly higher values at both the stages recorded with the application of 150% RDF + $ZnSO_4$ though this treatment was at par with 150% and 100% RDF while significantly lower RGR was recorded in natural farming treatment. As explained earlier higher quantities of nitrogen, phosphorus and potassium applied in higher fertility level resulted in higher photosynthetic activity which ultimately led to higher dry matter production and hence higher RGR (Ronanki *et al*. 2017, Rychter and Rao, 2005). The RGR of different varieties followed the trend similar to that of CGR with AZ 6508 showing significantly higher RGR while inbred check HPR 2143 logging in significantly lower RGR.

Net Assimilation rate was not significantly influenced by fertility levels at first stage (30–60 DAT) while the differences were significant between 60–90 DAT during which application of 150% RDF recorded significantly higher NAR followed by 150% RDF + $ZnSO_4$, 100% RDF, 50% RDF and natural farming treatment in that order, all treatments differing significantly except 50% and 100% RDF which were at par. Lowest NAR recorded in natural farming treatment was due to the inadequate supply of nutrients which resulted in poor initial growth, lower leaf area index, poor photosynthetic activity and dry matter accumulation and consequently lower NAR. Varieties also behaved differently in respect of NAR at both the stages with AZ 6508 recording significantly higher NAR while lowest values were recorded in the check variety HPR 2143.

From the present study it could be concluded that adequate quantities of fertilizers must be applied to rice hybrids for achieving better growth. Application of zinc further improved the growth of hybrids while it is difficult to get a good crop of rice by adopting natural farming. Hybrids have a better growth and productivity as compared to the inbred check. Amongst the hybrids AZ 6508 performed better in terms of all the growth indices.

Conflict of interest: The authors declare that there is no conflict of interest among the authors in this research paper.

Table 2. Effect of varying fertility level and varieties on growth indices of rice

Treatment	AGR (cm day^{-1})		CGR (g m^{-2} day^{-1})		RGR (mg g^{-1} day^{-1})		NAR (g cm^{-2} day^{-1})	
	30–60 DAT*	60–90 DAT	30–60 DAT	60–90 DAT	30–60 DAT	60–90 DAT	30–60 DAT	60–90 DAT
Fertility level								
F_1: 50% RDF#	0.817	0.653	10.67	19.18	49.8	29.1	4.845	5.432
F_2: 100% RDF	0.800	0.680	11.43	21.33	50.3	29.9	4.718	5.584
F_3: 150% RDF	0.770	0.757	12.11	22.58	50.8	30.0	4.720	5.617
F_4: 150% RDF + $ZnSO_4$	0.803	0.730	12.55	24.12	51.0	30.6	4.788	5.875
F_5: Natural farming	0.720	0.573	9.63	14.65	47.9	25.7	4.772	4.759
SEm±	0.015	0.016	0.29	0.56	0.3	0.4	0.046	0.062
CD (P=0.05)	0.048	0.052	0.94	1.82	0.9	1.2	NS	0.203
Varieties								
V_1: Arize 6129	0.593	0.623	11.59	20.32	50.6	28.8	4.872	5.384
V_2: Arize Swift	0.553	0.697	10.97	20.34	49.5	29.7	4.675	5.455
V_3: AZ 6508	0.700	0.690	12.17	23.20	51.4	30.5	4.889	5.767
V_4: HPR 2143	1.367	0.630	10.38	17.63	48.3	27.8	4.616	5.317
SEm±	0.025	0.019	0.28	0.50	0.5	0.3	0.075	0.093
CD (P=0.05)	0.074	0.054	0.82	1.45	1.3	0.9	0.217	0.268

*DAT: Days after transplanting, #RDF: Recommended dose of fertilizer (90:40:40)

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