Potato Progress

Research & Extension for the Potato Industry of Idaho, Oregon, & Washington

Andrew Jensen, Editor. ajensen@potatoes.com; 509-760-4859

https://www.nwpotatoresearch.com/

Volume XX, Number 5 | *11 March 2020*

Avoid Planting Potatoes West/East if You Wish to Optimize Production

Mark J. Pavek, Zachary J. Holden, Bertie J. Weddell, Raul Garza Jr., Rhett R. Spear, Francisco Gonzalez-Tapia; Department of Horticulture, Washington State University

Introduction

The efficiency of dry matter production by plants can be defined as the ratio of energy output to energy input (Monteith 1972, 1977). Energy input depends on the spectral quality of solar radiation that is intercepted by plant tissue, which depends on leaf area and orientation as well as canopy architecture. Energy output depends on the efficiency with which intercepted radiant energy is used in photosynthesis, which is influenced by temperature, water availability, pest pressure, nutrient supply, and canopy density. The amount and quality of light that intercepts a canopy differs according to seasonal and daily cycles. The tilt of the Earth's axis causes seasonal changes in the absorption of solar radiation (Figure 1). On a typical summer day in the northern hemisphere, the earth rotates in such a way that the sun appears to move across our sky from the northeast to the northwest. Although the movement we see is caused primarily by the earth's rotation, row crops can be positioned to take advantage of this sun/earth interaction. Because solar radiation is an abundant and free production input, manipulating potato row orientation for improved light capture and plant growth is a promising strategy for improving crop productivity.

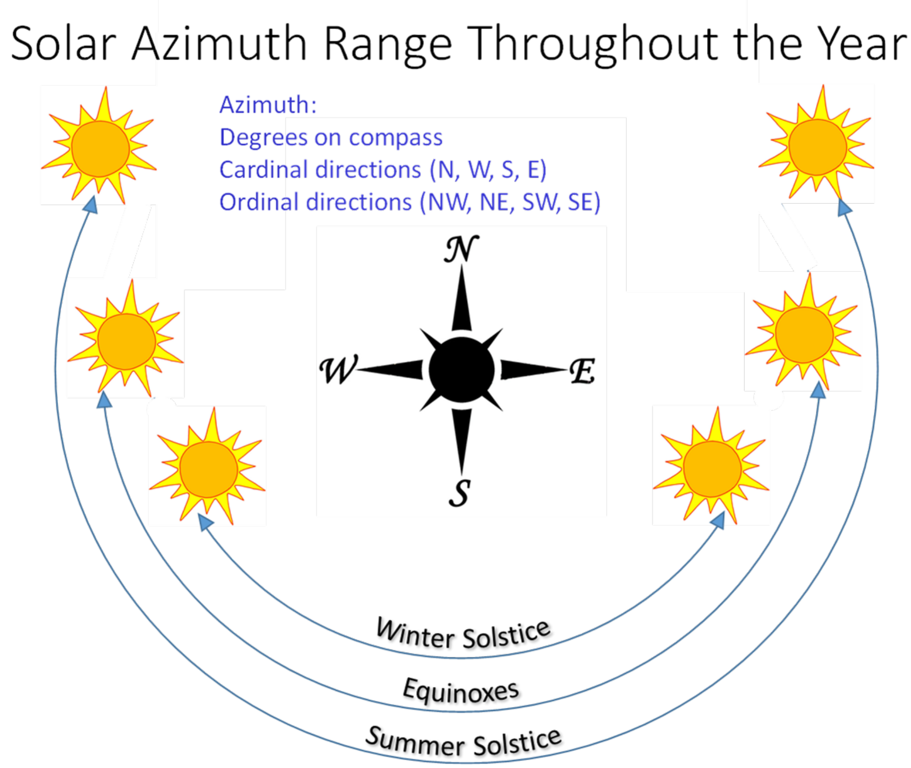

Figure 1. Solar azimuth range throughout the year for the Northern Hemisphere

Yield increases within the northern hemisphere from rows oriented along a north-south axis compared to an east-west orientation have been reported in oats (Pendleton and Dungan 1958; Austenson and Larter 1970), wheat and barley (Austenson and Larter 1970) in Illinois, USA; soybeans in South Carolina, USA (Hunt et al. 1985); bush beans in Kentucky, USA (Kaul and Kasperbauer 1988); maize in Uttar Pradesh, India (Dungan et al. 1955); Nebraska, USA (Lesoing and Francis 1999); Peshawar, Pakistan (Akbar and Klan 2002); and Illinois, USA (Kaufman 2013). However, higher yields in E-W oriented rows have also been reported for a summer crop of maize (Li et al. 2013) in Henan, China. Row orientation had no consistent effect on yields of maize in South Carolina, USA (Karlen and Kasperbauer 1989); sunflowers in Minnesota, USA (Robinson 1975); sorghum in Texas, USA; or cotton in Mississippi, USA (Anon. 1969).

Precise calculation of the amount of light absorbed by a canopy is complex. However, useful approximations can be arrived at with conceptual models if the assumptions of such models are realistic. When modeling light absorption by row crops, it is convenient to represent a canopy as a hedge separated by paths between the rows (Goudriaan 2014). If the amount of radiation absorbed by the canopy of a homogeneous hedge, and the radiation absorbed by the soil in the intervening paths are estimated, these values can be used to create models of radiation intercepted by a row crop. This approach is an oversimplification, however, because real canopies, even those of broad-leaved herbaceous crops such as potatoes–in which in-row canopy cover viewed from above during peak foliar growth can be close to 100%–are not homogeneous. Therefore, it may be necessary to incorporate a correction factor to the model results (Goudriaan, 2014).

In addition, the type of light that intercepts vegetation should be considered. Solar radiation is a combination of direct radiation from the sun and diffuse (scattered) radiation (Monteith and Unsworth 2008). Furthermore, light that goes through a canopy has two components: unfiltered radiation that has passed through canopy gaps, and filtered radiation, which has been absorbed, reflected, or scattered by foliage (Smith 1982). Methods of incorporating these distinctions into models are discussed in Goudriaan (2014).

The main objective of the study reported here was to evaluate potato row orientation, N/S, NW/SE, NE/SW, and W/E, for best production and economic return; alternately, to determine if one or more directions should be avoided when growing potatoes in the northern hemisphere. Row orientation and direction of planting will be used synonymously throughout the remainder of this report.

Methods and Materials: Five field experiments were completed between 2015 and 2019. Four cultivars, Umatilla Russet (2015-18), Payette Russet (2018 only), Clearwater Russet (2019 only), and Russet Burbank (2019 only) were planted into rows oriented across four directions: north/south (N/S), northeast/southwest (NE/SW), west/east (W/E), and northwest/southeast (NW/SE) and grown using standard practices. Each direction was replicated once per year in a strip-plot design for a total of five years, or five replications (Figure 2). The varieties were chosen because of their commercial popularity, non-uniform emergence (Umatilla R., Clearwater Russet) and dormancy issues (Payette R.). From planting to harvest, soil temperature was measured and recorded for each treatment, 2 inches above the seed piece.

Solar radiation (photosynthetically active radiation (PAR)) in units of Photosynthetic Photon Flux Density (PPFD), was collected using a 1 m LI-COR® LI-191R Line Quantum Sensor (LQS). Measurements started when plants were approximately 12-in tall and 12 to 16-inches wide and continued until row closure. Two 24-in stakes were hammered into the soil on each side of potato hill, 10 inches from hill center. The stakes on each side of row were located directly across from each other and the tops 7-in above hill top. A level was used to ensure that stakes were at identical heights. Stake locations were selected within uniform locations for each treatment where plants were of similar size. PAR measurements were collected at 8:30 am, 11:30 am, 2:30 pm, and 5:30 pm and from each side of the row by resting the LQS within the canopy across the two stakes, resulting in two measurements from each direction and time interval. Yield, size profile, US grade, tuber quality, and gross return (using a mock processing contract) were measured and calculated.

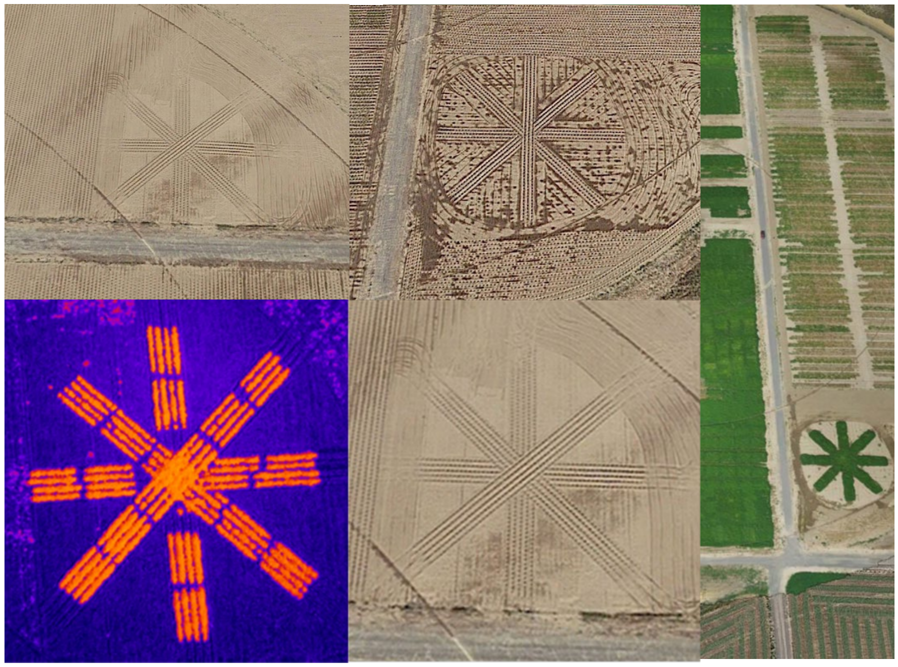

Figure 2. A near-infrared photo of the Direction of Planting trial taken by a drone (lower left) compared to a Google Earth snapshot (lower center). The photo on the lower left was taken near the end of June after potato plants had emerged. The photos without plants were taken after the trial had been planted and dammer-diked during various years. The trial was located on the WSU Othello Research Farm.

Results:

All varieties responded similarly each year, therefore, data were combined across years and varieties for ease of analysis and discussion. No obvious differences in average soil temperatures were found based on row orientation; however, differences may become apparent as the data are scrutinized further. Photosynthetic Photon Flux Density (PFFD) measurements indicated that depending on row orientation, rows did not always receive equal amounts of solar radiation on each row side. In addition, some row orientations received more total side to side solar radiation than others. Throughout the day, rows planted W/E inherently developed a shady side (north side) and a sunny side (south side). During a typical day in late June, the shady north side of the W/E rows received only 7.6 $\mu mol\ s^{-1}\ m^{-2}$ units of PFFD, between 8:30 am and 5:30 pm, while the sunny south side received 19.7 $\mu mol\ s^{-1}\ m^{-2}$. This concept can be seen in Figure 3. Moreover, W/E rows failed to collect as much total, side to side PFFD units during the day than other planting directions simply due to their orientation relative to the sun. When PFFD units from both row sides were measured and summed together for one day (8:30 am to 5:30 pm) in late June, the NW/SE and N/S row orientations collected more solar radiation than the NE/SW and W/E orientations; values for each were 32.0, 31.1, 27.7 and 27.3 $\mu mol\ s^{-1}\ m^{-2}$ units of PFFD, respectively.

Process adjusted gross return (grower return) was maximized when rows were planted N/S, NW/SE, and NE/SW. Planting W/E resulted in an economic loss (Table 1). Total and market yields were lowest from rows oriented W/E and NE/SW directions (Table 1). Moreover, W/E rows produced the fewest US 1 tubers, more undersized tubers (< 4 oz) and fewer large tubers (> 12 oz) than the other row orientations. NW/SE and N/S rows produced the largest quantities of market grade tubers > 6 oz. Interestingly, NW/SE rows produced the heaviest average tuber weight and about one less tuber per plant (Table 1). There was nothing obvious in the data that indicated why NW/SE rows produced fewer tubers per plant. Typically, favorable conditions, including ample solar radiation, encourage tuber production. Perhaps plant hormones were being altered in some fashion by an interaction between row orientation, solar radiation, and temperature. Specific gravity was not affected by row orientation.

Discussion:

Following five years of field trials near Othello, WA, the message appears to be clear: avoid planting potatoes in the W/E direction. That said, this may not be an option for all fields. The layout and slope of some fields may dictate the direction of planting. Slope can also alter how solar radiation is received by the plants. Because this trial was planted into relatively flat fields, these results may not apply in all situations. In most cases, however, N/S, NW/SE, and NE/SW oriented rows will likely collect more solar radiation than those planted W/E.

From row closure (late June/early July) until vine senescence, the crop canopy of many varieties provides what appears to be 100% groundcover. Although this is true, the plant canopy between rows is less dense (32-36 inches between plants) compared with that of the within-row plants (6 to 12 inches between plants). As sunlight is reflected off solar-saturated top leaves of the 100% groundcover, it bounces through cracks and crevices seeking out the path of least resistance, making its way into much of the canopy. The significant impact to grower returns and yield indicate that row orientation plays a role in optimizing whole plant photosynthesis, even when the canopy appears to be 100% and equal across the field.

W/E potato rows develop a shady, northern side and a sunny, southern side (Figure 3). This coincides with the well-known fact that moss typically grows on the north side of a tree, at least in the northern hemisphere. Moss grows better when not exposed to direct sunlight; moss favors shade. During the summer solstice, the sun reaches the highest altitude (67°) for the year at around 1 pm (Figure 3). The northern side of a W/E row only sees the sun shortly after sun-up and shortly before sun-down. At this time of day, the sun's angle ranges from 0° to 32° and the light quality is poor. Comparatively, when potatoes are planted N/S or close, the sides of the rows are facing west and east. As the earth moves between sun-up and sun-down, each side of the N/S row receives close to equal exposure to the sun during the day – maximizing the capture of solar radiation. If plants were not planted into a row or hedge pattern (say 10 x 34 inches), but were spaced in a perfectly square pattern, say 17 x 17 inches, planting direction would not matter. Plants within a square pattern will see the sun equally.

2015-2019 Planting Direction Study

Planting Direction	Process Adjusted Gross $/A	Total Yield CWT/A	Total Market Yield	US 1s > 4 oz %	US 2s > 4 oz %	Culls & < 4 oz %	Process Yield US 1 & 2s > 6 oz %	Average Tuber Weight oz	Average Tuber Number per Plant	Specific Gravity
N/S	5110 a	832 a	803 a	81 a	4	15 a	69 a	8.5 ab	9.8 a	1.0878
NW/SE	5190 a	832 a	791 a	82 a	3	15 a	72 a	9.5 a	8.8 b	1.0881
NE/SW	4885 a	810 ab	776 ab	80 ab	3	17 ab	66 ab	8.2 b	9.8 a	1.0889
W/E	4415 b	768 b	725 a	77 b	4	19 a	64 b	8.5 ab	9.4 ab	1.0888
LSD	435	58	63	3.5	ns	3.1	4	1.0	0.9	ns

Treatment values within a column are not signficantly different if followed by the same letter

ns = values within the same column are not signficantly different based on Fisher's Least Signficant Difference Test

Planting Direction	Market Yield (Percent of Market Yield) CWT/A					Cull Yield (Percent of Total Yield) CWT/A				
	0-4	4 to 8	8 to 12	12 to 16	> 16	Malformed	Knobs	Green	Crack	Rot
N/S	96 ab	249	185	104 a	170 ab	12	31 ab	24	13	20
NW/SE	82 b	214	179	120 a	196 a	11	28 b	23	15	24
NE/SW	98 ab	260	178	105 a	135 b	13	33 a	23	14	19
W/E	102 a	242	153	86 b	143 b	14	33 a	22	13	19
LSD	20	ns	ns	21	52	ns	4	ns	ns	ns

ns = values within the same column are not signficantly different based on Fisher's Least Signficant Difference Test

Varieties = Umatilla (2015-2018), Payette Russet (2018), Russet Burbank and Clearwater (2019)

Design: One year = one replication for each direction

Table 1. Yield, economics and tuber information from the 2015-19 WSU Direction of Planting trial.

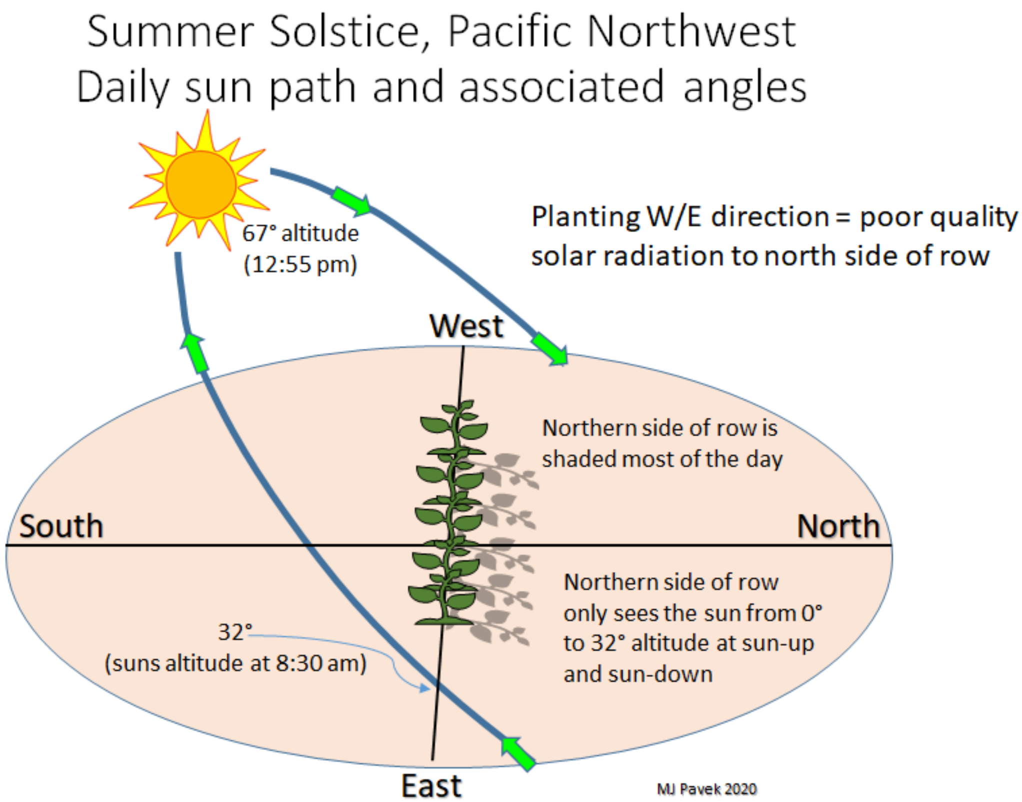

Figure 3. An illustration demonstrating why row crops in the Pacific Northwest should NOT be planted in the W/E direction. During the summer solstice, the sun reaches the highest altitude (67°) for the year at around 1 pm. The northern side of a W/E row only sees the sun shortly after sun-up and shortly before sun-down. At this time of day, the sun's angle ranges from 0° to 32° and the light quality is poor. The northern side of the row is shaded most of the day.

References

Akbar, M., and M.I. Khan. 2002. Effect of row orientation on yield and yield components of maize. *Pakistan Journal of Agricultural Research* 17: 186–189.

Anon. 1969. Row direction doesn't influence cotton yields. *Crops and Soils* 22. Imprint Journal of Production Agriculture 12: 399.

Austenson, H.M., and E. Larter. 1970. Cereal yields increase in north-south rows. *Crops and Soils* 22. Imprint Journal of Production Agriculture 12: 18–19.

Dungan, G.H., U.S. Sisodia, and G.D. Singh. 1955. The benefit of sowing maize for fodder in north and south lines. *Allahabad Farmer* 29: 8–13.

Dunlap, J.C. 1999. Molecular bases for circadian clocks. *Cell* 96: 271–290.

Goudriaan, J. 2014. Light distribution. In *Canopy photosynthesis: From basics to applications*, ed. Hikosaka, K., Ü. Niinemets, and N.P. Allen, 3–22. Advances in Photosynthesis and Respiration 42. Dordrecht: Springer Science & Business Media.

Hunt, P.G., R.E. Sojka, T.A. Matheny, and A.G. Wollum. 1985. Soybean response to *Rhizobium japonicum* strain, row orientation, and irrigation. *Agronomy Journal* 77: 720–725.

Karlen, D.L., and M.J. Kasperbauer. 1989. Row orientation and configuration effects on canopy light spectra and corn growth. *Applied Agricultural Research* 4: 51–56.

Kaufman, T.D. 2013. The effects of planting techniques on maize grain yield and silage production. MS Thesis, Illinois State University, Normal.

Kaul, K., and M.J. Kasperbauer. 1988. Row orientation effects on FR/R light ratio, growth and development of field-grown bush bean. *Physiologia Plantarum* 74: 415–417.

Lesoing, G.W., and C.A. Francis. 1999. Strip intercropping effects on yield and yield components of corn, grain sorghum, and soybean. *Agronomy Journal* 91: 807–813. doi:10.2134/agronj1999.915807x.

Li, C.X., X.G. Zhou, J.S. Sun, X.Q. Qiu, and X.Q. Li. 2013. Ground distribution of light and temperature under furrow irrigation methods and ridging directions. *Journal of Drainage and Irrigation Machinery Engineering* 31: 1095–1099.

Monteith, J.L. 1972. Solar radiation and productivity in tropical ecosystems. *Journal of Applied Ecology* 9: 747–766.

Monteith, J.L. 1977. Climate and the efficiency of crop production in Britain [and discussion]. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 281: 277–294.

Monteith, J.L., and M.H. Unsworth. 2008. *Principles of environmental physics*, 3rd ed. Amsterdam: Elsevier.

Pendleton, J.W., and G.H. Dungan. 1958. Effect of row direction on spring oat yields. *Agronomy Journal* 50: 341–343.

Robinson, R.G. 1975. Effect of row direction on sunflowers. *Agronomy Journal* 67: 93–94.

Smith, H. 1982. Light quality, photoperception, and plant strategy. *Annual Review of Plant Physiology* 33: 481–518.

To fill in this white space, a challenge for you: **Name this cultivar!**

2020 WA Commercial Potato Seed Lot Pick up &Trial Information

Info also available each year at: **www.potatoes.wsu**

Commercial potato seed samples are requested from WA Growers for the 2020 Washington Seed Lot Trial. **Two hundred whole (single drop) seed is an acceptable sample size, or 50 lbs of 4 oz single drop seed.**

Requested: 50 lbs of 2-4 oz whole seed, no seed treatments We want a representative sample - if applicable, include a representative amount of rotten tubers!

(Seed over 6 oz is not acceptable)

A representative sample is needed. Sampling the first (or last) 200 seed from the truck is not likely to provide a representative sample of the lot. Sample tags may be obtained by calling the Potato Commission at 509-765-8845.

Your assistance with collection and drop off of seed samples is needed. Seed samples may be taken to the WSU Othello Research Unit (509-488-3191); located on Booker Road ¼ mile south from State Highway 26 and about five miles east of Othello. For sample pick up and any questions regarding the seed lot trials please call:

South Basin: Tim Waters (509-545-3511), Mark Pavek (509-335-6861), or Zach Holden (509-335-3452).

North Basin: Carrie Huffman Wohleb (509-754-2011), Mark Pavek (509-335-6861), or Zach Holden (509-335-3452).

Westside: Don McMoran (360-428-4270), Mark Pavek (509-335-6861), or Zach Holden (509-335-3452).

In the North Basin, one seed "drop-off" has been established. It is located at Qualls Ag Labs (Mick Qualls, 509-787-4210 ext 16) on the corner of Dodson Road and Road 4; come to front office between 8 am and 5 pm. Please call the numbers below to arrange additional pick up sites. Samples will be picked up at 2:00 pm the day before each planting date (below) to be included. Growers planting in early March should drop their samples off at the Othello Research Center or store the samples and call the numbers below for pick up. For all alternative pick up locations or questions please call Mark Pavek at 509-335-6861 or Zach Holden at 509-335-3452.

PICK UP DATES ARE ONE DAY PRIOR TO THE PLANTING DATES BELOW

The seed lot planting dates for 2020 are:

1st (Early)	March 31
2nd	April 14
3rd	April 28
4th (Late)	May 5

2020 Potato Field Day - Thursday June 18

This year's virus reading of the seed lots will take place on June 9 and 16

Save the date: Next year (2021) Potato Field Day will be June 24