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Promoting Efficient Water Management through Effective Outreach Education in the High Plains and Beyond: Role of the Ogallala Aquifer Program

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Abstract. *The Ogallala Aquifer Program (OAP) is a consortium between the USDA Agricultural Research Service and partnering universities in Texas and Kansas. The OAP has coordinated and leveraged highly effective irrigation research and extension programs with overarching goals to prolong the life of the Ogallala Aquifer and enhance rural economies in the US Southern High Plains. The OAP has increased capability of research and extension programs to address local and regional issues more collaboratively and comprehensively, generating national and international recognition. Stakeholders include agricultural producers; irrigation practitioners; crop and technical advisers; educators; off-farm decision makers; water resource planners/managers, in particular; and the general public. Stakeholders possess wide ranges of specific interests, technical understanding, and information delivery preferences. This paper describes how educational events, research and extension publications and products, media outreach, and mentoring are used to meet stakeholder information needs and promote basic and applied research programs in the High Plains.*

Keywords. *irrigation scheduling, water management, education, water conservation, communication, agricultural extension*

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Introduction

Limited and declining water resources; increasing regulatory limits on pumping; drought; economic and environmental concerns, and other impacting issues enhance the need for efficient and advanced water management in agriculture. Physical and regulatory limits on irrigation capacities and program requirements (USDA-NRCS-EQIP cost-share, crop insurance requirements) complicate water management decisions from field to regional levels. Decision-makers (landowners, policy makers) are better equipped to address these complex issues when they have access to appropriately presented, pertinent, objective information resources. Ongoing Extension and other technology transfer programs supported through the Ogallala Aquifer Program (OAP) provide excellent educational support for traditional audiences (agricultural producers, crop consultants, technical service providers) and new audiences (small acreage landowners, new agricultural irrigators, and others). They also have been expanded to provide greater support for other decision-making stakeholders, including landlords, policy makers, agricultural lenders, educators and similar “off-farm” leaders and decision makers. Online tools and advanced educational resources are being developed to complement traditional methods to support distance education and CEU programs for these audiences.

Agricultural irrigators in the Ogallala Aquifer region are among the most progressive adopters of efficient irrigation technologies and best management practices (Colaizzi et al., 2009; Wagner, 2012). Still there is a need for sustained and expanded technology transfer to support agricultural irrigators (as new products, technologies, and management tools emerge), as well as significant emerging audiences. Informational materials relevant for agricultural water management decisions are being developed and provided for both technical and non-technical audiences that include educators, practitioners, and a variety of decision-making stakeholders. Some very useful technical resources have been developed for less technical audiences, emphasizing the “big picture”, as well as local considerations, with special consideration of “bottom line” economic analyses. The scope of subject matter addresses a range of issues from irrigation technologies and best management practices (selection, applicability), program requirements (crop insurance, NRCS-EQIP), water resources management tools, and strategies for mitigating physical and regulatory limitations to water availability.

Technology transfer and the OAP: The OAP has leveraged, strengthened and connected established applied research programs in irrigation systems and technology; water management; cropping systems; animal agriculture; economics; hydrology and climatology. Through supporting multi-agency and interdisciplinary research, the OAP fosters comprehensive systems approaches to find answers to critical questions of water resources management and practical solutions to agricultural water users’ problems. Innovative applications of advanced irrigation technologies, crop rotations and tillage systems to sustain production in water limited cropping systems; multi-faceted technical and economic analyses of water management strategies; and local and regional scale groundwater resources modeling provide relevant information and sound management recommendations. Dr. Terry Howell and other OAP leaders acknowledged early in the program planning that one key to maximizing the impact of OAP associated research and sustaining the program is an effective technology transfer program to interpret the research for the various audiences, increase visibility of the program, and promote adoption of appropriate tools and strategies. Like the applied research projects and programs, the OAP technology transfer program has leveraged, connected and strengthened established educational venues (Extension programs, university courses, and mentoring of students, staff and faculty of research programs). A measure of success of the OAP effort has been the national recognition and awards associated with the program

The objectives of the OAP technology transfer program are to 1) enrich OAP capabilities and extend benefits and visibility of OAP efforts; 2) deliver useful, objective information and educational opportunities for stakeholders efficiently; and 3) promote OAP-developed resources to an expanding stakeholder base to improve water management decisions.

Methods

The goal of amplifying water conservation and economic benefits of the OAP and associated agricultural research programs is met through reaching diverse audiences in communicating economic impacts of agricultural water use and effects of declining water resources; promoting adoption of appropriate technologies and management practices; and interpreting research results and developments for targeted audiences (agricultural producers, crop consultants, crop insurance, irrigation professionals, policy makers, Extension educators, and general public).

A variety of methods and media are used to deliver and promote relevant resources for expanding and diverse audience needs. Among the accomplishments of the OAP technology transfer team are increased public awareness and adoption of technologies and management practices for efficient agricultural water use, including development, improvement and adoption of decision support tools, including the Bushland Reference ET Calculator (Gowda et al, 2012), KanSched ET-based irrigation scheduler (Rogers and Alam, 2012), Crop Water Allocator (Klocke et al, 2006), Ogallala Agro-Climate Tool and Cotton Irrigation Tool (both available at <http://ogallala.ars.usda.gov/>), TAMU water management irrigation scheduling program (Marek et al, 2013) and others; advancement and adoption of appropriate crop genetics for improved drought tolerance, increased yield and quality; increased adoption of efficient irrigation technologies and BMPs, including low pressure center pivot and microirrigation technologies; and adoption of improved crop rotation strategies and cropping practices to improve overall profitability with limited water resources.

In addition to developing Internet based tools, including a secure website to facilitate communications among OAP participants and a public website to provide access to vetted (reviewed) reports, presentations and other resources, the OAP technology transfer team has leveraged established technology transfer vehicles (websites, communications programs, mass media and other venues) and fostered collaborative outreach efforts between research programs. Examples include SDI Field Days conducted at Colby, KS and Halfway, TX that were well attended and well received by the public and highlighted the collaborations between OAP researchers from USDA-ARS, Kansas State University and Texas A&M AgriLife Research and Extension Service. Regional irrigation conferences (examples listed in Table 1), technical sessions at commodity conferences and professional/technical society conferences, multi-state research group meetings, webinars and other venues provide updates of OAP sponsored research for a range of audiences, from the general public and agricultural water end-users, to policy makers, and to the science and research community.

With resources, networks and collaborations in place, the OAP technology transfer team is positioned to take advantage of “teachable moment” opportunities, such as the severe drought that affected much of the region over the period 2011 through 2013; adoption of groundwater pumping limits in the Texas High Plains and changes in Kansas’ water allocation policies (such as the multi-year allocations). Stakeholders depend on Land Grant Universities and USDA-ARS for reliable, objective information to adapt to changing environmental, regulatory and crop production conditions. With increasing pressure on (and competition for) limited groundwater resources in the region, especially in the Texas High Plains where surface water availability also has declined, water policy has emerged as a priority in state and federal legislation. This has highlighted the need for research to support policy decisions and for evaluation of policy options and interpretation of these policy options (and their effects) on the interests of stakeholders. This in turn has increased interest and demand for user-friendly and practical smartphone apps, internet based tools, and online courses that reflect emerging user preferences. Consequently, there is an implicit and ongoing need for maintenance of advanced tools, apps and other software. Additional considerations are a general increasing interest in water issues, increasingly diverse audiences, and an understanding that even traditional agricultural audience numbers represent increasingly larger acreages per person.

Publications and Media

A variety of information delivery options are used to reach these increasingly diverse audiences. Agency-produced news releases, publications (fact sheets, bulletins, white papers, etc.), videos, software (including smartphone apps), and websites are readily available to the public, and with few exceptions, free of charge.

These materials and other articles and tools are promoted through agency, other public and commercial media outlets. Commercial mass media outlets (local television and radio, newspapers and trade journals, for instance) are especially cost-effective (and time efficient) for communicating new developments, highlighting research results, and promoting availability of programs and information resources to targeted audiences, as well as the general public. The use of these audience-targeted media outlets facilitates matching of information format and technical level / context emphasis to stakeholder interests.

Articles citing OAP research and expertise have appeared in high impact, high profile publications, including National Public Radio (Gordon, 2013), the *New York Times* (Galbraith, 2013), *The Telegraph* (Laurence, 2011), *Scientific American* (Little, 2009), and the *Christian Science Monitor* (Gillam, 2013). These articles have generated international interest in the status of the Ogallala aquifer, as well as in the technologies, practices and policies employed to address sustainability concerns. This interest, in turn, highlights the research and outreach efforts of the OAP.

Agricultural trade journals reach a wide and diverse readership, and they generally have both hardcopy and electronic delivery. Numerous articles authored by OAP participants and/or by journal staff and editors with OAP participant involvement have been published in Penton publications, including *Southwest Farm Press* (print circulation 29,100), *Delta Farm Press* (print circulation 26,200), *Southeast Farm Press* (40,600), and *Western Farm Press* (19,400); these numbers are based upon BPA Worldwide Business Publication Circulation statistics for June 2012 (Southwest Farm Press, 2012). Other large audience agricultural trade publications featuring OAP research and programs include *High Plains Journal* (circulation 53,000); *MidWest Producer* (circulation 29,500); *Cotton Grower* (Meister Media, estimated circulation 46,000), and others. Local media (newspapers, television and radio) regularly feature OAP research and programs, emphasizing accomplishments of local research programs, highlighting local water issues, and promoting local and regional educational opportunities. Educational programs are even broadcast live over radio stations, and/or made available for on-demand listening on websites. Local affiliates of radio and television networks frequently share broadcasts with nearby affiliates, effectively increasing the coverage area of stories. Outreach and education staff of groundwater conservation districts, irrigation districts, commodity organizations and farm organizations also regularly feature OAP research and programs of interest to their target audiences. News releases by communications staff of OAP participating universities and agencies are very effective in promoting OAP sponsored events and highlighting accomplishments of research programs. These news releases are published in local newspapers and regional trade journals, and frequently will be published in a large number of journals and newspapers simultaneously. Agency communications departments are increasingly using agency websites, YouTube and social media to deliver video and multi-media materials. Some of these also are re-posted on commercial websites.

Since USDA-ARS and OAP participating university researchers are academic professionals, publications in refereed professional/technical journals are required deliverables. These journals include *Transactions of the ASABE*, *Applied Engineering in Agriculture*, *Agronomy Journal*, *Journal of Hydrology*, *Advances in Water Resources*, *Irrigation Science*, *Advances in Remote Sensing*, and others. Conference proceedings papers, abstracts, presentations and posters also support important technology transfer among peers and colleagues. Many of these were made available to the public free of charge through the USDA-ARS Conservation and Production Laboratory Website, and are now available through the USDA-ARS scientific manuscript database, "TEKTRAN" (<http://www.ars.usda.gov/services/TekTran.htm>). The academic publications are essential to supporting standards developments, justifying recommendations for practice, and for informing and mentoring graduate students and research peers.

Websites, Tools and Apps

For over ten years USDA-ARS OAP public information portal (Fig. 1) provided essential information about the OAP, its participants, the Ogallala aquifer, research areas and summaries of research projects, videos of presentations from meetings, photos, online tools and other information. The USDA-ARS Conservation and Production Laboratory website provided free access to USDA-ARS publications and software. The Kansas State University Research and Extension General Irrigation website (<http://www.ksre.ksu.edu/irrigate/>) and SDI in the Great Plains website (<http://www.ksre.ksu.edu/sdi/>) offer additional irrigation information, news

articles, research reports, photo galleries and more. The Texas A&M AgriLife Research and Extension Water Management website (watermgmt.tamu.edu) links users to Texas High Plains irrigation research and extension summaries, and the Texas A&M AgriLife Research and Extension Centers at Amarillo and Lubbock provide program-related and commodity specific research updates at Amarillo.tamu.edu and Lubbock.tamu.edu. Smartphone apps, including the Bushland Reference ET calculator (Fig. 2) (Gowda et al., 2012) are available at widely used applications download sites.

Educational Events

From agricultural producer meetings and field days (Fig. 3) to regional and national commodity conferences and irrigation workshops, educational events provide effective technology transfer for target audiences, including agricultural producers; landowners; extension educators; crop consultants; and irrigation, environmental and engineering professionals. CEUs are offered as appropriate. OAP supported research programs and products have been featured in numerous venues; examples are listed in Table 1.

Student Training, Peer Mentoring, and Professional Development

In addition to technology transfer and outreach to external stakeholder audiences, an essential function of OAP affiliated research is training of undergraduate and graduate students, primarily at OAP participating universities: Kansas State University, West Texas A&M University, Texas Tech University and Texas A&M University. Research and extension peer collaboration and mentoring is also very important to increasing technical competencies of individual professionals and improving the overall quality of research, accuracy of research result interpretations, and appropriateness of recommendations stemming from these results.

Some OAP researchers are university classroom professors; others train students and young professionals in their laboratories and field stations. Extension specialists and research faculty conduct training programs for county-based Extension educators, who in turn propagate additional local educational programs for stakeholders.

OAP participants are active on technical committees of professional societies and in multi-state collaborative research programs, providing technical guidance in developing research papers, white papers, engineering practices and standards. Examples include the American Society of Civil Engineers Environmental and Water Resources Evapotranspiration Task Committee, American Society of Agricultural and Biological Engineers technical committees and groups, Irrigation Association groups, American Society of Agronomy/Crop Science Society of America/Soil Science Society of America sections and others. OAP member participation in multi-state projects, such as the Western Association of Agricultural Experiment Station Directors Regional Projects, Microirrigation Research Group and Meteorology and Climate Data Research Group, offer opportunities for peer interaction, research feedback, and mentoring with OAP and other researchers, increasing subject matter expertise, improving quality of research and technology transfer products, and further increasing collaboration in research and technology transfer.



Figure 1. Background information, presentations, research reports and other information available through the public website of the Ogallala Aquifer Program (site removed August, 2015).

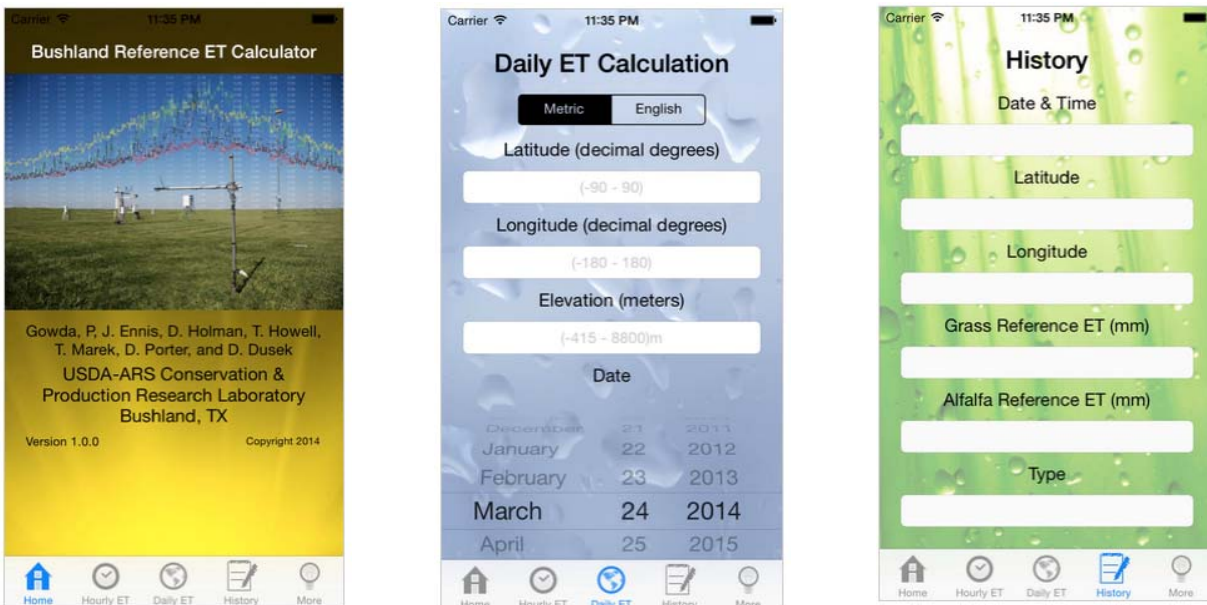


Figure 2. The Bushland Reference ET Calculator is available from widely used App stores.



Figure 3. Irrigation workshops, targeted conferences, and field days offer traditional in-person education and other information exchange opportunities.

Table 1. Selected educational events promoting technologies, management strategies and programs of the OAP.

Event	Location and Date(s)	Target Audiences
OAP Annual Meetings/Workshops	Rotate between Texas and Kansas locations. Meetings held annually in March.	OAP participants (scientists, educators, students); stakeholders (commodity groups, water districts, research agencies, and policy makers).
Central Plains Irrigation Conference	Rotates between Colby, Kansas, Kearney, Nebraska and Burlington, Colorado. This annual event is held in February.	Agricultural producers, irrigation industry professionals, agribusiness, research and extension professionals.
High Plains Irrigation Conference	Amarillo, Texas. Annual in January/February	Agricultural producers, irrigation industry professionals, agribusiness, research and extension professionals, landowners and policy makers.
Irrigation workshops at major commodity meetings, such as the Beltwide Cotton Conferences	San Antonio, TX; New Orleans, LA. Workshops January 2000, 2004, 2006, 2010, 2013.	Cotton producers, irrigation industry professionals, agribusiness, research and extension professionals.
Irrigation/agricultural applied research and demonstration field days, tours, and similar programs	Colby, KS; Garden City, Tribune and Hays, KS; Bushland, TX; Etter, TX; Halfway, TX; Lamesa, TX; other locations. Some of these are annual events; others are occasional.	Agricultural producers, landowners, irrigation industry professionals, agribusiness, research and extension professionals.
County and regional events for target audiences	Various locations; most are annual events	Agricultural producers, landowners, irrigation industry professionals, agribusiness, other water users (homeowners, Master Gardeners, etc.), research and extension professionals.
County agent training	Webinars and in-house meetings at research and extension centers in Kansas and Texas; some events are annual.	County extension agents, other technical advisors, research program staff
Invited workshops, seminars, presentations	Various locations, including large conferences (Irrigation Association Conference and Trade Show; trade associations; industry/manufacturer sponsored training; water planning groups)	Technical service providers, irrigation professionals, consultants, policy makers, industry/trade association professionals
Technical sessions at conferences	Various locations at large conferences and/or at focused research meetings	Irrigation and/or agricultural research and education professionals; stakeholders
Webinars	Webinars are made available through agency venues, industry groups/trade associations and professional/technical societies.	Audiences vary; many are earning CEU credits.

Economic considerations are essential to decisions regarding adopting and applying irrigation technologies and BMPs. Economic assessments in the OAP include estimated impacts at the farm-scale and larger scales. Successful implementation of technologies and BMPs depends upon the selection of technologies and BMPs that are appropriate for given conditions, which requires understanding of the applicability (suitability, practicality, advantages, and limitations) of these tools. Implementation of programs and adoption of technologies and practices have local and broader economic implications. These considerations are explored, summarized and presented for use according to stakeholder interests and format preferences.

Results

Promotion of the OAP program through mass media

Awareness of the Ogallala aquifer and related water issues (in general) and of the OAP (in particular) has been significantly increased through OAP technology transfer efforts. Because of the wide variety of publications, formats, and high levels of updated packaging and re-publishing of articles, it is not possible to accurately assess the total number of published articles, let alone the complex distribution of readership of these articles. In the Penton media publications (Southwest Farm Press, Delta Farm Press, etc.), there have been over 50 articles published addressing contributions and accomplishments of the OAP program. This outlet represents well over 1.45 million potential readers, and often feature individual OAP researchers, projects or events. Internationally recognized popular press (*New York Times*, *The Daily Telegraph*, *The Christian Science Monitor*) represent fewer article occurrences for OAP content, but they represent larger numbers of potential readers. The *New York Times* has reported 831,000 digital subscribers (Somaiya, 2014), and combined daily (Monday – Friday) print and electronic delivery of approximately 1,926,800 copies, according to their 2013 Annual Report. *The Telegraph* has an estimated 1.7 million browsers daily on its website (according to http://en.wikipedia.org/wiki/The_Daily_Telegraph) and 330,000 print edition subscribers (Bishton, 2012). The *Christian Science Monitor* reported over 75,000 subscribers in 2011. *Scientific American* has an estimated circulation of 3.5 million readers worldwide, according to their website, <http://www.scientificamerican.com/pressroom/about-scientific-american/>. Most of these very large volume media outlets feature interviews with the OAP Program Manager, Dr. David Brauer, who readily confers credit to the individual OAP participants and collaborative teams, while presenting the material and accomplishments clearly, concisely, and in audience-friendly terms.

With much lower numbers than the national outlets, local media outreach (news releases and other news stories, television and radio) has increased local/regional audience familiarity with the OAP and its associated programs. Similarly, local meeting presentations, invited presentations, training events and other frequent features foster familiarity with OAP participants as local/regional water experts. These also generate grassroots support for the OAP and for associated research programs and educational events.

Educational program effectiveness

Surveys of participants in educational events are used to assess program effectiveness, as indicated by participant satisfaction, subject matter knowledge gained through what was presented, and intent to adopt (will adopt, probably will adopt or already have adopted) appropriate water efficient technologies and best management practices. Aggregated survey results from evaluated programs are summarized in Figs. 4a and 4b; these results indicate high levels of satisfaction, notable gains in subject matter knowledge, and effectiveness in promoting technologies and BMPs, as well as improved familiarity with OAP and USDA-ARS-OAP sponsored applied research programs.

Awards and Recognition

Individuals and teams associated with the OAP have received local, state, and national recognition. Some awards are directly related to OAP Programs; for instance, the Texas Water Development Board Water Conservation Advisory Council recognized the OAP Team with the 2012 Blue Legacy Award in Agriculture (Save Texas Water, 2012). The team was later recognized with the 2013 USDA Secretary's Honor Award (Allen, 2013; Perry, 2014). Other national and international level recognition, such as the American Society of Agricultural and Biological Engineers Educational Aids Competition Blue Ribbon awards, (ASABE, 2014), the Excellence in Multistate Research Award (2014) awarded both at the regional and national level to Western Regional Project, W-2128, Microirrigation Research Group by the Western Association of Agricultural Experiment Station Directors and Association of Public Land Grant Universities, respectively (Agriculture is America, 2014); major awards and fellows honors for OAP participants from American Society of Agricultural and Biological Engineers, American Society of Agronomy, Soil Science Society of America, American Society of Civil Engineers, The Irrigation Association and others may also be attributed in part to projects, programs and accomplishments involving OAP. While the recognition of individuals and teams is certainly justified and gratifying, it also promotes the overall OAP program and associated collaborations and

programs.

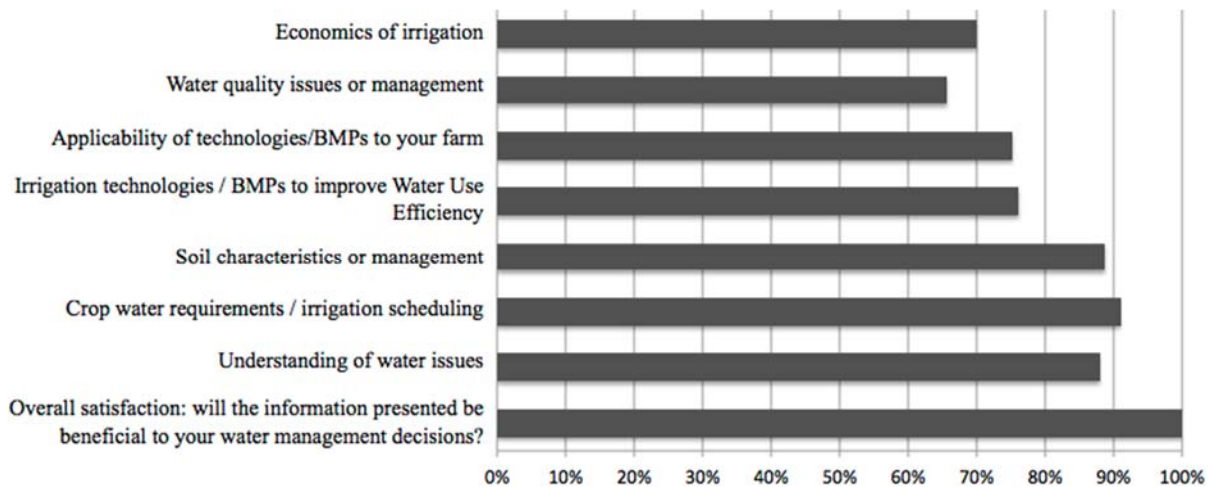


Figure 4a. Percent survey respondents indicating increased knowledge by subject matter area.

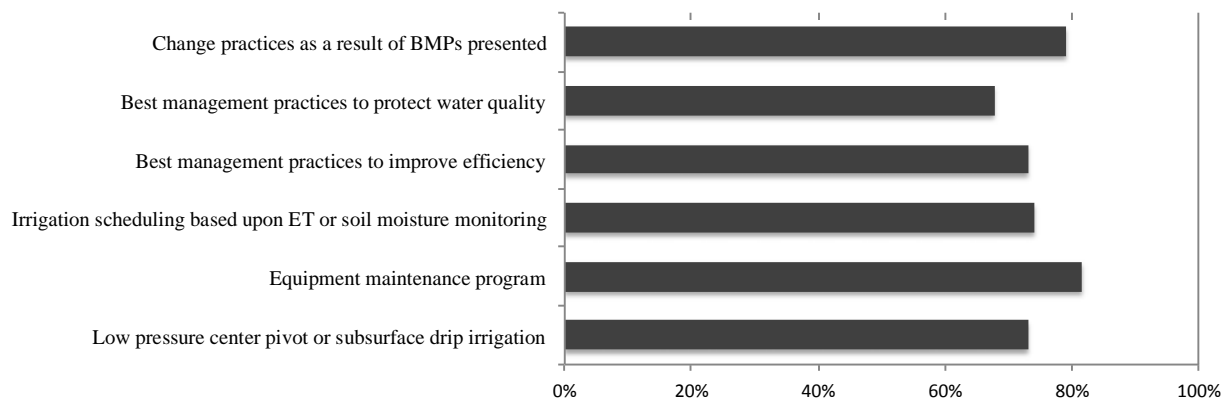


Figure 4b. Percent survey respondents indicating intent to adopt technologies / strategies. (It should be noted that no follow-up survey was conducted to verify actual level of adoption.)

Conclusion

Technology transfer has been a key and forthright priority for the Ogallala Aquifer Program from its inception. Dr. Terry Howell, Dr. Nolan Clark, Dr. David Brauer from USDA-CPRL and others have emphasized the value of communicating OAP accomplishments to stakeholders and have supported technology transfer team members and activities. Various media outlets, print and electronic media, and educational event venues have been used effectively to increase visibility of OAP and of the associated research programs; to increase stakeholder understanding of water issues and technologies; and to increase adoption of applicable technologies, tools and practices to improve water management decisions in the Ogallala Aquifer region, the US and even internationally.

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